Fraunhofer magazine

2/11 special issue

Organs on demand

Health
On-site diagnostics

Europe
Simulation in motion

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Fraunhofer magazine

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Fit for recovery

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

Good news! The German Bundesbank revised its growth forecast significantly upwards. It seems the German economy has recovered remarkably swiftly from the biggest crisis of the post-war era. There are two main reasons for this: Firstly, the federal government's stimulus programs have proved effective. And secondly, the German economy reacted to the financial crisis in a restrained and considered manner. Companies did not lay off swathes of employees as in previous recessions, but instead used the time to implement rationalization programs and continuing professional development. And now, in these times of economic recovery, they are reaping the benefit of experienced and highly-skilled workers. The added investment firms put into their employees during the crisis is now paying off in the form of added value.

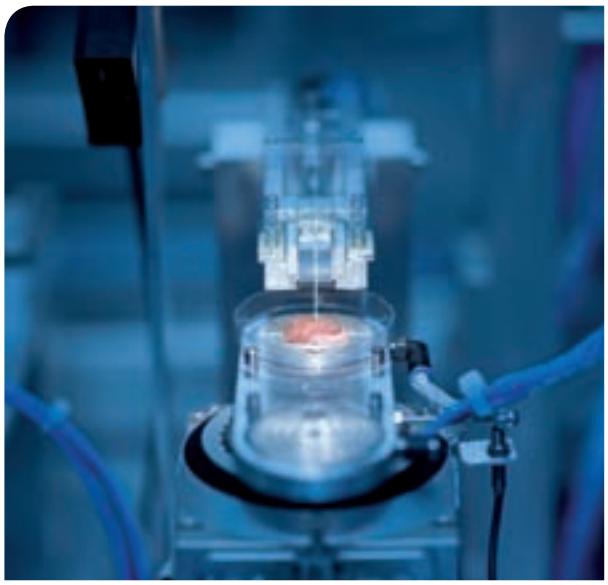
Efficient and productive employees are without doubt the most important asset of any enterprise. Their knowledge and skills are the keys to success in global innovation competition. So how can businesses do more to help their employees become more efficient and productive? Performance is dependent on motivation, skills and fitness – both mental and physical. Currently, in all three of these areas, we are in the midst of a paradigm shift. We promote motivation within an enterprise when we establish a culture of trust, rather than mistrust. Motivated workers need more than just ideal working conditions. They also require development opportunities. And a management style that not only promotes autonomy and assumption of personal responsibility, thus giving them the freedom and encouragement to run with new ideas, but is capable, above all, of dealing with risks and mistakes.

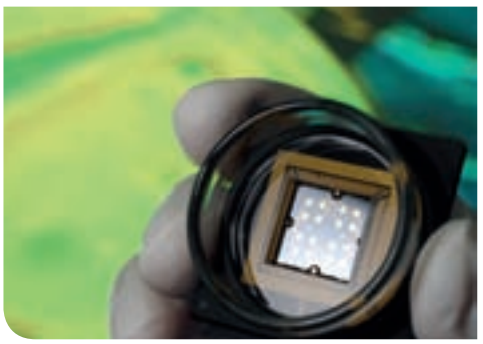
Times have changed when it comes to skills, too. A good education is no longer enough to last a lifetime. On the contrary, continuing professional development is now de rigueur, and retraining has become the norm. Many companies are reacting to this sea change in the working world by laying on intensive training and development programs.

Finally, let us consider the last essential component of motivation: health. In the past, a great deal has been achieved through programs to humanize the world of work. But here, too, we are facing a radical transition to a holistic approach that encompasses both physical and mental well-being. Just as in sport, fitness is also a prerequisite for excellent performance in the workplace. We must ensure that employees remain healthy – particularly if they are to continue working for longer in future. Many companies have already recognized this and are seeking to establish work practices that promote health, targeting their efforts not least at older workers, who suddenly find themselves back in high demand. Today, almost all branches of industry are desperately seeking new blood to help them take full advantage of the economic upturn.

The German Federal Ministry of Education and Research has also put the spotlight on health by proclaiming the Year of Science 2011 "Research for Our Health". Accordingly, in this issue, we have elected to focus our attention on the concept of regenerative medicine. In our lead article, you can read how it is possible to grow skin in a "factory", and how stem cells will help to cure serious diseases in the future.

After the difficult and turbulent times experienced by so many businesses and employees, it is now more important than ever that we remain fit and healthy. For only if we are in peak condition will we be able to meet the challenges of tomorrow.





Content

Wireless endoscope

In order to minimize the impact of surgery on patients, wounds should be kept as small as possible. Doctors use endoscopes to see inside the body. For these, only a tiny incision is needed. But then, during the operation, both the surgeon's field of view and freedom of movement are seriously restricted, because the endoscope is connected to the endoscopy tower via a relatively heavy light conductor and a camera cable.

A wireless endoscope should help solve this conundrum, and scientists from the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart are currently working on just such a system. It is fairly small, extremly light, and is therefore easy to guide. It can wirelessly transmit smooth, high-resolution images to a conventional computer over a period of one to two hours. The endoscope has an LED light that uses very little power and produces very little heat.

Tiny channels

Biochips with microchannels measuring 100 micrometers in diameter, the same thickness as a strand of human hair, are used in rapid medical test kits. The channels in these small, thin plates hold a tiny drop of fluid – blood in most cases – which is analyzed with the aid of specialized medical equipment. At present, biochips made out of plastic are used for this kind of application. However, substances from the plastic can diffuse into the test fluid and distort test results.

By contrast, biochips made out of glass are chemically neutral. Until now, however, there has been no process for manufacturing microchannels in glass components. The In-volume Selective Laser Etching (ISLE) process developed by the Fraunhofer Institute for Laser Technology ILT enables micrometer-fine structures to be created in transparent materials such as silica glass, borosilicate glass, sapphire and ruby. The greatest challenge is to avoid damaging the glass, because the process produces stresses that can cause the material to crack and make the component unusable.

Glass components microstructured using the ISLE process © *Fraunhofer ILT*

The chip's fingerprint

These days, counterfeiters are increasingly using their skills to reproduce chips and electronic components. Quite apart from the resultant sales losses, low-quality imitation products can also damage a company's brand image. At the Fraunhofer Institute for Secure Information Technology SIT, a new security technology, which utilizes a component's individual material properties to generate a digital key, is beeing investigated and further developed.

Every component has a kind of individual fingerprint, since small differences inevitably arise between them all during production. Integrated circuits, for instance, end up with minimal variations in thickness or length during the manufacturing process. And while these variations do not affect functionality, they can be used to generate a unique code.

Digital fingerprint prevents counterfeiting of microchips. © *Fraunhofer SIT*

Smile, please!

If dental prostheses are to blend in with the rest of a patient's teeth, dentists and dental technicians need to get the color exactly right. Researchers at the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB in Karlsruhe have now developed a color measurement system that detects even minimal color differences in materials, obviating the need for time-consuming test samples.

Key to the ColorControl system is an imaging spectrograph that does not simply produce a tricolor digital red-green-blue image, but captures an entire 60-color spectrum in the visible wavelengths from 400 to 700 nm. When the generated image is subsequently evaluated, those ranges that contain reliable color information are automatically selected for analysis, while hidden or superimposed sections that would distort the measurement findings are automatically excluded.

Bioplastics for engineering

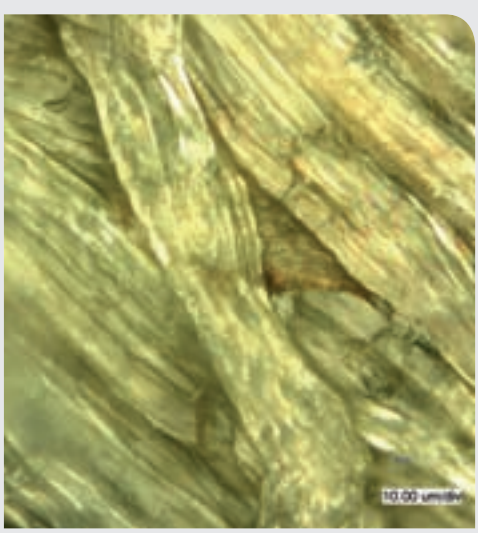
The automobile industry wants to become greener, and there's more to it than reducing fuel consumption or developing alternative power units – the materials the industry uses can also contribute to a better carbon balance. The Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT is one of a total of 13 partners from five European countries taking part in the four-year EU project ECOplast. The consortium is developing biocomposite materials based on renewable resources for applications in automotive engineering. This involves modifying and reinforcing bioplastics that are readily available on the market with natural fibers, mineral fillers and additives. These new materials should be processable on existing production lines, but the consortium still intends to look into new processing technologies at the same time.

Interactive window shopping

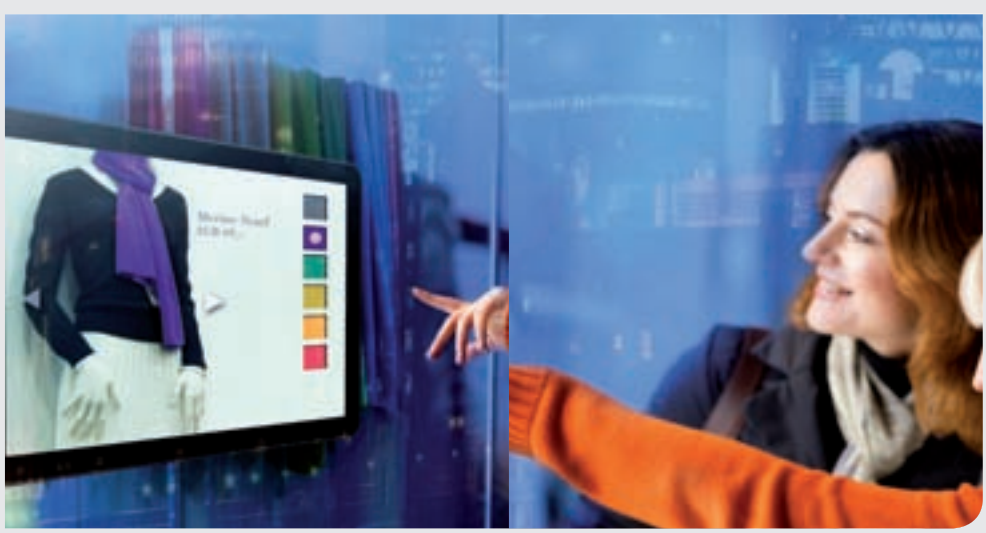
Too late for that spending spree! The shops are now closed, and the only remaining option is to do a little window shopping. New technology developed by the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI in Berlin will soon make that a much more exciting prospect.

The HHI researchers have devised a system comprised of two cameras. It records the 3-D positions of hands through a shop window and converts them into input commands, enabling passers-by to point to a product, see it displayed on a monitor, and zoom in on or rotate it as desired. But not only that: They can also request additional information on the product – and even buy it. The 'Interactive Shop Window' is compatible with all displays and can be combined with existing software. The 3-D recording system allows shop owners to display their complete range of stock, and is already available as a prototype.

Microscopic images of hemp fibers used to reinforce biopolymers. © *Fraunhofer UMSICHT*



Using the window display system, women passing by the shop can get the facts they want on the scarf they like, and even buy it then and there. © *Fraunhofer HHI*



Organs on demand

In future, stem cells will help to cure disease.

In future, it is predicted that regenerative medicine will help patients with a wide range of diseases - whether slow-healing wounds, defective cartilage, strokes, or Parkinson's. Medical practitioners hope that tissue engineering and stem cell therapy will allow them to repair damaged cells, tissues and organs, and develop treatments for diseases that are currently incurable. But before the new methods can make the transition from laboratory to everyday clinical practice, a great deal of research and development work remains to be done.

Text: Birgit Niesing

Do you suffer from slow-healing wounds, defective cartilage, a stroke, or Parkinson's disease? Then fetch some skin from the factory! The very idea may sound like science fiction, but it's not. Artificially produced skin is no flight of fancy by an inventive novelist; it has actually been developed by biologists and engineers of the Fraunhofer-Gesellschaft. Their ambitious goal is to manufacture skin models of the highest quality, and to do this, they have developed and set up a "tissue factory", which will begin operation in 2011.

The factory is sterile, the production process fully automated. It begins with each skin sample being chopped into small pieces. Then the different cell types in the skin are isolated and stimulated to grow. In due course, the resultant cells are reassembled into a two-layer model in a three-dimensional matrix – and the artificial skin is ready for use.

This unusual factory is located at the Fraunhofer Institute Center Stuttgart IZS. In it, the researchers cultivate 5000 roughly thumbnail-sized skin models a month. Artificial skin is highly sought-after: Manufacturers of pharmaceuticals, chemicals, cosmetics and medical engineering products need it to test the compatibility of these products with human skin. Until now, skin samples have generally been produced in a complex laboratory process involving a great deal of manual work. "For the first time ever, we've succeeded in establishing a continuous process chain in a single facility – from cell extraction through cell proliferation to three-dimensional tissue formation," says Dr. Michaela Kaufmann of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart. The factory was built as part of the Automated Tissue Engineering on Demand project, which is sponsored by the Fraunhofer-Zukunftsstiftung (Fraunhofer Future Foundation).

www.tissue-factory.com

Biologists, physicists and engineers at four different Fraunhofer institutes are working closely together on this project. Researchers at both IGB and the Fraunhofer Institute for Cell Therapy and Immunology IZI in Leipzig are responsible for the basic biological research, as well as validation of the facility and all its component modules. The tasks of prototype development, automation and integration of the facility into an operational whole fall to the experts at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA

in Stuttgart and their colleagues at the Fraunhofer Institute for Production Technology IPT in Aachen. The scientists achieved their first project goal – development of a functioning tissue factory – in just three years. And now production is due to start in a few short weeks.

But why exactly do we need to produce artificial skin in a factory? "I've been working in tissue engineering for ten years now," says project initiator Professor Heike Walles, head of IGB's cell systems department, "and I find it a great pity that so few products have been launched onto the market to date. The problem is that there's no standardized way of manufacturing them, because much of the work is done by hand. That makes it very expensive, too." Her solution is to cultivate tissue using automated systems. "Seamless automation of all the steps in the process made it possible to introduce production technology and business benchmarks such as reproducible quality, throughput and cost optimization to skin model production," she states.

Not only is the automated process ideal for producing skin models for test purposes, in the future it also should be used in transplant medicine. Doctors treating massive burns injuries need healthy tissue to replace the skin that has been destroyed, and scientists at IGB are currently working on a full-thickness skin model that includes blood vessels. Once the research is completed, these transplants will also be manufactured using the fully-automated production process. The facility has been designed to comply with the high standards set out in the Good Manufacturing Practices (GMP) guidelines for the manufacture of products used in medicine, which means the facility could in future also be used to produce artificial skin for transplants.

But the scientists don't just want to use the factory to manufacture skin. Over the next two years, the aim is to further develop the technology so that other tissue types such as cartilage can also be produced automatically. Researchers at IZI have furthermore devised a way to generate induced pluripotent stem (iPS) cells. In future, these stems cells could be used to cultivate various types of tissue in the tissue factory. "It was important for us that the entire mechanical process be divided into separate modules," explains Dr. Kaufmann, "because it means we can replace or modify individual modules, depending what is needed for the production of different tissue types."

Skin and cartilage from the lab

Recent years have seen the first patients being treated with factory-produced skin and cartilage. The advantage of these two tissue types is that they have relatively simple structures. It is considerably more difficult to cultivate more complex tissues or organs such as livers or kidneys, which have a fine vascular system and are composed of different cell types. And, of course, there is the added challenge that the cells must form a three-dimensional structure.

Researchers at IGB have devised a special process for producing such complex tissues in the laboratory. They start out with a piece of pig's intestine, which has an artery for supplying blood to the tissue and a vein for taking blood away. The animal cells are then removed, leaving only the proteins of the extracellular matrix and the vessels of the circulatory system. The composition of this cell-free scaffold is similar to that of human tissue. The scientists line this mesh from the inside with human endothelial cells; as soon as artificial blood is running through the vascular system, the cells of a wide variety of organs can be grown on the matrix. Since the tissue has its own vascular system, it can be kept alive in a bioreactor for several weeks, with a computer controlling the arterial pressure, temperature and rate of flow.

The new process can be used in many applications, and one example is the cultivation of new airways made of human tissue. Traditionally, it has been impossible to repair extensive accident or tumor-related damage to the trachea or esophagus; patients who have survived such damage have done so thanks only to permanent and intensive in-patient medical care. But now, IGB researchers working with a team of doctors led by Dr. Thorsten Walles, senior physician at the Schillerhöhe Hospital, part of the Robert Bosch Hospital in Stuttgart, are devising ways of treating patients using artificially-grown autologous tissue. To do this, the scientists use the prepared pig intestine as the scaffold. Heike Walles explains: "We seed cells taken from the patient on the matrix and then cultivate them in special bioreactors under physiological conditions."

Autologous tissue with its own vascular system is generated within four to five weeks. "So far we've applied this process, which is still in the experimental stage, to three individuals with severe tracheal and esophageal defects, growing replacement tissue for them from their own cells," says Thorsten Walles. "In each case, we were able to repair the damage in a single operation." If the treatment proves successful in wider clinical use, it will be possible to adapt the technology for other surgical applications as well.

Scientists at IGB are also using the ingenious process to create a liver model for testing drugs. In the early stages of drug development, it has been customary to use animal experiments to gauge how medicines work and whether or not they have side effects. Now, however, the new test model permits reliable assessment of the effects of new medicines on human liver tissue for the very first time – thus helping to reduce the need for animal experiments. The IGB researchers also intend to build a 3D intestinal test system. It is in the small intestine that the majority of the digestive process takes place, and both medicines and foods are resorbed via the in-

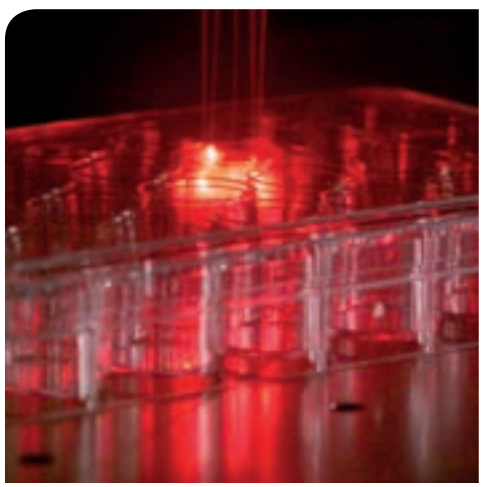
The skin factory has a modular design.
© Rafael Krötz/ Fraunhofer IGB

A fully automated system is used to process and cultivate the skin samples.
© Rafael Krötz/ Fraunhofer IGB

Regenerative Medicine

Regenerative medicine is still a very new area of biomedical research. Its aim is to cure a variety of diseases by repairing damaged cells, tissues and organs. Scientists working in this field are not only looking into biological replacement, for example using cultivated tissues, but are also seeking to stimulate the body's own regeneration and repair processes. Their main areas of focus are stem cell research and the cultivation of tissue and cell structures (tissue engineering).

Scientists from the around the world will present current research findings at the World Conference on Regenerative Medicine, which will take place in Leipzig from November 2 through 4, 2011. The international conference is being organized by the Fraunhofer Institute for Cell Therapy and Immunology IZI.



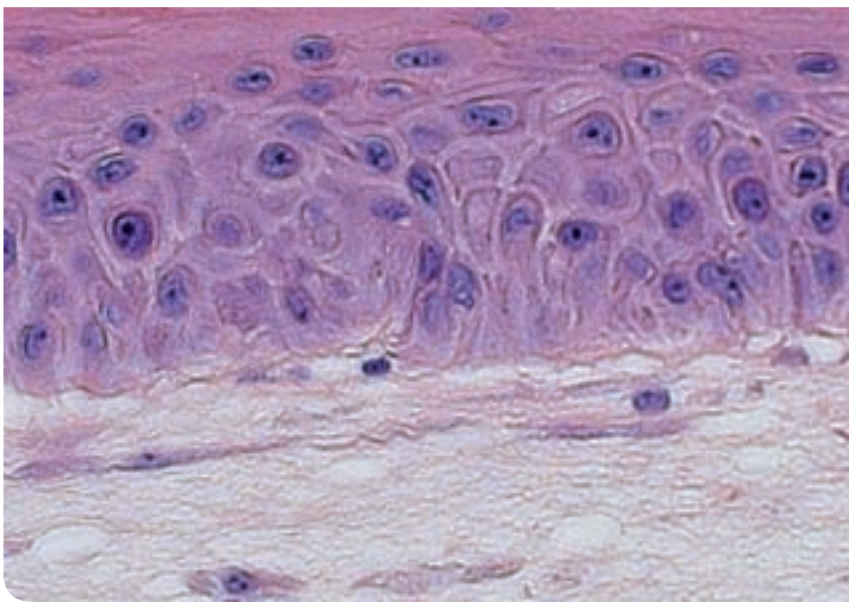
The quality of the skin models is measured automatically.
© Fraunhofer IPT

Fraunhofer Group for Life Sciences

Six Fraunhofer institutes have pooled their resources in the Fraunhofer Group for Life Sciences. Scientists from these institutes are studying the causes, diagnosis and curing of diseases, as well as their prevention. Tissue engineering and stem cells feature high on their list of priorities.

The Fraunhofer institutes for
– Biomedical Engineering IBMT
– Interfacial Engineering and Biotechnology IGB
– Molecular Biology and Applied Ecology IME
– Toxicology and Experimental Medicine ITEM
– Process Engineering and Packaging IVV
– Cell Therapy and Immunology IZI
are all members of the Group.

www.lifesciences.fraunhofer.de



testinal villi. In future, it should be possible to use this model to test the effects and action of new drugs in the laboratory.

Both researchers and medical personnel are pinning great hopes on stem cells. These are expected to help cure serious diseases such as Alzheimer's or Parkinson's, as well as repair damage to tissues and organs, for example after a heart attack. What makes them special is their ability to differentiate into different cell types or tissues. Embryonic stem cells are obtained from fertilized human egg cells, and can then be used to develop almost all of the 300 or so distinct human cell types such as muscle or brain cells.

Healing with stem cells

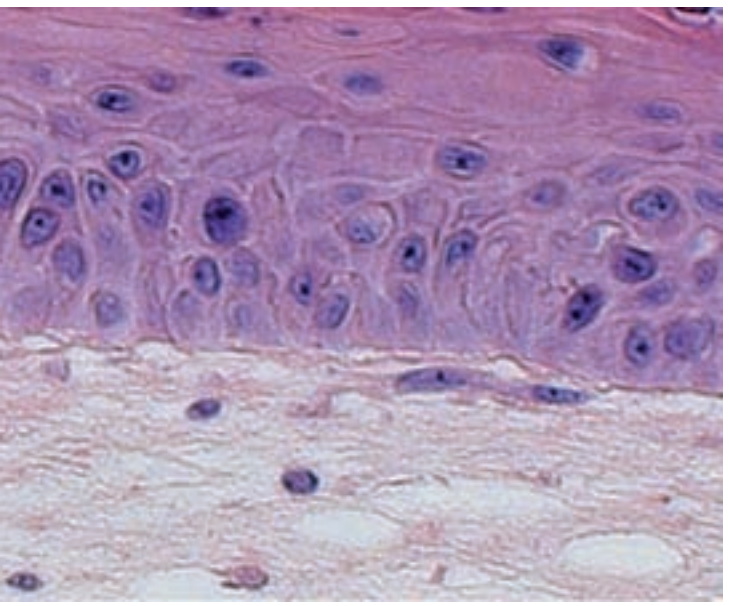
But every human being also has adult stem cells. These can be found in bone marrow, in the umbilical cord blood of newborns, in the brain, liver, skin or pancreas. From these adult stem cells, it is only possible to create the various cell types present in one given organ. For example, neural stem cells can develop into all the cell types present in the nervous tissue – but not into liver or muscle cells. One advantage of adult stem cells is that since they are taken from an individual's own body, there is no risk of rejection.

Since the mid-1970s, doctors have been successfully treating leukemias and lymphomas using stem cells from the bone marrow and blood of adults. Some medical practitioners also use adult stem cells to treat patients who have had a heart attack. In order to reduce the resultant heart damage, doctors take bone marrow from the patient's pelvic bone. They then isolate the stem cells and inject them into the coronary vessels using a catheter. It is not yet known exactly how they work there, but studies have shown that new capillaries subsequently form at that location.

Studies conducted on animal models by researchers at IZI indicate that stem cells could also help treat stroke patients. New treatments for cerebral infarction are urgently needed: Every year, in Germany alone, 250,000 men and women suffer a stroke. This happens when a blood vessel in the brain closes, preventing sufficient oxygen from reaching the cells. The longer the situation persists, the greater the number of nerve cells that die. People who survive a stroke are often disabled for the rest of their lives. Many battle with paralysis or speech disorders for months or even years after the event. Until now, the only possible clinical treatment has been thrombolysis, which dissolves the blood clot. And even that can only be carried out within the first four and a half hours of a stroke occurring.

Stem cell therapy now offers a potential alternative. Experiments by Fraunhofer researchers on rats and sheep have shown that the neurological deficits which result from moderately severe strokes disappear again just a few days after a stem cell transplant. "These are encouraging findings, although they have yet to be tested in clinical trials on human patients," says Professor Frank Emmrich, Director of IZI. British researchers are already trialing the clinical procedure on humans: They gave a stroke patient stem cell therapy for the first time in November 2010. The United States recently also green-lighted the testing of embryonic stem cells on humans. In a Phase I clinical study, doctors injected a paraplegic man with embryonic stem cells just a few weeks ago – the results have yet to be observed. In Germany, however, the use of embryonic stem cells is not permitted.

Skin is made up of several layers of cells.
© Fraunhofer IGB



Consequently, many German researchers are counting on induced pluripotent stem cells, iPS cells for short, which demonstrate similar characteristics to embryonic stem cells. A few years ago, Japanese scientists succeeded in restoring skin cells into a kind of original state by inserting specific regulatory genes. This genetic manipulation restarted the cell's embryonic program, leading to induced pluripotent stem cells. One major advantage of this procedure is that it allows the production of iPS cells specifically adapted to each individual patient. However, the method is inherently risky, as it uses viruses to insert the genes. Happily, researchers at IZI have now developed a procedure for obtaining patient-specific, individualized stem cells from body cells without using viruses or genetically modifying the cells. These iPS cells demonstrate the typical characteristics of embryonic stem cells.

A high potential for treatment

The Cellular Biotechnology Department in the Fraunhofer Research Institution for Marine Biotechnology EMB in Lübeck is working to develop gentle procedures for the isolation of adult stem cells derived from animal and human tissue. The researchers are focusing primarily on glandular stem cells, which they isolate from exocrine glandular tissue, the pancreas, the sublingual gland and sweat glands. These glandular cells have superb growth characteristics and long life spans, can be cultured as three-dimensional organoid bodies and can be cryopreserved without losing any of their vitality. The researchers also intend to use these cells to test innovative treatments for skin regeneration. In an experimental mouse model for full-thickness skin injuries, such cells have been shown to accelerate the healing process, improve the restructuring of the skin, and increase the regeneration of small blood vessels. Professor Charli Kruse, site manager of the Lübeck institution, says: "The fact that it proved possible to identify sweat glands as a cell source means we're now able to work with cells that are readily obtainable for potential treatments."

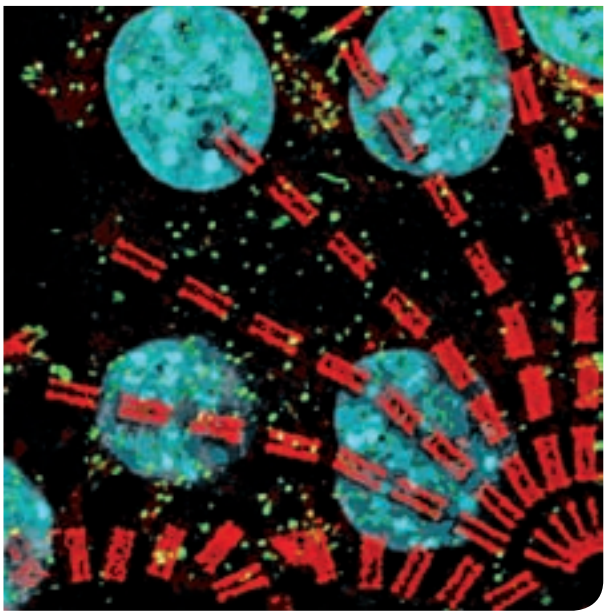
Intensive research being conducted all around the world is slowly bringing us closer to the day when stem cells are used regularly in clinical applications. However, it will take new, automated procedures – along the lines of the tissue factory – to ensure that the highest quality stem cells are available at all times as a matter of course. Various Fraunhofer institutes are working on developing such procedures. For instance, researchers at IPT are cooperating with colleagues at the Max Planck Institute for Molecular Biomedicine, RWTH Aachen University and the University of Bonn, as well as the companies Life & Brain, Bayer Technology Services GmbH and HiTec Zang, in order to establish a standardized method of producing iPS cells for pharma testing. And in the EU HYPERLAB project, scientists from the Fraunhofer Institute for Biomedical Engineering IBMT in St. Ingbert are working with eight European partners to develop novel contactless automation technologies for the culture, expansion and differentiation of reprogrammed, embryonic and adult stem cells. "The aim is to use new, high-throughput solutions to find new factors and mediums for stem cells," states Professor Heiko Zimmermann of IBMT.

www.hyperlab.eu

Organs from the laboratory, substances that stimulate self-healing, the use of stem cell therapy – regenerative medicine is ushering in new treatment options, and the Translational Center for Regenerative Medicine (TRM) in Leipzig, which is headed by Professor Emmrich of IZI, is currently working to achieve more rapid implementation of research outcomes in the preclinical phase. The TRM focuses on four main research areas: tissue engineering and materials science; cell therapies for repair and replacement; regulatory molecules and delivery systems; and imaging, modeling and monitoring of regeneration.

"Regenerative medicine has made great strides in recent years," says Professor Emmrich, "but there is still much work to be done by all the scientists, companies and regulatory authorities involved to ensure that our emerging knowledge is brought to patients safely and reliably." In future, it is predicted that regenerative medicine will help patients with a wide range of diseases. Medical practitioners hope that tissue engineering and stem cell therapy will allow them to repair damaged cells, tissues and organs, and develop treatments for diseases that are currently incurable. But before the new methods can make the transition from laboratory to everyday clinical practice, a great deal of research and development work remains to be done. ■

On your marks, get cells, go



Researchers have developed intelligent surfaces that are tailor made for the targeted culturing of cells – and their subsequent release at the touch of a button.

Text: Monika Offenberger

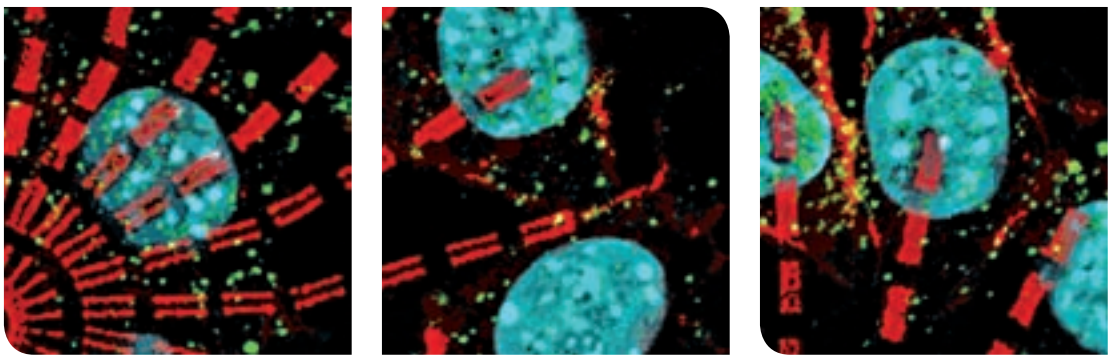
Picture driving onto a passenger ferry: coaches are sent to the back of the parking deck, trucks form a row in front, and cars fill the spaces in between. When the need arises, different vehicle types can be directed to designated parking spaces. Biologists would be delighted if they could do the same with different cell types on a culture dish, getting them to grow at particular spots – and then leave again if necessary. That would make laboratory recreations of cells' natural environment more lifelike. "In the body, organs and tissues are made up of various cell types. The whole can only function if all the parts are working together correctly," states Dr. Andreas Lankenau of the Fraunhofer Institute for Biomedical Engineering IBMT in St. Ingbert. Until now, though, it has only been possible to grow stem cells, cancer cells, muscle cells and nerve cells in monoculture.

That could soon change, thanks to novel materials developed at the Fraunhofer Institute for Applied Polymer Research IAP in Golm. For three years, scientists at IAP and IBMT have been working with four research groups from the Max Planck Institute of Colloids and Interfaces and the University of Potsdam to find surfaces that can be colonized by living cells and then cause the cells to detach again – effectively at the touch of a button. Experts from a wide variety of disciplines, including chemistry, physics, molecular biology and nanotechnology, shared their knowledge in order both to clarify fundamental theoretical aspects and to solve practical problems of application. This interdisciplinary exchange was helped along by the geographical proximity of the participating institutes: They are all located at the Golm Science Park near Potsdam. This remarkable joint project received federal funding under the German government's Pact for Research and Innovation. The researchers are proud of their achievement. "We have developed materials to which cells bind at targeted points before growing and reproducing," reports project coordinator Prof. André Laschewsky, division director at IAP. But that is not all: "Simply by reducing the temperature slightly – in other words, using a non-invasive stimulus – we are able to change the surface properties in such a way as to cause selected cells to actively detach themselves," he continues. It is this gentle, switchable release procedure which is the real novelty. Until now, cells could only be removed from culture dishes using digestive enzymes such as trypsin. This destroys elements of the cells' membranes, impacting on their proper functioning and making subsequent analyses more error-prone, if not impossible.

Getting cells to attach and detach at the touch of a button

Cells only remain undamaged if it is they who detach themselves. But how to get them to do this? "We simply make the surface less comfortable for them, so they willingly heave their little anchors and let go. Then all you need is running water to rinse them off," says Laschewsky. This feat is made possible by polymers based on polyethylene glycol (PEG), a water-soluble substance that has long been approved for use in cosmetics and medicines owing to its high tolerability.

Dr. Jean-François Lutz, a researcher at IAP, has succeeded in combining PEG fragments in such a way that the polymers either repel water or attract large quantities of it, depending on the ambient temperature. What is particularly fascinating is that just by slightly modifying its structure, Lutz can set the polymer's critical transition temperature anywhere between 0 and 100 degrees. One variant of the polymer is especially suited to biological applications because its state change



Connective tissue cells adhere to a bioactive g lass surface.
© Fraunhofer IBMT

occurs between room temperature and body temperature. At 37 degrees the polymer repels water, becomes compact like rubber and offers living cells ideal attachment conditions. However, at 25 degrees it swells up to become a soft jelly on which the cells are no longer comfortable, causing them to detach themselves. The process is reversible and can be precisely controlled by heating or cooling – with very high spatial resolution. Laschewsky states: "Using microelectrodes, defined points can be heated or cooled with micrometer accuracy. We hope in this way to encourage individual cells to depart from a culture."

This technology should allow different cell types to be placed alongside one another in a predetermined pattern, just like coaches and cars on a parking deck. "All you would have to do is get individual cells in a cell lawn of type A to detach through local cooling and then flush them away," says Lankenau, "then reheat the dish and add cells of type B, which would colonize the vacated sites. In this way you could create any combination of cell types you like." This impressive idea has not yet been put into practice, but patent applications relating to several materials and methods have already been filed, and conceivable uses for the technology abound. For instance, stem cells only develop into a particular tissue type if they receive the appropriate signals from cells that have already differentiated. "It doesn't work if the stem cells are just sitting there on their own in the Petri dish; even in a culture, they need to have the right neighbors," explains Lankenau.

Fraunhofer researchers have demonstrated the faultless functioning of the novel polymers using various tissue and tumor cells. However, some cell types are detached more easily than others. "This raises the question of what exactly is going on here. What forces are in play, and what are the crucial factors in the adhesion of cells to particular surfaces? Once we understand that, we will perhaps be better able to handle aggressive cancer cells in the laboratory or create implants that are more readily accepted by the body," hopes Professor Helmuth Möhwald of the Max Planck Institute of Colloids and Interfaces. A thorough understanding of the fundamentals of these processes could also help to keep away unwanted cells – for instance in hospitals or in food production. "Today, we can only keep harmful bacteria in check by using vast amounts of chemicals," says Laschewksy. "It would be better if we could design surfaces that inhibit the formation of biofilms in the first place. And then, even if one did form, we could simply switch the surface properties periodically to initiate a cleansing process."

The switchable polymers can be used to hold and release not only whole cells but all sorts of biomolecules. Describing another possible application, Laschewsky states: "We can influence the adherence of individual proteins and separate them out much more thoroughly than with current methods – and that in aqueous solutions, without damaging them." Lutz adds: "On top of that, we can bind enzymes to the polymers and control how they operate. In its swollen state the PEG is open and the enzymes can react. Collapsing specific areas blocks the enzymes."

The Fraunhofer scientists have even ventured into the third dimension by using thick layers of modified PEG to encourage the formation of multi-layer cell colonies. A touch of the temperature button makes the polymer scaffold fall in on itself and releases the cells. This might make it possible in future to culture bone cells, which need a certain degree of mechanical resistance to grow. ■

Scalpel wielding robots

When difficult surgery is performed, it is often the skill and experience of the operating surgeon that makes the difference between life and death. In future, intelligent machines will assist these experts in their work. Researchers have set up a test laboratory to demonstrate how the OR of the future might look.

Text: Klaus Jacob

The laboratory OR is used to familiarize doctors with the ultra-modern technology. © Fraunhofer IPA

These days, it's hard to imagine a factory without robots. Industry relies on intelligent machines for all manner of things, from automobile assembly to the manufacture of computer chips. But the same cannot be said of hospital operating rooms, where the surgeon's hand remains the measure of all things. Yet here, too, a great deal of work could be automated – and thus made safer and more efficient. Jan Stallkamp, head of department at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, and a team of colleagues are already well on the way to revolutionizing work in the OR. But Stallkamp is in no way seeking to put surgeons out of work; he simply wants to support them with smart machines when they are working at the very limits of manual surgery.

Let's take a peek at the hospital of the future: A brain tumor patient lies on the operating table, a scanner automatically moving back and forth above his head, producing a continuous picture of his brain. Compare this with today's operating rooms, where surgeons generally have to rely on old images captured in the run-up to an operation. This makes the process inherently risky, since simply easing the patient into a different position will move their brain around – it will "float about", as Stallkamp puts it, altering the location of the tumor in their head. The new scanner not only provides up-to-date images, it produces them in high-definition 3D, rendering visible all the vessels and other structures down to a hundredth of a millimeter. The surgeon uses these images to inform his final decisions before commencing surgery. He plans the operation like an engineer does a construction site: with the aid of the 3D image, he ponders processes and procedures, position plans, logistics and danger zones. The surgeon doesn't even need to get his hands bloody, as he stays behind his displays and monitors throughout the operation; with the help of a robot, he is able to control all the required instruments from his remote command post.

First, the robot drills a hole in the patient's skull – in one continuous movement, more gently

and more quickly than any surgeon could. Then, moving forward under its own power, the head of the endoscope makes its way slowly but surely through the brain to the tumor, trailing supply lines in its wake. As it does so, it tries to avoid blood vessels and other sensitive tissues. But if, despite its best efforts, it does accidently nick a vein, it stops the bleeding immediately. Once in situ, a mini-scanner on the end of the endoscope assesses whether the targeted cells are healthy or cancerous, and tumor tissue is then vaporized and extracted. This method ensures that only damaged tissue is removed. At present, it is often difficult for surgeons to clearly identify tumor cells by visual appearance alone, so they have to remove healthy tissue as well, yet they can still never be certain of having removed all the cancerous cells. In this respect, the smart endoscope represents a huge step forward. And last but not least, the entire operation is recorded and archived, thus creating an important database to which doctors can refer as they continue to treat the patient.
Although the above scenario is still a rather fanciful vision of the future, the Fraunhofer team of researchers is already working on some of the basics. They have, for example, developed a "tumorscope" that uses a fluorescence system to distinguish between healthy and cancerous cells in a fraction of a second – and without causing any damage. The apparatus is still somewhat bulky for use in the OR, but has already proved its worth in various operations. The interdisciplinary team, comprising mechanical engineers, microsystems engineers, mechatronics specialists, electrical engineers, physicists and IT experts, has also invented an automatic exchange system for the endoscope. Until now, surgeons have had to feed every instrument, whether mini-pliers or ultrasound cutters, individually through a tube to the endoscope. Now, the various applications are held at the ready in a drum, like cartridges in a revolver; six different items of equipment can thus be inserted automatically and changed rapidly, and the development also represents an initial step along the path to miniature robotic systems.

Close cooperation between engineer and surgeon

The operating room of the future will contain many other innovations too, such as wireless endoscopes, robots and network systems. In order to be able to test the equipment – and above all the interplay between the different components – in realistic conditions, the Fraunhofer researchers have now set up an entire OR at the IPA in Stuttgart. The Bozzini Lab, as it is known, is named after German doctor Philipp Bozzini (1773-1809), who was the first person to design a light conductor, a primitive endoscope, in order to see inside the body. Although it has not yet been officially inaugurated, the laboratory is already better equipped than many a hospital operating room, and it will soon even boast its own breathing apparatus.

However, no genuine operations on human beings are permitted there. Its sole purpose is to evaluate equipment and to familiarize doctors with the ultra-modern technology it contains. It offers a safe environment where surgeons and engineers can play with new systems to their heart's content, working on dummies and specimens. The lab has two robots which are particularly conspicuous. These 400-kilogram giants are able to suction themselves to the floor, so they remain rock steady during operations and are able to carry out movements with the required degree of precision. In the Whole'O'Hand project, the IPA scientists and their colleagues from the Fraunhofer Institute for Integrated Circuits IIS in Erlangen and the Fraunhofer Institute for Computer Graphics Research IGD in Darmstadt are seeking to demonstrate new technological concepts for minimally invasive liver tumor resections. This is an entirely new type of operation, given that this kind of treatment is still almost always carried out using traditional open abdominal surgery. The liver that is operated on in the laboratory OR is made of plastic, but has similar characteristics to a real organ. One robot holds the instrument exchange system, into which the intention is also to integrate the endoscope. Attached to the second robot is an ultrasound sensor, which provides a continuous stream of real-time data. Thanks to these data, the knife is able to stay on its prescribed cutting path even though the organ is constantly moving. These ad hoc corrections – experts talk of a "closed loop system" – are an integral part of the project and a significant prerequisite for automated processes.

Sensors provide real-time data during the operation

Stallkamp is working closely together with surgeons from Tübingen and Stuttgart. He knows exactly how important this cooperation is, because it provides the necessary practical element. If the mechanical engineers fly off on a flight of fancy, the doctors soon pull them back down to earth – for example by bringing along a section of artery and showing them precisely how difficult it is to handle the tiny, slippery vein. Indeed, not all the surgeons are brim full of enthusiasm for their revolutionary place of work. "Some of them don't trust the robot at all," acknowledges Stallkamp, who himself comes from a family of doctors. "But we really need their cooperation, because at the end of the day, it is they, not us, who will be standing there next to their patients."

Success will be the determining factor. If the new technology proves reliable and useful, it is quite possible that roles and responsibilities in the operating room will be redistributed. And that robots will be given a permanent position in the OR, as elsewhere. ■

Electrifying cells

A new testing method precisely indicates the effects of pharmaceuticals and toxins on human cells.

Text: Monika Offenberger

Cell cultures have come to play an essential role in biomedical research. They make it possible under controlled laboratory conditions to precisely observe how particular types of cell or tissue change their behavior after contact with the test substance. In the search for new pharmaceutical products and therapies, such in vitro tests offer a useful alternative to animal experiments. Many of the conventional testing methods, however, have disadvantages. For instance, specific biological reactions can often only be observed if the cells have been prepared in advance with dyes or antibodies. This not only costs time and money but can also affect the measurement results. Another problem is that many methods are based on two-dimensional cell combinations growing on artificial surfaces. Certain medical questions, however, can only be investigated using three-dimensional tissues.

These problems are avoided with a cell-based biosensor developed at the Fraunhofer Institute for Biomedical Engineering IBMT in St. Ingbert, Germany. Dr. Hagen Thielecke from IBMT explains the basic principle: "We combine various technical microsystems with living cells to create a biohybrid system which enables us to investigate the electrical impedance of cells and small tissue samples." Depending on the frequency spectrum of the current, the electrical impedance of living tissues is influenced by biological processes and structures. For many medical issues, therefore, it is an excellent indicator of the physiological condition of cells and tissues. The actual measurement takes place in a glass capillary tube filled with a nutrient solution, to which the cell sample is added. The glass capillary tube is connected at both ends to a platinum electrode. When current is applied, the voltage shows a characteristic drop for a given sample material. This drop can be determined by potential derivations.

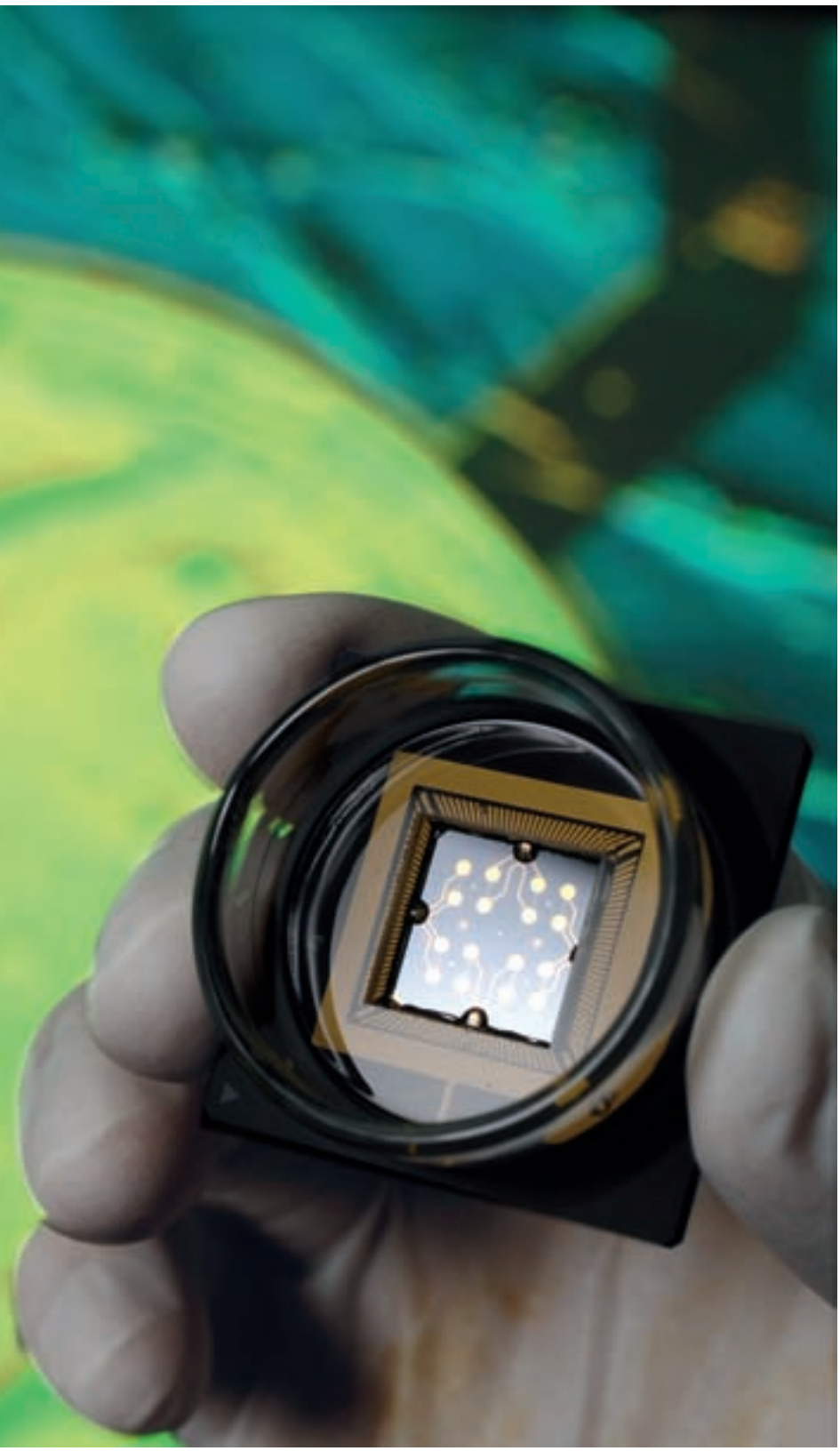
Measuring the effect of active substances

The measurements provide information about the effect of possible pharmaceuticals or environmental toxins without damaging or destroying the cells. These non-invasive measurement methods can be used on individual cells and on sections of tissue. "We have special expertise in that we can even characterize three-dimensional cell aggregates," says Thielecke. Depending on the purpose of the test, the Fraunhofer research scientist uses either tissue samples up to 10 millimeters thick from biopsies or artificially produced spheroids consisting of up to 100,000 cells with diameters of 200 to 500 micrometers. Depending on their constituent cell type they serve as models for nerve tissue, the retina, blood vessels, heart or lung.

The tissue spheroids more closely reflect the natural conditions in the body than single-layer cell cultures. Spheroids of heart muscle cells, for example, are spontaneously active and in their normal state beat in a coordinated rhythm. "We can derive the field potential from this, as well as the connection between mechanical contraction and electrical excitation – depending on what the pharmacologists or medical researchers want to test. When you add a beta-blocker or other active substance, this behavior changes," explains Thielecke. Such changes can be precisely measured over a very long period. In suitable nutrient solutions the cells remain alive for days or even weeks. In the joint CARDIOWORKBENCH project, funded by the EU, the IBMT research scientists working in cooperation with eleven partners from science and industry have developed a testing platform which optimizes the search for active substances to treat cardiovascular diseases. In addition to heart muscle cells the research scientists also use smooth muscle cells and endothial cells from blood vessels to analyze the effect of various substances.

Versatile biohybrid testing

The versatility of IBMT's biohybrid testing methods is illustrated by three further joint projects involving international partners, which were likewise funded by the European Union. The OsteoCord project looked into the question of how human stem cells develop into bone cells. Thielecke once again: "In this process the cells store up more and more calcium, which changes their impedance spectrum. Over several weeks we were able to track the individual steps of differentiation through to bone cell formation and



The effect of substances on human cells is examined in the biosensor. © Bernd Müller/ Fraunhofer IBMT

observed how homogeneous this development is and when precisely which cell types undergo specific changes."

Future possibilities of genetic therapy for vascular and ophthalmic diseases were the focus of the EU project PoLexGene. The idea behind it is interesting – the insertion of functioning DNA fragments into the affected organs to remedy pathogenic genetic defects. Various viruses can act as the genetic carriers, but their use entails unforeseeable health risks. Nanoparticles of biocompatible polymers present a promising alternative, and the biosensors developed at IBMT are a great help in the search for the best candidates: "While previously we were able to determine the differences in the genetic transfer rates of various polymers, we did not know why they differed," says Thielecke. "Now we can measure their effect on the cell membrane continuously over several hours, for example on endothial or retinal cells. This means that we can provide important information to chemists on how to optimize the production of polymers so that they achieve a high transfer rate but do not have a toxic effect on the cell."

What noanparticles do

The influence of nanoparticles on cells was the subject of the major European joint project DIPNA, and here too IBMT's expertise was in demand. This project looked at the substances used for coating surfaces and addressed the question as to whether they are harmful. "To investigate this we used cells of lung mucous membrane specially prepared by scientists at the University of Salzburg," explains Thielecke. "We combined them with our biosensors in a microculture system and were thus able to determine how many nanoparticles have to come into contact with a single cell in order to trigger an inflammatory reaction."

The different subject areas addressed in the four EU projects demonstrate the flexibility of IBMT's biohybrid testing systems. "We have developed a basic technology and now know what we can achieve with our methods," states Thielecke in summary. ■

On-site diagnostics

The disposable cartridge contains all the reagents that are required to test a blood sample. Evaluation in the mini laboratory produces quick results. © *Fraunhofer IBMT*

The future of medical laboratory diagnostics is compact, decentralized and paperless. An international team of researchers has developed the prototype of a mini laboratory for medical practices, hospitals and home-based patients.

Text: Monika Weiner

The worst thing is the waiting. When a physician suspects a malignant tumor and takes a blood or tissue sample to send to the laboratory, the patient will typically endure days of worry and uncertainty. Until the results come through, the patient has no idea whether life will continue as before or whether a cancer diagnosis will change everything. This delay, which causes major psychological stress, is the inevitable downside of transporting the sample to a central laboratory where it can be prepared, analyzed and evaluated with the aid of expensive technical equipment. Only once this lengthy process is complete can the results be sent back to the attending physician.

Dr. Thomas Velten from the Fraunhofer Institute for Biomedical Engineering IBMT in St. Ingbert is confident that things will move much faster in the future. Working in collaboration with 30 groups of researchers from Europe and Australia, his team has developed a new concept of laboratory diagnostics that could drastically reduce the time the process takes. "The aim of the EU project SmartHEALTH was to develop an innovative diagnostic technology that could be used at the patient's point of care – in other words at medical practices and hospitals, or even in the patient's home. The technology had to be easy to use and capable of delivering results that could be checked online and integrated in hospital IT systems."

Medical technicians, nanotechnologists, biomedical experts, chemists, electrical engineers and software specialists spent four years wrestling with the task before coming up with the prototype for an "all-inclusive" system. Their solution eliminates many of the steps that used to be unavoidable, for example transportation to a central laboratory, sample preparation and data evaluation on an external computer. The SmartHEALTH researchers succeeded in integrating a complete analysis system within their mini laboratory, including everything from sample preparation to PCR for the duplication of gene sequences. All the processes run automatically – the only thing the user has to do is to insert the disposable cartridge for the required test and start the program. The results are ready just half an hour later.

Lab-on-a-chip

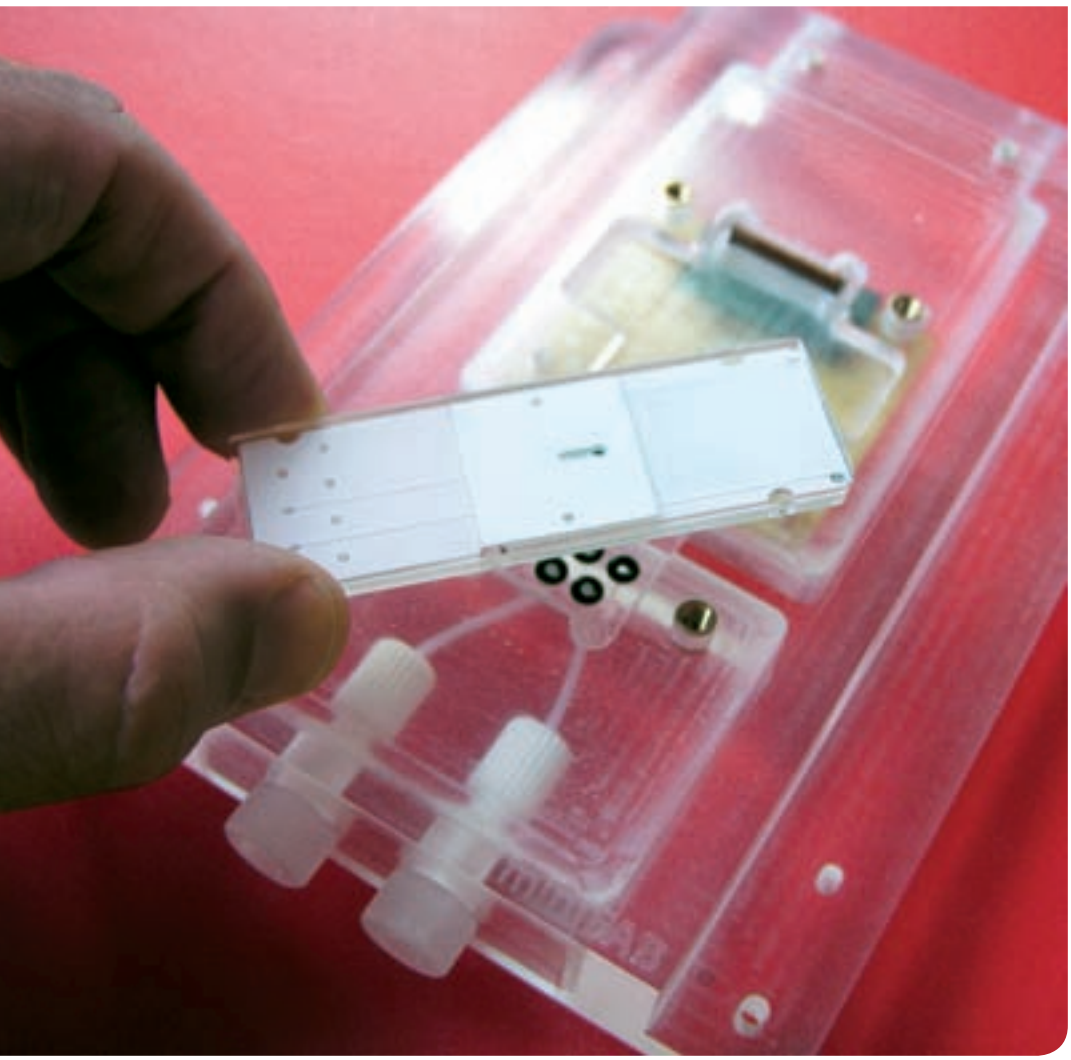
At the system's core is a four square millimeter chip with a membrane in the center. The membrane is equipped with capture molecules which can detect certain proteins or fragments of DNA in the sample solution. These are important for the diagnostic process because each type of cancer is accompanied by typical changes in DNA or in protein formation. If these so-called "tumor markers" are picked up by the capture molecules, this indicates that the patient is suffering from a specific type of cancer, for example colorectal cancer. The chip technology makes it relatively easy to determine the concentration of the different tumor markers in a blood sample. The biomolecules on the surface alter the membrane's physical properties – the more molecules that bind to the membrane, the lower will be the frequency at which it vibrates when a voltage is applied. A software program is used to calculate the concentration of the molecules in the sample from these results.

The analysis chip was developed by researchers at Newcastle University in the United Kingdom. Velten and his team then succeeded in integrating it within the mini laboratory: "That was a huge challenge," says the researcher. "The chip has dozens of electrical contacts packed tightly together. It is difficult to find a stable way of connecting it to the outside world because the connection methods used in microelectronics are not "biochip compatible", so they can't be directly applied. You also have to insulate the contacts arranged around the membrane when you connect up the biochip in order to prevent the chip from coming into contact with liquids during the measuring process. That was no easy task on a chip which is only 2x2 square millimeters!"

After much experimenting, the Fraunhofer researchers finally came up with a solution. They began by gluing the chip to a circuit board. Next, they formed the electrical connections between the biochip and the circuit board using ultra-thin conductors just 500 nanometers across embedded between polyimide layers. The conductors are thinner yet more robust than the gold wires typically used in microelectronics. Finally, the engineers insulated the contact points of the biochip and circuit board with a 0.5 millimeter thick layer of plastic, leaving only the 200 micrometer diameter of the membrane exposed. "We used an encapsulation technology that ensured the electrical contacts would be impervious to liquids and mechanical loads," says Velten. The circuit board embedded in plastic is attached to a disposable cartridge. Plugging this into the mini laboratory is easy – the spring electrical contacts engage automatically to form a connection with the circuit board.

Online evaluation

The prototype of the mini laboratory – which the researchers presented recently to mark the end of the EU project – offers different



cartridges for diagnosing breast cancer, cervical cancer and colorectal cancer. Data on the measured tumor markers is analyzed and interpreted directly within the device itself using a software program developed by computer scientists at IBMT: "The aim was to increase the reliability of the diagnostic process by enabling a whole set of tumor markers to be measured in parallel and interpreted by the software on the basis of reference measurements and statistical methods," says Stephan Kiefer from IBMT.

The results of the test can be viewed directly on the display by the doctor and patient – assuming they have first identified themselves using an electronic health card or fingerprint reader. "Data security was an issue we took very seriously in the EU project," says Kiefer. With the help of his colleagues, he developed special communication modules for use in hospitals which ensure that the analyses are transferred directly to a hospital's information systems and recorded in the respective patient's file. "The innovative aspect of this software component is that it is compatible with all the standard information systems that are used in hospitals. Previously you couldn't carry out ad-hoc data transfers because there was no established standard for data communication between medical devices, but this solution overcomes that hurdle."

Patients benefit from quick results that eliminate the anxiety of a long wait. ■

SmartHEALTH Partners

- Newcastle University, United Kingdom
- miniFAB (Aust) Pty Ltd., Australia
- microfluidic ChipShop GmbH, Germany
- Institut für Mikrotechnik Mainz, Germany
- Zarlink Semiconductor Ltd., United Kingdom
- Fraunhofer Institute for Biomedical Engineering IBMT, Germany
- TNO Industrial Technology, The Netherlands
- Ikerlan Sociedad Cooperativa, Spain
- Fundación Gaiker, Spain
- IMEC, Belgium
- Universitat Rovira i Virgili, Spain
- Wicht Technologie Consulting, Germany
- The NEXUS Association, France
- National Centre for Sensor Research, Dublin City University, Ireland
- Centre Suisse D'Electronique et de Microtechnique, Switzerland
- University of Trento, Italy
- Norchip AS, Norway
- TATAA Biocenter, Sweden
- iXscient limited, United Kingdom
- Fujirebio Diagnostics AB, Sweden
- Olivetti I-Jet, Italy
- Forschungszentrum Karlsruhe, Germany
- Telecom Italia Labs, Italy
- Applied InSilico, United Kingdom
- Universitätsklinikum Charité, Germany
- Friedrich-Schiller-Universität Jena, Germany
- BIOEF, Spain
- St. Georges Hospital Medical School, United Kingdom
- The NEXUS Association, Switzerland
- SINTEF ICT, Norway
- MultiD Analyses AB, Sweden
- 4M2C PATRIC SALOMON GmbH, Germany
- Karlsruhe Institut für Technologie, Germany

www.smarthealthip.com

Apps for all!

Today, it is nearly impossible to imagine smartphones without apps. In the future, online-capable televisions and cars will also run on these useful mini-programs. What has been missing to date is an open platform on which these applications can be developed and operated, regardless of the device or operating system. This is something researchers intend to change.

Text: Chris Löwer

Webinos are designed to offer the very same apps for different devices and systems. © *Radius Images/ Montage Vierthaler&Braun*

The ad for the weekend trip to the Alps on commercial television was so enticing that the Wedel family booked it right from the couch, using their TV's Internet connection. But the route to the ski hotel over winter roads is a long and arduous one – it would be best not to get lost along the way. So the Wedels plan their route in advance online. When it's time to travel, their car has long known the destination, because the home PC has already informed the car's navigation app. The children shorten the travel time with films and music from their online media library. Along the final yards of the trip, on foot from the village's central parking lot to the hotel, the family is guided by their smartphone, which naturally has long since been fed the hotel address by the app in the car.

This scenario is still a futuristic one, but before long an open platform for mobile Web services will make just such a stress-free trip possible. Technically speaking, it makes no difference at all what operating system the home PC uses, which navigation system is installed in the car, and what cell phone is used. In the future, there will be no more unbridgeable gaps, and devices will be able to communicate with one another. If software designers use this open-source technology for their mobile mini-programs, they only need to develop a single application that can run on a variety of terminals, from computers and tablet PCs, from game consoles and home televisions to Internet applications for the car.

A dream, you ask? Too cool to be true? No, an international research consortium is already working on this open-source software, dubbed "webinos." The project is directed by Dr. Stephan Steglich, of the Fraunhofer Institute for Open Communication Systems FOKUS in Berlin. "We will be presenting the first prototype with applications in a year and a half," Steglich observes. The standardized technology is expected to be in place after a total of three years. Then, Steglich's vision of a universal and secure ap-

plication platform will be a reality. And it's high time, because the market for mobile services is still dominated by a virtually Babylonian mishmash of languages: the various smartphone manufacturers and software giants still bank on closed systems of their own. The result: exchanging data services among different makes of Internet-capable devices is an impossibility. In a certain sense, in the future a single language will be spoken under the label of the newly coined open-source software, "webinos." Users will then have barrier-free use of their favorite apps on any terminal device of their choosing. And providers can then quickly develop new, personalized applications.

www.webinos.org

"When it comes to smartphones, the subject is already fairly well worked-over, but there's enormous potential for Internet television and Web applications in the car," Steglich emphasizes. Which explains why the consortium with ten million euros of funding from the European Union includes, along with research institutions such as Fraunhofer, TU München and the University of Oxford, electronics companies such as Sony Ericsson and Samsung, not to mention carmaker BMW.

"Webinos provides an interesting solution platform, one that in the future can help the BMW Group integrate innovative applications quickly into its vehicles," explains Dominik Schnieders of BMW Forschung und Technik GmbH, a wholly-owned subsidiary of BMW AG. An open platform uses new software to keep the car's technology up to date. Schnieders: "This is how we intend to fulfill our goal of making our cars part of the customer's networked world." Transformations in consumer electronics are even faster than in the world of carmaking: While the development cycle for a car is around seven years, mobile terminals are now appearing on the market after just six to 12 months.

Fraunhofer researcher Steglich is convinced that the future standard will become a heavyweight in the developer and user world: "First of all, because there is major pressure to act, and secondly because the consortium has strong members." Among the other players on board is the international standardization organization W3C (World Wide Web Consortium) whose members also include Apple and Microsoft. Another heavyweight on the team is Deutsche Telekom. "Networked life and work is the vision at Deutsche Telekom. We are part of webinos because we wanted to join with strong partners in industry and science to develop the future potentials of Web services. The focus is on use beyond the realm of domains, and in the car," adds Telekom project manager Katrin Jordan. But they are particularly drawn to the broad, user-friendly approach – from which the group expects great results. "What is essential is that webinos delivers specific results in a short period of time," Jordan adds. Telekom is also a member of the Wholesale Application Community (WAC), a consortium of leading telecommunications companies that will create a standard open platform for app developers. The two approaches are complementary. With its primary focus on smartphones, WAC will develop into a counterweight to the dominating app stores of Google and Apple.

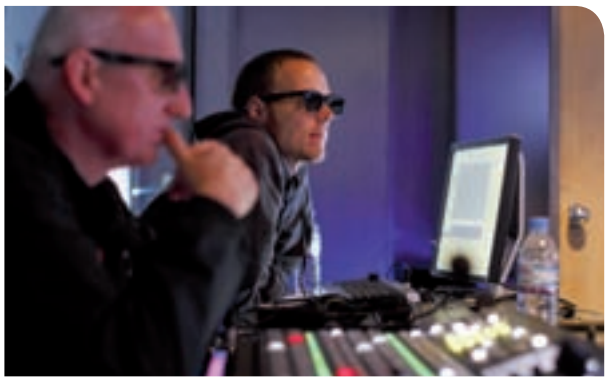
The entertainment industry – with providers of hybrid TV leading the way – is also banking on quick results. Its vision: to be able to simply telephone anywhere in the world from one's TV armchair with the Internet telephone Skype, and if the conversation takes a bit longer, it can simply be continued in the car or via smartphone. Stephan Steglich is convinced that there will be fundamental changes in usage behavior: "It's no longer about fixed-installation services but about being able to use these easily over the Internet." Thanks to economical data flat rates and high-speed mobile Internet via UMTS and its successor, Long Term Evolution (LTE), the time for this has come.

So why bog a cell phone's memory down with an opulent navigation app if the simple route descriptions a user needs at the moment can be downloaded just as easily? "A standard open platform provides an opportunity for lots of new business models, for instance where multiple users share the cost of renting a particular app," the Fraunhofer researcher underscores. Small and medium-sized enterprises would also benefit from an uncomplicated and low-cost "foot in the door" of the world of apps. They do not need to go to the expense of purchasing or developing the software themselves if they want to tailor services such as a mobile online shop to a wide variety of terminals. ■

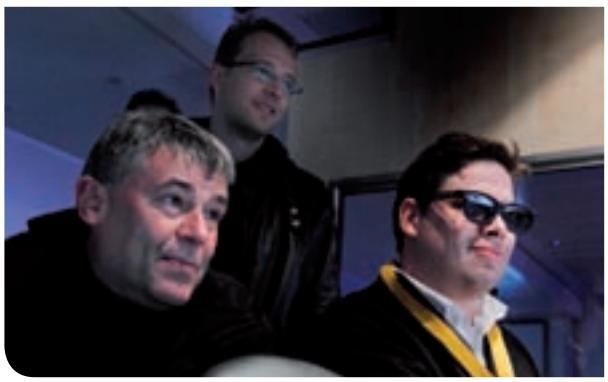
Live in cinema: Fanta 4 in 3D

Successful world premiere: For the first time a concert was broadcast live in 3D to 91 movie houses in five countries. Over 30,000 fans saw the hip hop band perform.

Text: Marion Horn, Fotos: Matthias Heyde



In the outside broadcast truck Josef Kluger from cooperation partner KUK Filmproduktion directed the production.



Fraunhofer researchers Peter Kauff, Florian Krassow and Frederik Zilly (left to right) analyzed the image processing with the stereo assistance system.

The live 3D transmission required twice as many cameras as a 2D broadcast, expensive equipment and even its own satellite.

The stage is bathed in green light as rapper Smudo welcomes the fans watching live at the concert venue in the central German city of Halle and at the same time in movie theaters across Europe. "We are the Fantastic Four – appearing tonight in Germany, Austria, Switzerland, Belgium and Luxembourg." More than 30,000 people are experiencing the first Europe Live concert to be broadcast to five countries.

Stars in close-up

The Fantastic Four – Thomas D, Smudo, Michi Beck and Ypsilon – are performing a very special show: "Today is a European tour. This is the last gig of a past era. We are now looking to the future," Michi Beck shouts to the audience. They are the first band to appear at several locations at the same time. They aim to get their fans in the distant venues rocking.

The rapper urges on the 1200 Fanta4 fans who managed to get a ticket for the actual concert on September 28, 2010: "You guys are gonna make the atmosphere for the people in the cinemas. We need you." And the televiewing fans nibble popcorn and adjust their 3D glasses. Will the concert atmosphere come across in the transmission? The stage lighting changes to red. A large 3D camera circles round Smudo. He winks at the black camera. The first fans are already bobbing up and down and clapping along. The guitarist moves towards the audience. The neck of the guitar points into the auditorium. In Munich a girl ducks. She's amazed: "It's as if they're here! I can see right into Smudo's eyes."

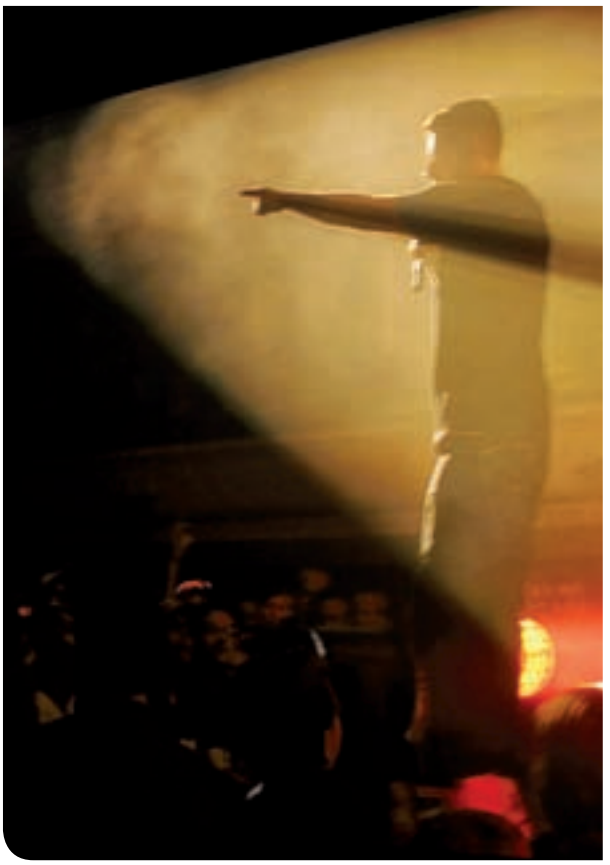
Pioneering work

The camera looks over the keyboard player's shoulder. Back in the cinemas, the hip hop fans can see him playing the black-and-white keys from really close up – as if they were standing directly behind the musician on stage. The atmosphere in the concert hall gradually spreads to the movie houses. To make this possible and ensure that the three-dimensional transmission functions smoothly, the engineers and technicians have to meet exacting demands. "It takes utmost precision," says Josef Kluger from KUK Film. "To get the 3D effect we shoot the scene with stereo cameras, which incorporate two HD cameras and a special mirror system. For spatial viewing people need two images from slightly different perspectives. Stereo systems like ours use two cameras to capture the action from slightly different viewing angles. We're basically making a separate film for each of the viewer's eyes."

In Halle, 150 experts are working behind the scenes: in the control unit, operating the cameras and doing the live editing. The crew in the outside broadcast truck are really focused as they check the image data coming in from the five stereo systems. "Much more technology and effort is needed for this world premiere than for a normal transmission," emphasizes production director Kluger, who is also responsible for stereoscopic 3D transmission in the OB truck. He is helped by the stereo assistance system STAN, the Stereoscopic Analyzer, a piece of software developed by KUK Film in cooperation with research scientists at the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI in Berlin.

The countdown on screen, an exciting moment for all involved behind the scenes and the audiences in the movie houses.

The fun's about to start: 30,000 fans experience the show, which is transmitted simultaneously to 91 movie houses in five countries.



So far away and yet so close: The band performs live in Halle and within the grasp of their televiewing fans in cinemas.

"STAN ensures that the stereo video images are correctly processed during filming," explains Dr. Ralf Schäfer, head of the Image Processing department at HHI. "That's what makes a trouble-free live broadcast possible." This combination of hardware and software checks whether the editing and 3D transmission are functioning correctly. The German Federal Ministry of Economics and Technology (BMWi) funded the development of STAN under the research project PRIME. "The stereo images are analyzed with the help of STAN and any distortions are immediately rectified electronically – not in post-production, as with well-known 3D movies such as 'Avatar', but in real time during live transmission," explains Schäfer. To get the digital data to the viewers, the cameras, satellites, receivers, projectors and glasses all have to be equipped for 3D.

Viewers in the middle of action

"I almost forgot that I'm not at the gig," says a girl in the crowd. "Some more space to dance would be nice." Michi Beck comes straight towards her, singing 'Einfach Sein', one of the band's best-known hits. The fans in Halle are going wild. In the movie houses too more and more youngsters are standing up to dance. "Are you ready to rock?" shouts Michi Beck. The camera crane extends over the heads of the fans and captures the atmosphere. They dance and stretch their arms upwards. The virtual and real worlds mix together like the hands of the live audience and the televiewers in the movie houses.

"Not even I get that close to myself," jokes Thomas D, describing the intense 3D experience. After the rehearsal the band had watched the film recording and changed their choreography for the show. "You have to work differently and develop new approaches. More forward and backward movements, looking into the camera, and less to the right and left than before." Kluger adds: "The camera movement is also smoother than for two-dimensional transmissions because wild panning shots and fast cuts would irritate the viewers." Hopes are high that livestreamed concerts will breathe new life into Germany's entertainment sector. The technology for this landmark event was provided free of charge by all the companies and research bodies involved. The German Federal Ministry of Education and Research (BMBF) is funding the 3D Cinema project. The broadcast was initiated and organized by the Innovation Forum 3D Cinema and Stereoscopic Media Productions and the Halle Multimedia Center under the direction of Katerina Hagen and Alexander Schaefer. "The great thing about the whole project is that more than 50 companies were willing to enter unknown territory together on the strength of their conviction that this innovation will have a major impact," concludes a delighted Kluger.

Feeling like in concert

All the fans are singing along and clapping. Shredded paper drops from above stage in Halle and flutters down onto the applauding viewers in Germany, Austria, Switzerland, Belgium and Luxembourg. And how did the moviegoers like the show? "At first it was a bit strange, everybody sitting on rows of seats in the darkened movie theater cheering at the screen. But soon I felt I was really at the concert," a female fan enthuses. ■

Stagnant water is a breeding ground for infectious diseases.
© Ulrich Doering/mauritius

Does the environment damage our health?

Rising temperatures, solar radiation, fine dust particles – what impact do these and other environmental factors have on our health? Researchers working on an EU project are seeking to answer this question.

Text: Klaus Jacob

The fact that the environment can make us ill is something we have known since the industrial revolution, when miners began to suffer from 'black lung' (pneumoconiosis) and many town dwellers from respiratory diseases. The correlations between environmental variables and human health are many and varied: Floods, for example, increase the risk of infection with cholera, while rising temperatures exacerbate the spread of malaria. And a recent study by the University of Duisburg-Essen revealed that increased levels of fine dust particles in urban street canyons push up inhabitants' blood pressure, thereby raising their risk of developing arteriosclerosis, heart attacks and strokes. Yet we are still a long way from fully explaining the precise impact that environmental influences have on human health. To date, no-one has ever carried out a detailed comparison of environmental and medical data. Now an interdisciplinary research project involving 13 research institutes, universities and companies has undertaken to complete the painstaking task, and experts are already working on software solutions that will allow them to identify potential cause-and-effect relationships.

The EU project EO2HEAVEN (Earth Observation and Environmental Modelling for the Mitigation of Health Risks), which was launched in February 2010, will run for three years and is coordinated by the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB in Karlsruhe. Spanish IT company Atos Origin has taken on responsibility for scientific coordination of the project. The researchers have set themselves ambitious goals: They will have to process vast amounts of environmental data and then draw connections between these and data held by the health sector. They will use correlation analysis to help them identify possible links between the two datasets, then, once the analysis work is finished, it will fall to medical experts to verify the validity of their findings. Ultimately, the project will facilitate the compilation of so-called hazard maps, which can be used, for example, to depict the risk of someone contracting an allergy in a particular area.

www.eo2heaven.org

Above all, however, the aim is to develop early warning systems. If, for example, specific weather conditions were known to increase the number of cases of cholera, timely analysis of meteorological data could point to a rising danger in advance. Similarly, environmental data could be used to warn of a surge in ground-level air pollutants likely to raise the incidence of respiratory diseases. Appropriate models would enable specific threats to be identified and analyzed even several days before they took effect, and this type of forecasting would in turn allow hospitals, doctors and health authorities to prepare for big influxes of patients ahead of time. It has even been suggested that, in a second project phase, personal warning systems could be developed for individuals at particular risk, such as those with cardiovascular diseases or asthmatics. Anyone likely to be seriously affected could then take preventive medicines, stay at home, or avoid strenuous physical activity. But that's not all: In the event of an alert, the authorities could potentially even reduce harmful emissions for a while, perhaps by imposing traffic restrictions or by temporarily shutting down facilities known to produce particularly high levels of emissions.

How risks can be dealt with

In order to develop the tools they need, the EO2HEAVEN experts are currently conducting three case studies. In southern Africa, they are investigating whether specific climate constellations encourage outbreaks of cholera; in the South African city of Durban, they are studying whether the inhabitants of the industrial basin are made ill by air pollutants; and in Dresden, they are looking into the potential effects of the environment on allergies and respiratory diseases. Dresden has a population of around half a million and is regarded as a typical European city. There, as indeed in the rest of Germany, one in ten children and one in twenty adults suffer from asthma – and environmental factors such as pollens, ozone and fine dust particles cause particular problems for these individuals.

In Dresden, the scientists have recourse to large amounts of data on the environment and health that will help them in their work. Records from the years 2003 to 2006 will form the basis for their models. The data originate from weather satellites, environmental stations and emissions registers, and even topography, traffic density and vegetation will be included in the models. Anonymized health data will likewise be incorporated. "Finding a way to integrate all the different data is posing a real challenge for information and communication technology," admits Kym Watson, project coordinator at the IOSB. The ultimate aim is to utilize the data to predict whether the concentration of air pollutants is likely to rise.

The EO2HEAVEN researchers also want to develop an early warning system for Durban. In the city's sprawling industrial basin, a plethora of refineries, paper manufacturers and other industrial concerns spew an unhealthy mix of pollutants into the air – including several metric tons of sulfur dioxide a day. On top of that, surrounding mountain ranges impede the circulation of air and lead to frequent atmospheric inversions. The impact of these environmental conditions on the health of the 200,000 or so people living in the region is clear from a study at one particular school, where every second child suffers from asthma.

The third case study is looking into the spread of cholera – a subject that has never yet been exhaustively researched. That said, one thing we do know for certain is that the environment has a significant influence on the disease, because the number of cases generally fluctuates in line with the seasons. The bacterium that causes cholera – Vibrio cholerae – lives in saline and brackish water, where it attaches itself to algae and zooplankton. An algal bloom, which may be triggered by high temperatures or increased nutrients, will lead to a surge in these bacteria. And through human waste, the bacteria can also enter the freshwater environment, where, if the drinking water becomes contaminated, it can give rise to epidemics, particularly in the event of flooding.

Parameters involved

In order to gain a better understanding of the various interdependencies at play, the project partners are incorporating a wide range of parameters in their studies. These include not only the salinity, pH value, temperature and nutrient concentrations of salt and river water, but also meteorological data such as rainfall, hours of sunshine, temperature and atmospheric humidity. Should they prove able to determine the correlations between environmental variables and the spread of the cholera pathogen, the authorities and medical experts might well be able to take effective countermeasures in good time in the future.

The EO2HEAVEN research project is all the more important because mankind is intervening more and more in the environment. Not only are we constantly polluting the air and sea with new substances that can make the local population ill, we also find ourselves in the midst of global climate change. Rising temperatures, more frequent floods and prolonged periods of drought may well impact significantly on our health, and the researchers are seeking to develop tools that should prove valuable in evaluating all these eventualities. ■

Water for Mongolia

Clean water is a rare commodity in many countries of the world, and governments often struggle to meet their population's water needs. An interdisciplinary team of researchers in Mongolia is showing how to make the most effective use of scarce resources.

Text: Monika Weiner

Mongolia is a land of contrasts: swelteringly hot in summer and freezing cold in winter; humid in the north and bone-dry in the south. One million of the country's three million inhabitants live crowded together in the capital city of Ulan Bator, a modern metropolis, while the rest of this vast country is largely left to the use of nomads and their livestock. Under these conditions, providing everyone with clean drinking water is a challenging prospect — nobody is willing to take on the task of laying frost-resistant water pipes over an area of 1.5 million square kilometers. As a result, people outside urban areas continue to draw their own water from rivers or from wells they dig themselves.

More people but less rain

However, climate change, demographic shifts and economic developments are now stretching these traditional water supplies to breaking point. The last few decades have seen fewer and fewer of the rainy periods that used to gradually refill underground aquifers during the summer months. These have been replaced by severe storms and torrential rain, causing catastrophic floods that then drain away on the surface because they have no time to soak in to the ground. At the same time, the fast-growing population, herds of livestock and industry are cranking up the pressure on water supplies while the mining of gold and ore deposits steadily consumes and pollutes ever greater quantities of water. "These circumstances are making it even more difficult to provide people with drinking water. To keep supplies flowing in the long term, you have to take all sorts of different factors into account and find out how they influence each other," says Dr. Buren Scharaw from the Fraunhofer Application Center System Technology AST. Born in Mongolia, he has spent the last four years running a project known as MoMo, an abbreviation taken from the project's full title of "Integrated Water Resources Management for Central Asia: Model Region Mongolia."

A qualified engineer, Scharaw works on MoMo with a team of geographers, geologists, meteorologists and hydrologists. As well as AST, the project partners include the Universities of Heidelberg and Kassel, the Bauhaus-Universität Weimar, the Helmholtz Centre for Environmental Research, the Leibniz Institute of Freshwater Ecology and Inland Fisheries, and private businesses. The model region that the researchers are studying covers the catchment area of the River Kharaa and the city of Darkhan, which is 250 kilometers from the capital city. Darkhan is a typical Mongolian city of some 100,000 inhabitants, approximately half of whom live in permanent housing while the other half live in yurts on the city's outskirts.

Since the start of the project in 2006, Scharaw has journeyed to the country of his birth some two dozen times to carry out a wide range of tasks: holding meetings with representatives of water authorities, water suppliers and municipal authorities; mapping and analyzing aquifers;

Wide open spaces: Mongolia is sparsely populated. Large areas of the country are not connected up to any central water supply networks or wastewater treatment facilities. All photos © *Fraunhofer IOSB*

investigating the water quality of public and private wells and of the water distribution network; measuring the energy consumption of pumps; and determining the effectiveness of the wastewater treatment plant. All the data and results have been stored in a computer model developed by AST. "Our water management solution HydroDyn finally gives us a way to visualize both the quality and quantity of water flows and to model how they will develop in the future," Scharaw explains.

Saving energy, securing supplies

There is no doubt that improvements are urgently needed. The water that supplies the public wells may be of good quality, but the infrastructure is obsolete – the pumps consume disproportionately large amounts of energy and the pipelines are dilapidated, with almost half of the drinking water lost to leakage on its way through the pipes. The houses in Darkhan have running water, and the yurts' inhabitants can buy drinking water drawn from public wells at "water kiosks." Many yurts also have their own shallow wells to provide them with water, though this is frequently contaminated with microorganisms washed in from the latrines situated on the same plots of land.

So how can the situation be improved? "Now that we've completed the first phase of the project – which basically involved gathering data and developing models – we can now start coming up with concrete proposals that make sense from both an economic and an ecological perspective," Scharaw says. To do this, his team has developed software that can identify how to secure water supplies while maximizing sustainability and energy savings: "One thing you can do is to shift the pumping of the 20,000 cubic meters of water that are required each day to times when electricity is cheap – for example at night. You can also save energy by pumping water into the nearest elevated tank in order to avoid long stretches

Room for improvement: Researchers want to boost the effectiveness of the wastewater treatment plant.

Many of the yurts on the city's outskirts have their own well, but the water they pump out is often contaminated with germs.

of pipeline. It is always important to take into account how much water is available in each of the various groundwater layers whenever you pump out water."

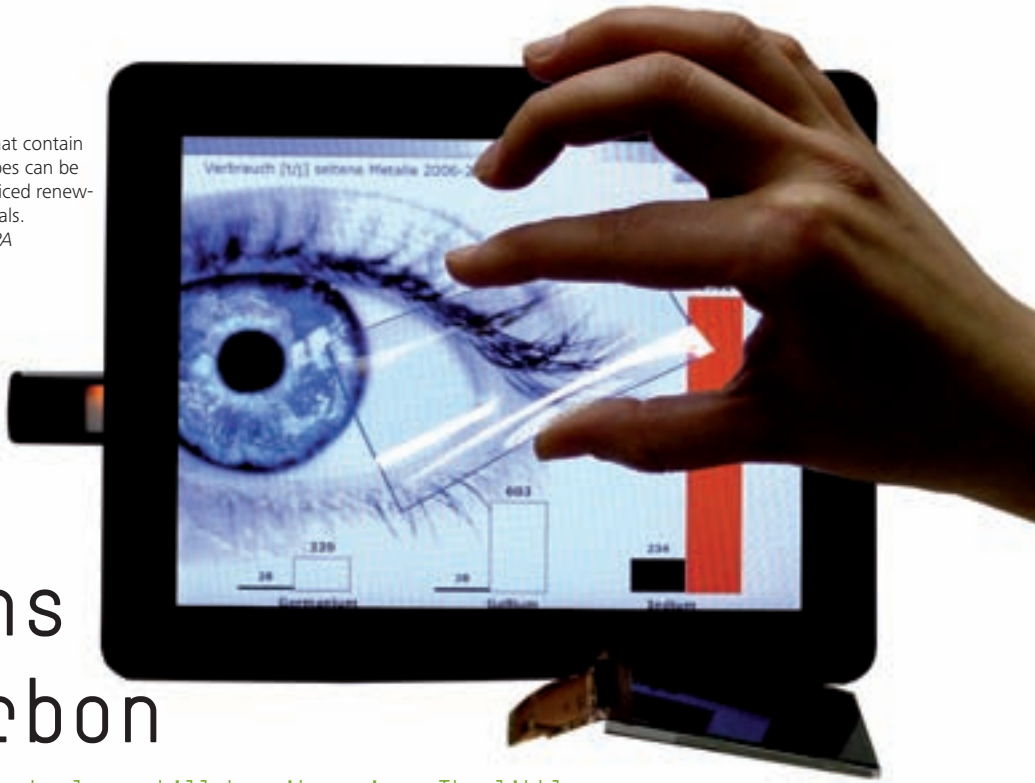
To minimize losses in the drinking water distribution network, Fraunhofer researchers have developed a measurement system designed to pinpoint leaks. Small sensors pick up pressure losses in the pipes, allowing the holes to be located with relative precision. Once the leak has been tracked down, the stretch of the pipe can be dug up and repaired.

Effective wastewater

To reduce the amount of pollution in the water, the MoMo researchers are looking for alternatives to the methods currently employed for disposing of sewage. The effectiveness of the wastewater treatment plant could potentially be improved by implementing some simple measures: Scharaw and his colleagues are busy building a pilot plant that contains a high concentration of microorganisms: "We expect this plant to continue providing good results even in the cold season when microorganism activity decreases. These results can then be transferred to a future plant." The experts recommend building small, local wastewater treatment plants in the yurt settlements designed to both treat sewage and produce biogas for heating. Until those are built, the latrines in the yurts should be equipped with plastic containers to collect the feces so that they can be properly dealt with in the wastewater treatment plant.

In three years' time, when the MoMo project comes to an end, the experts intend to present the authorities in Darkhan with a package of measures to clearly show how they can secure their water supplies and wastewater treatment in the future in a way that maximizes efficiency and minimizes costs. ■

The "water kiosks" provide clean water – at a price.



Touchscreens that contain carbon nanotubes can be made of low-priced renewable raw materials.
© *Fraunhofer IPA*

Touchscreens made of carbon

Touchscreens are in - although the technology still has its price. The little screens contain rare and expensive elements. This is the reason why researchers at Fraunhofer are coming up with an alternative display made of low-priced renewable raw materials available all over the world.

Text: Tim Schröder

Just touching it slightly with the tips of your fingers is enough. You can effortlessly write, navigate, open menu windows or rotate images on touchscreens. Within fractions of a second your touch is translated into control commands that a computer understands. At first glance, this technology borders on the miraculous, but in real life this mystery just is a wafer-thin electrode under the glass surface of the display made of indium-tin-oxide, ITO. This material is nothing short of ideal for use in touchscreens because it is excellent at conducting slight currents and lets the colors of the display pass through unhindered. But, there is a little problem: there are very few deposits of indium anywhere in the world. In the long term, the manufacturers of electronic gadgets are afraid that they will be dependent upon the prices set by suppliers. This is the reason why indium is called a "strategic metal."

Therefore, private industry is very interested in alternatives to ITO that are similarly efficient. The researchers at Fraunhofer have succeeded at coming up with a new material for electrodes that is on the same level as ITO and on top of it is much cheaper. Its main components are carbon nanotubes and low-cost polymers. This new electrode foil is composed of two layers. One is the carrier, a thin foil made of inexpensive polyethylenterephthalate PET used for making plastic bottles. Then a mixture of carbon-nanotubes and electrically conducting polymers is added that is applied to the PET as a solution and forms a thin film when it dries.

In comparison to ITO, these combinations of plastics have not been particularly durable because humidity, pressure or UV light put a strain on the polymers. The layers became brittle and broke down. Only carbon nanotubes have made them stable. The carbon nanotubes harden on the PET to create a network where the electrically conducting polymers can be firmly anchored. That means that this layer is durable in the long run. Ivica Kolaric, project manager from Fraunhofer Institute for Manufacturing Engineering and Automation IPA, concedes that "the electrical resistance of our layer is somewhat greater than that of the ITO, but it's easily enough for an application in electrical systems." Its merits are unbeatable: carbon is not only low-cost and available all over the world. It is also a renewable resource that you can get from organic matter such as wood. In Spring Kolaric and his colleagues presented their carbon touchdisplay at the 2011 nano tech fair in Tokyo. Recently a new Fraunhofer Office for the Process Engineering of Functional Materials and Robotics in Osaka, Japan was opened. The development of nanomaterials will be one key issues for the researchers at the office.

There are a whole series of implementations for the new technology. This foil is flexible and can be used in a variety of ways. Kolaric sums up by saying "we could even make photovoltaic foils out of it to line corrugated roofs or other uneven structures." The researcher has already set up pilot production where the foil can be enhanced for a wide range of applications. ■

Cars and road signs in dialog

Interconnected automotive assistance systems will warn each other about traffic build-ups at roadworks or after an accident. © CAR 2 CAR Communication

Motorists will soon be able to make detours around traffic jams, avoid accidents and save energy on the basis of pinpointed information. New simulation software is helping in the development of intelligent traffic and driver assistance systems.

Text: Chris Löwer

For Ilja Radusch the idea was as simple as it was irresistible: Why shouldn't cars communicate with each other directly, like we do using a cell phone? For nearly ten years the Fraunhofer Institute for Open Communication Systems FOKUS in Berlin has been working on translating this vision into reality. Radusch, who heads the Automotive Services and Communication Technologies department, has gone a long way towards achieving this goal thanks to a new piece of simulation software. The software makes it possible to test at a very early stage of development the exchange of information by cars with each other or with the surrounding infrastructure, such as traffic lights and warning signs.

Vehicle-2-X or V2X communication is the technical term for these software solutions, which will make traffic safer, cleaner and faster-flowing. Given the traffic jams in towns and the congestion on freeways, this is an attractive prospect – because if cars can communicate with each other, they can warn their drivers in good time about stationary traffic around blind corners, slow-moving traffic at roadworks, or early-morning fog patches that pose an unexpected hazard. Most of this information is already collected by assistance systems, it just needs to be networked intelligently.

Communication prevents traffic jams

It could happen like this: As a car approaches a roadworks site, the driver is automatically informed about the speed restriction, which lane is affected and whether there is a traffic jam. This information can be distributed by radio

communication units at the site. The system is highly dynamic: "Cars can be diverted to various other routes so that no further traffic builds up," explains Radusch. If the vehicles report that traffic is back to normal, the cars subsequently approaching are once again guided through the roadworks. Very little data is needed for this smart solution, just the current speed of the vehicles, from which an algorithm works out the traffic situation in real time. This is then channeled into the navigation system's route calculation, which depending on the traffic recommends suitable alternative routes.

New service for auto manufacturers

In town, too, the system provides important information to car drivers, for instance on the best speed for riding the green wave of phased traffic lights. Radusch states: "This improves the traffic flow, saves fuel and therefore benefits the environment."

This type of communication is not a problem for today's technology. What is currently missing, however, is experience of how the different information sources will interact. And this is where the new Fraunhofer simulation software VSimRTI comes in. "In the past, only field tests involving a few cars were performed or simulations conducted for which individual traffic and network simulators were merely connected together in a fixed link. Now, we can combine a whole range of simulators dynamically for the period required," explains Radusch.

This means the interplay of several assistance and communication systems on the computer and their impact on road traffic and emissions can be tested very early in the development phase, and factors that might interfere with the wireless connection can be determined. But the software can do more: "Car manufacturers, automotive suppliers, navigation system producers and cell phone operators can use it to develop new services," says Radusch. The software's first users include Daimler, Opel and VW, and also research groups such as the German Research Center for Artificial Intelligence (DFKI), the Fraunhofer Institute for Secure Information Technology SIT and the Karlsruhe Institute of Technology.

VSimRTI was developed under the PRE-DRIVE V2X project, in which a European consortium of car manufacturers, automotive suppliers, electronics firms and research institutes headed by Daimler conducted work on innovative transport systems. It incorporates intelligent assistance systems which interact to enable dynamic route guidance and cooperative traffic light sequencing, as well as hazard-warning and safety applications. VSimRTI is also an important tool for combining different simulators flexibly with each other, making it possible to assess whether V2X applications and assistance systems will bring about a general improvement in the traffic flow.

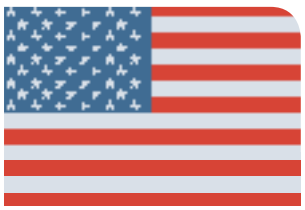
Even if V2X communication systems prove themselves on the computer and the field tests are successful, they will still have to find their way into our cars. "At present a communication box for automobiles is expensive, costing around 2000 euros," says Radusch. The investment in antennas, the WLAN module and control unit is only worthwhile, however, if enough cars are equipped with the new technology. Otherwise, simply not enough information will be generated. The market breakthrough can be achieved if as many vehicles as possible are equipped as quickly as possible. "An adequate level will be reached when about ten percent of vehicles have a communication box," affirms Radusch. If the infrastructure – the traffic lights etc. – were already fitted with the equipment on a wider scale, motorists could benefit now from certain services, even with less than ten percent participation in the exchange of information between vehicles.

Interestingly, progress could receive a decisive boost from quite a different direction. The extensive traffic information and individual motoring data make it possible to precisely determine how far an electric car can travel on a battery charge. The limited range of electric vehicles is one of the main problems associated with electromobility. If drivers knew exactly when they should seek out the nearest charging station, they would probably have fewer reservations about using a battery-powered car.

Active energy management

It would also be possible to actively pursue energy management. Siemens and BMW have already presented a system which transfers data between traffic lights and vehicles in order to optimize their automatic engine start-stop technology. In addition, having communicative traffic lights makes it possible to precisely control the braking energy recovery system if an approaching vehicle is out of sync with the green wave.

Radusch expects that in five years' time at the latest, enough new vehicles will be equipped with the technology to make it affordable. Old vehicles could then possibly be retrofitted at little cost. "All the major car manufacturers and automotive suppliers already have these systems on their product road map," states the Fraunhofer research scientist confidently . ■

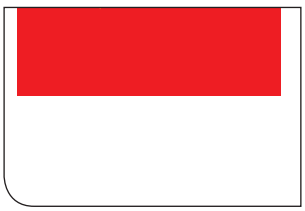


Building America

According to a 2009 report by the US Department of Energy, buildings account for 40 percent of energy consumption and 73 percent of electricity use in the United States. Attention-grabbing figures that highlight the need for urgent action. Developing energy-efficient, environmentally friendly solutions that consumers will accept is essential if the United States is to achieve its climate targets over the coming decades and reduce its energy consumption and carbon dioxide emissions.

One step already taken by the US Department of Energy is the refocusing of its Building America initiative, a research program launched 15 years ago which is designed to help industry develop structural engineering and energy-saving technologies for new and existing buildings. The Fraunhofer Center for Sustainable Energy Systems CSE in Boston has now been chosen to lead a research group comprising a total of 15 teams.

Researchers from the Building Energy Efficiency Group at Fraunhofer CSE carry out projects to investigate, test and demonstrate energy-efficient technologies, working closely with partners from all sectors of the US construction industry as well as with Fraunhofer ISE and Fraunhofer IBP.



Research in Qatar

Fraunhofer researchers will be working with scientists in Qatar to develop a reactor that can produce hydrogen from natural gas using solar energy. The joint research agreement between the Fraunhofer-Gesellschaft and Qatar Science & Technology Park was signed recently by Dr. Tidu Maini, Executive Chairman Qatar Science & Technology Park, and Professor Dr. Ulrich Buller, Senior Vice President Research Planning, Legal Affairs of the Fraunhofer-Gesellschaft.

Solar thermal cracking of methane to produce hydrogen and carbon particles is seen as a promising new technology because it does not release any toxic or environmentally harmful gases. Compared to producing energy from fossil fuels, the solar thermal production of hydrogen emits significantly lower quantities of CO_2. The carbon particles make up an important part of the value chain, since they are used as additives in the manufacturing of rubber tires and conveyor belts.

"It is a unique chance for us to work on an applied research project with Fraunhofer," said Maini at the contract signing ceremony. "We value the deep experience and know-how of the Fraunhofer Institute for Material and Beam Technology IWS. This project builds on Her Highness's vision that Qatari research should focus on its inherent strength in oil and gas to produce environmentally friendly and value added products."

Apps for Europe

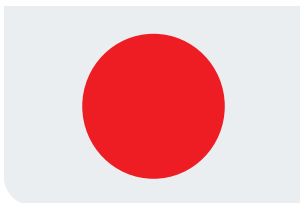
As our lives become increasingly internet-focused, more and more people are demanding the flexibility to use web-based services wherever and whenever they want. Although numerous standards and technologies have emerged to address this need, they are generally not compatible with each other – but that could be about to change. 22 of the world's leading research institutions and companies from the telecommunications, automotive and media industries – including Deutsche Telekom, BMW, Samsung and Sony Ericsson – have joined forces to develop a universally accepted open source technology for programming web-based services and facilitating their use on a range of different devices. The "webinos" project, which kicked off in fall 2010, is being coordinated by the Fraunhofer Institute for Open Communication Systems FOKUS. The EU is providing 10 million euros of funding for the project.

Over the next three years, engineers from the participating companies are hoping to develop an open source platform and software components that will enable web applications to be programmed and deployed across multiple platforms. The idea is that people should be able to use the apps of the future whenever and wherever they want, through their cell phone, PC, TV – even in their car.

Fraunhofer in Italy

The Fraunhofer Innovation Engineering Center IEC in Bolzano has officially opened for business. Its international and interdisciplinary team of researchers will be developing tailor-made solutions for small and medium-sized companies in South Tyrol. Fraunhofer IEC – which the Fraunhofer Institute for Industrial Engineering IAO was instrumental in setting up – is the first facility to be established under the umbrella of the company Fraunhofer Italia Research Konsortial GmbH.

The researchers at Fraunhofer IEC will be working on projects in collaboration with scientists from the Free University of Bolzano and industry partners. The Center's new research and demonstration laboratory offers the most up-to-date information and communication technologies together with applications for developing products and services. One example is the "Powerwall", a high-resolution projection system that uses virtual reality to help visualize complex data. The laboratory also allows researchers to determine the extent to which companies and their customers could benefit from integrating new technologies in their products.



Smart nano-materials

Nanoparticles are enabling the world's engineers to create products with new and useful properties. Take carbon nanotubes – "CNTs" for short. The first to recognize the potential contained in the nanotechnologies were Japanese companies. They remain the leaders in this area, accounting for a large portion of the world's production of CNTs.

The longstanding working relationships between Fraunhofer's "nano-specialists" and their counterparts in Japan were recently broadened by the commissioning in Osaka of the "Fraunhofer Office for the Process Engineering of Functional Materials and Robotics". The office is, from the organizational point of view, an extension of the Fraunhofer Representative Office Japan.

"Our objective is to set forth our networking with Japan's excellent researchers, who work for both the country's companies and scientific institutes, and, by doing such, to create areas of application for the nanotechnologies," states Ivica Kolaric of the Stuttgart-based Fraunhofer Institute for Manufacturing Engineering and Automation IPA. Kolaric is the head of the new office in Osaka.

Automotive development

Cycles of development and production in the automobile industry are getting shorter and shorter. To enable Europe's manufacturers to keep up with this trend and thus to retain their viability, the EU has launched its "Pegasus" project. Its objective is to develop software networking the Union's SMEs with each other to the point of their having the speed and flexibility of response and effectiveness of customer outreach of a single company.

This new software platform has an early stage of development intervention capability. The platform analyzes the requirements placed upon a product and then comes up with the materials capable of satisfying them. Case in point: an automobile roof that is to be manufactured from a new material. This tool employs a digital-based analysis of the component's data to select materials that are automatically suitable for processing procedures. These, in turn, are also chosen by Pegasus.

The platform was put through its paces in the development of a mudguard featuring a built-in LED backlight. "We took a mudguard that is standard to a Smart car, and showed how new processing procedures, materials including glues, and tools enable the cutting of the times and costs of its manufacturing," states Timo Huber. He is a staff scientist at the Pfinztal-based Fraunhofer Institute for Chemical Technology ICT, which is one of the 23 participants in the Pegasus projects.

Exploring the seas

How quickly are the world's oceans warming up? How do seaquakes and tsunamis come into being? What raw materials are buried in the seabed? The answers to these questions may well come from ships equipped with the high-powered sensors enabling them to explore the seas and their beds. To permit the rapid analysis of the data stemming from the sensors, the ships also have to be equipped with software systems intermeshed with landside data processing centers.

In the EU project Modelplex Scientists and engineers from 20 research units, among them the Berlin-based Fraunhofer Institute for Open Communication Systems FOKUS, now develop systems capable of controlling such complex networks of sensors. Entailed in this is the creation of an open tooling infrastructure. Such software instruments will facilitate the modeling, programming and securing of quality of new and more comprehensive programs. These, in turn, will be applied in the crunching of geo-data – and, possibly, in the development of systems managing the operations of airports and large-scale retailing chains.

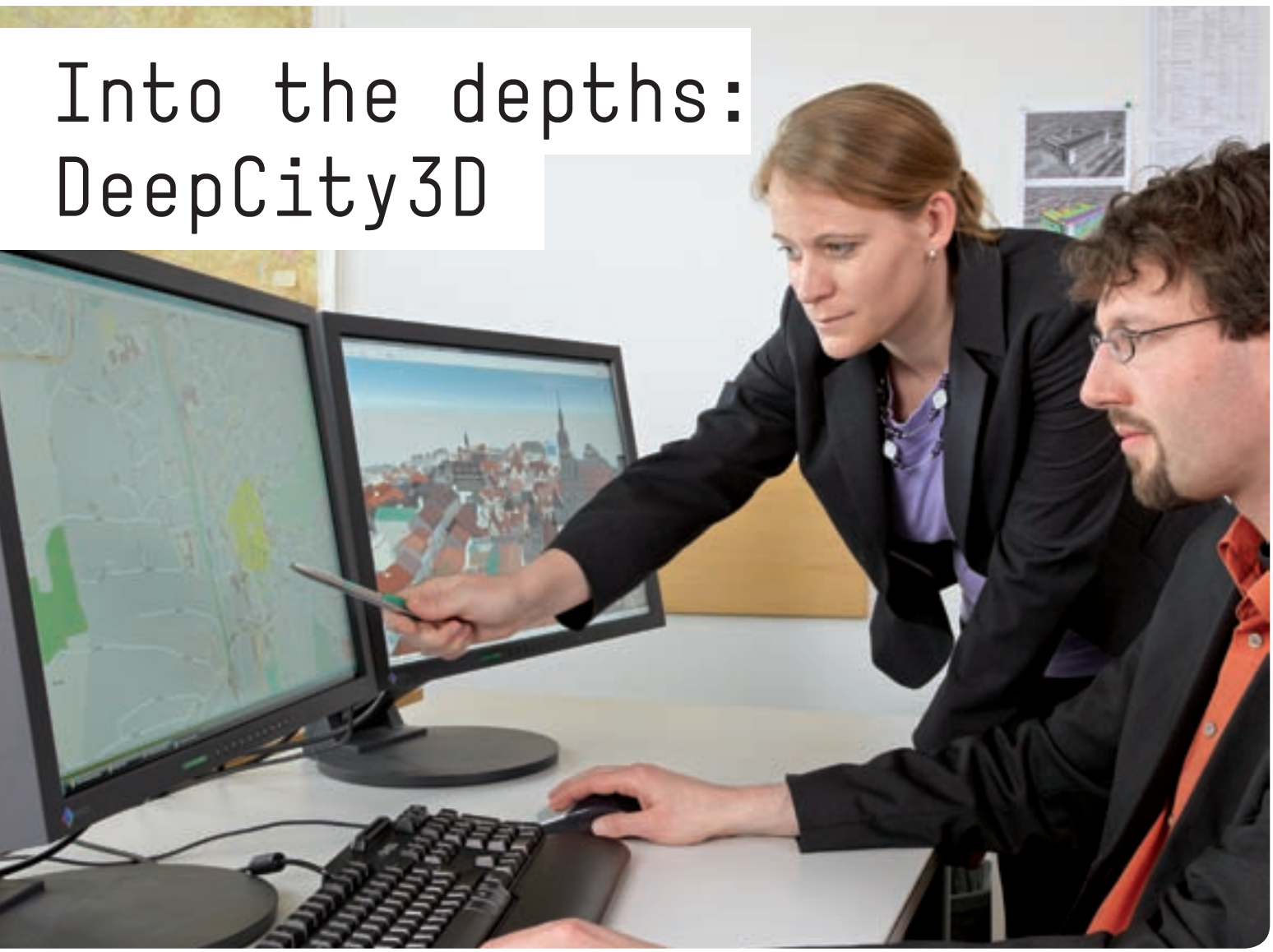
Effective assistance

The only way of stopping liver tumors from being fatal is often by undertaking an operation. These, in turn, require of surgeons the utmost of proficiencies. To make this highly-demanding job easier, a liver navigation system has been developed by researchers at the Bremen-based Fraunhofer Institute for Medical Image Computing MEVIS – and at the ARTORG Center for Biomedical Engineering Research of the University of Berne. This system is being tested and optimized at the Eastern Hepatobiliary Surgery Hospital. Located in Shanghai, the hospital is the world's largest center of liver operations, with its surgeons attending to more than 5,000 patients a year.

MEVIS' researchers take radiological and layer-specific image data transmitted electronically and turn it into a 3D model of the patient's liver. This, in turn, is employed by the surgeons in Shanghai in the planning of the operation – and in the assessing of the associated risks. This data is then called upon by the surgeons during the operation itself. The new navigation system then avails itself of the data in assisting surgeons during the operation. This assistance takes the form of precisely displaying the data-generated positions of tumors and blood vessels and the planned incisions on the patient's liver.

Modern and sustainable urban development needs information about tunnels, mine workings, pipeline systems and geological formations. © Fraunhofer IGD

Into the depths: DeepCity3D



The collapse of the Cologne city archive was a stark reminder that underground infrastructure is a major factor in safe and sustainable urban planning. The DeepCity3D project dives down into the depths and links up overground information with underground pipes, basements, tunnels and geological structures.

Text: Katja Lüers

It has been raining for hours In Mainz. The drains can no longer cope with the huge volumes of water. The force of the water pushes up manhole covers. The roads are so flooded that they are impassable to traffic, and water is collecting in basements. The fire department and disaster prevention agency are working non-stop. When such a dramatic natural event occurs, the emergency plans prepared in advance often prove inadequate. The situation gets worse and worse and it is difficult to coordinate the emergency services effectively. It would be useful to have a continuously updated, inter-agency, three-dimensional representation of all the essential information. This would enable the people in charge to see at once where help is needed most and jointly take the rapid decisions required.

Bringing information together

While state of the art geoinformation systems (GIS) and CAD software are able to visualize town models or underground information in three dimensions, they cannot as yet provide a combined picture. The DeepCity3D project takes this extra step. Research scientists at the Fraunhofer Institute for Computer Graphics Research IGD in Darmstadt are developing a tool which displays underground information on pipes, basements and tunnels in three dimensions and links it with overground information. They have succeeded in creating the first software system for integrated visualization of overground and underground factors in a town model, and CityServer3D is already being successfully used by several German municipal authorities to administer and link together two- and three-dimensional geographical data. DeepCity3D is an add-on module.

"We hope this project will increase awareness that in modern, sustainable urban development it is essential to visualize what is going on below ground," explains Michel Krämer from IGD. It is no longer enough to simply plan outwards and upwards. In some cases the space for development above ground has already been completely exhausted – but there is still plenty of scope below ground. Public agencies responsible for urban planning, environmental protection and disaster management as well as private-sector organizations involved in the maintenance or expansion of municipal infrastructure will in future have to increasingly include underground factors in their planning. DeepCity3D will provide the communications link between the various parties. The newly developed software system will give everyone involved access to all the relevant information in continuously updated form and in the highest quality.

Viewing geological conditions

Underground infrastructure is as varied as it is visually impenetrable. Below our streets there is a labyrinth of sewers, gas pipes, electricity cables and telecommunications lines. And the ground itself is characterized by cavities, broken rock and layers of earth. No map can reflect this variety, but reliable information on such underground conditions would be enormously useful – enabling repairs to pipes etc. to be carried out more efficiently, permitting a fast response to incidents such as floods or fires and reducing the time required for carrying out planned expansion work on existing systems.

"In addition to the underground structures, we want to visualize geological conditions," says Krämer. The research scientists in Darmstadt have therefore teamed up with colleagues from France's BRGM institute in the project, which is being funded by the German Federal Ministry of Education and Research (BMBF) until 2012. "We are the geography specialists, they are the geology experts. Our different areas of expertise complement each other ideally," Krämer adds.

The research scientists are conducting work on scenarios relating to the cities of Mainz and Toulouse. For the German city the focus is on the groundwater level together with the sewer system, and the question as to the extent to which the drains will be affected by flooding if the groundwater level changes. Krämer continues: "In this context the connection with overground systems is always important."

DeepCity3D provides 3D visualizations to help answer questions such as where the fire department should go first, where the manhole covers are overflowing or, in the event of a fire, where the fire hydrants are located.

In the Toulouse scenario urban planning is at the forefront, dealing with issues such as whether the ground is suitable for building a high-rise structure on a particular site. "This scenario ties geological aspects and their visualization much more strongly into the urban planning process," says Krämer. Whether for Toulouse, Mainz or any other town, the software tools in DeepCity3D can be used intuitively to display whatever information is required for the situation at hand, and the scientists are aiming to make the system as easy as possible to use.

How to visualize the data

But why is it so difficult to display underground structures in three dimensions? "The biggest problem is inaccurate data," explains Krämer. Little data exists, for instance, about the exact position of power lines. And whereas it is easy for a surveyor to take measurements above ground, this is not possible below ground. The researchers at IGD are now compiling and integrating all the data available from two-dimensional sources and are adding further information, e.g. meter depths, plotted on maps. The scientists aim to produce a helpful high-precision 3D visualization from all the imprecise data. The next step will be to develop innovative technologies which will highlight uncertainties in the data when it is visualized.

"We are just at the beginning of the project," states Krämer. But one thing is certain: Combining the visualization of data on overground and underground structures with geological information and a system of data exchange between the organizations involved will not only reduce costs and increase efficiency but might also help to prevent disasters such as the collapse of the Cologne city archive building in March 2009. ■

Police 2.0

Information technology is changing the way police officers go about their daily work. Within the EU's COMPOSITE research project, scientists are investigating how law enforcement officials are coming to terms with modernization measures.

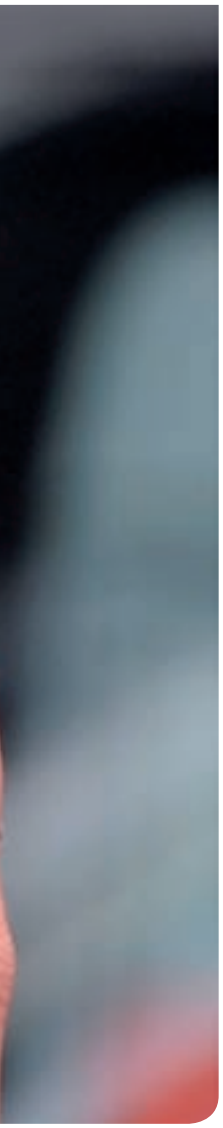
Text: Boris Hänßler

Scientists are investigating how new technologies will change the way in which police officers work in the future. © ddp

Picture the following: Would-be robbers have fled the scene of a bank heist gone wrong. A police car is in hot pursuit, dispatched at once to catch them. The officers inside the vehicle use a satellite-based navigation system to coordinate the chase. At the flick of a switch they change every traffic light to green as they approach, so they are able to pass through intersections safely. When they finally corner the culprits, they run their fingerprints through a central database and scan their ID cards right then and there. And from start to finish, the entire operation is captured on camera by a police officer.

The above scenario is far from science fiction. Police forces have long recognized the advantages of modern information technology, and have been using it on the streets for some time now. Yet advances in technology can be both a blessing and a curse for law enforcement authorities: IT undoubtedly makes the job easier, but blanket use of modern technology is expensive – and may even ask too much of individual employees, who are constantly forced to rethink the way they do things and to familiarize themselves with new systems. As a result, there is often a great divide between the theoretical development of IT systems and their practical implementation. "Generally speaking, IT experts will ascertain the needs of their clients, work on a project for a few months, and then deliver their solution. Sometimes it will be good, but sometimes it completely fails to meet user requirements," states Sebastian Denef of the Fraunhofer Institute for Applied Information Technology FIT in Sankt Augustin.

Denef is currently involved in an unusual assignment: He is part of the team working on a European research project entitled 'Comparative Police Studies in the EU', or COMPOSITE, in which an interdisciplinary and international group of



scientists is looking into change processes in police forces all around Europe. Denef describes how the FIT fits in: "We're studying how information and communication technologies are used within the various police organizations, and to this end, we're conducting interviews with the relevant authorities in all ten of the countries involved." The Fraunhofer scientist stresses: "We're not developing any technologies. We're just out to learn about how things are dealt with in practice, and above all, how this impacts on the development and adaptation of technologies." COMPOSITE is funded by the EU to the tune of almost seven million euros, and is coordinated by Erasmus University Rotterdam.

Taking organizational cultures into account

Denef already has some experience of another, similar project: He was part of the team that developed the 'landmarke' [landmarks] concept for fire brigades, a mobile navigation system that helps firefighters keep their bearings and find their way around burning buildings. And that experience will stand him in good stead now. "We bear in mind that introducing new technology is not just a technical challenge, but a social one too," he says. It can be difficult to push through changes, particularly when organizations have a very pronounced culture, notes Dr. Jochen Christe-Zeyse, deputy principal at the police training college for the Land of Brandenburg and head of the German contingent of COMPOSITE: "Police officers identify very strongly with their work and with their profession. If they think modernization measures will pose a threat to that identity, you have to expect resistance." And that goes for technological changes too.

The European researchers are currently conducting interviews with IT experts in the police forces of ten European countries, including Germany, the United Kingdom, Italy, Romania and Macedonia. This wide-angle approach is wholly intentional; border police in Macedonia, for instance, have completely different IT problems to their German colleagues. Denef illustrates the point succinctly: "Police forces along the eastern fringes of the EU must now find a way to adapt to the Schengen rules, while Germany has to cope with increasing numbers of travelers, for example by introducing automatic passport scanners." Indeed, even within Germany, IT priorities vary between the different Länder.

In the eastern part of the country, for instance, the police face a huge problem: The population has been declining rapidly for some years now. Although the city of Berlin is still expanding, there has been a mass exodus from the rest of the structurally weak region. Demographic forecasts and associated pressures to make savings will undoubtedly have a lasting impact on police force personnel and equipment. In fall 2010, the government of Brandenburg announced its structural reform initiative, 'Police 2020'. The Land is to cut 1900 jobs by 2020 – a reduction of around 20 percent. Yet its public police presence must not be seen to suffer. Ultimately, the police force will have to come up with new and innovative ways to make sure it continues to get the job done.

Police stations on wheels

One rather promising idea is that of the 'interactive radio patrol car', a vehicle equipped with a car PC, or mobile office, that could take over at least some of the functions of a police station – e.g. report filling, fingerprinting, logging or retrieving personal and/or vehicle data – and also boasts a navigation system, video technology for documenting operations, and a type of black box which would record what happened in the event of an accident. "The system has been tested successfully in recent years," says Ingo Decker, spokesman for Brandenburg's interior ministry. The most important thing was to ensure that all the individual components were compatible with each other. Now the high-tech vehicle is ready to go into production – and the police force is evaluating how many they will need. Decker is pleased to report: "The first 20 or 30 of these vehicles are likely to enter service in Brandenburg before the end of the year."

A virtual policeman is being put to the test in the Netherlands to see if he can fit the bill as a first point of contact in police stations, while Italy is introducing voice-controlled software that will allow officers to verbally operate central databases. These are just two examples of how IT is now being used in Europe. "We already have several hundred pages of reports on current IT measures," states Denef. The first phase of the COMPOSITE project draws to a close in spring 2011; by then, he will have a clear picture of what is happening all over Europe, and what kinds of hopes and fears police officers associate with IT.

In the second phase of the project, the researchers will select a number of priority topics such as 'mobile technology', and draw up examples of best practice for each of them. They will consider what problems the German police have already overcome that the Spanish still have to resolve – and vice versa. The final phase of the project will begin in two years' time, when the team will look into how people on the street relate to police technology. What do people think of automatic border controls? Are they scared of being kept under constant watch? Or do they welcome them as a convenience?

Sebastian Denef is not one for simply sitting at his desk and evaluating survey questionnaires, however. As the project progresses, he wants to go out on police operations – just as he did with the fire brigade. His ultimate objective? "To gain a much better understanding of the demands that are made of technology. After all, it should be oriented towards day to day work requirements.". ■

Surface effects

What happens when a raindrop falls on to a window? Absolutely nothing - one might think. Absolutely wrong. Complex interactions take place on the surface of glass. Understand them and you can engineer material characteristics.

Text: Monika Weiner

Partners in the ADGLASS project

- Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Bremen, Germany
- Fraunhofer Institute for Mechanics of Materials IWM, Freiburg, Germany
- Abdus Salam International Centre for Theoretical Physics, Trieste, Italy
- Aérial, Strasbourg, France
- King's College London, United Kingdom
- Schott AG, Mainz, Germany
- Technion – Israel Institute of Technology, Haifa, Israel
- University of Cambridge, United Kingdom

Nothing can be allowed to stick to the surface of glass used in the pharmaceutical industry. New research is showing how to prevent this adhesion. © *istockphoto*

Solar panels and medication containers from glass would seem at the first glance to have few things in common. Both are smooth, both contain the element silicon. Aside from that, that was it. "Despite the differences, engineers developing alternative energy systems face problems similar to those experienced by their counterparts in the area of pharmaceutical technologies," says the materials researcher Prof. Lucio Colombi Ciacchi. Born in Italy and residing in Bremen, he has identified the cause of these difficulties. "All glass surfaces are capable of interacting with their environments. These interactions influence their physical and chemical properties." Those striving to investigate such reciprocal interactions have to take very close looks: the chemical and physical reactions between solid bodies, gases and liquids take place on 'stages' whose size is a mere several nanometers.

The surface layers may be very thin, but their influence is enormous. Reciprocal interactions on the surface can lead to solar cells quickly getting soiled, and, as a result, to their producing less electricity. This is because only part of the sunlight makes its way into the cell's interior. It's a risky business when proteins stick to medication bottles. This can change the concentrations of active ingredients. In the worst case, reactions can take place on glass surfaces that modify the proteins, causing toxic effects in the process.
Experiments extending experience

Producing glass having precisely those characteristics that the customer wants: it's a very special skill. Up until now, the producers of glass had to rely on their experience. The scientific foundations are only now being established. In the EU consortium ADGLASS – "adhesion and cohesion at interfaces in high performance glassy systems", an international team of researchers is investigating the physical and chemical interactions taking place on the surfaces of glass-based materials. The team is comprised of engineers, chemists, and physicists from institutes based in five countries (please see box). "Our objective is to make processes occurring on glass surfaces that have up until now only been partially comprehended fully understandable, calculable and visible," explains Colombi Ciacchi, who is coordinating the project at Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Bremen. "Manufacturers of glass and of other vitreous materials will profit from the project's findings – be they employed in the solar, pharmaceutical or microelectronics industries."

On the information escalator

Innovative about the project is its interdisciplinary approach to research. "Up until now there were only two ways of simulating in computers what happens on material surfaces: on the atomic and the quantum mechanical level, it is possible to make chemical processes visible. This approach, however, makes use of model systems that are so small that they are not often relevant to industrial processes. The other level uses methods from classical physics. It enables the tracking of the dynamic processes involving large-sized molecular systems. Investigated, for instance, was the question whether proteins come into contact with surfaces. Not taken into account while doing such were possible chemical changes. These, however, do have effects upon both atomic and protein structures," notes Ciacchi. The researcher is fond of comparing the above situation to a house lacking a stairway or elevator between its ground and first floors. "The people below don't know what's going on above them – and vice-versa. Through our newly-developed software tools, we have, in a first, managed to generate a simulation intermeshing chemical processes and molecular reactions. By doing such, we have, so to speak, created an escalator facilitating the exchanging of information between the floors."

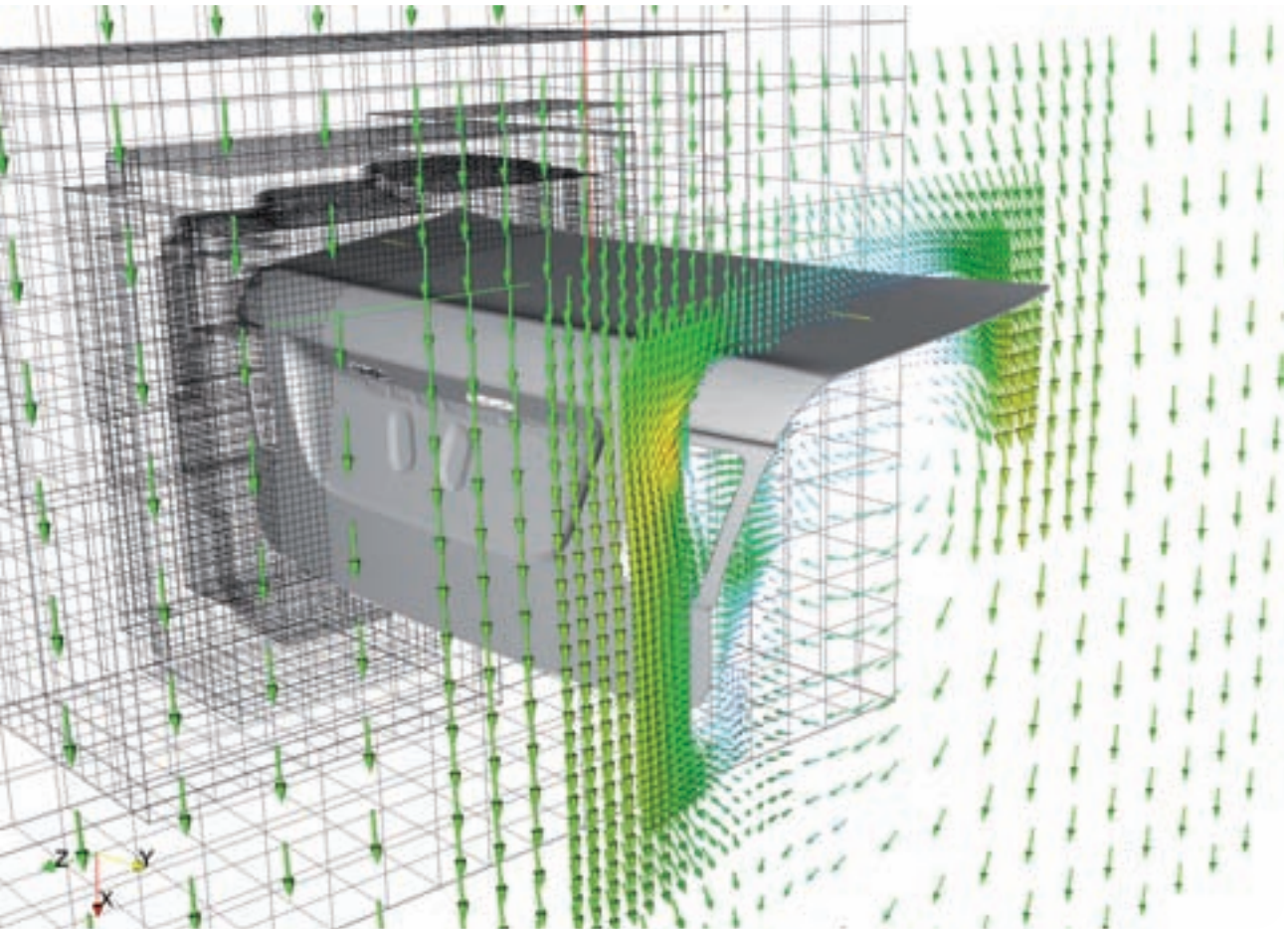
A rip becomes a point of testing

It took two years of painstaking work by the international team to create this inter-level link: physicists based in King's College London and at the University of Cambridge developed the algorithms incorporated into the new software. The first job undertaken by Ciacchi's team, comprised of researchers at the Freiburg-based Fraunhofer Institute for Mechanics of Materials IWM in Freiburg and at IFAM, was to apply the new simulation technology to silicon. Working with the English researchers, the team simulated what happens when the surface of a silicon wafer is sprayed with hydrogen and then subsequently heated up to 600 degrees Celsius. "This so-called smart cut technology is routinely employed in the semiconductor industry to severe - with the utmost of precision - nanometer-thin and crystalline layers from the surface of wafers. However, no one knew until now which individual processes take place."

The simulation revealed the complexity of the interactions taking place among the factors: the injection of hydrogen causes a dissolving of the links among the silicon atoms in crystals. The result is a small rip. This, in turn, creates a stress field weakening the bonds among the atoms. Hydrogen can make its way to the tip of the tear, where it unleashes a chemical "attack" destroying the weakened bond. The result is a broadening of the tear.

The interaction between silicon and hydrogen is highly complex – unless you are looking at it from a chemical point of view, from which it is relatively simple. Much more complicated are the interactions between glass and acid rain or solutions containing biomolecules. The next step for ADGLASS's researchers is to investigate what happens when inorganic molecules or organic compounds are deposited upon a surface. The scientits are delivering the proteins being used in the experiment: responding to wishes, they can join in their laboratories amino acids into peptides -- the building blocks of the proteins.

"Once we have really comprehended adhesion, we will be capable of designing surfaces repelling soiling and proteins," forecasts the project coordinator. "Highly interested in this is our industrial partner Schott AG, a manufacturer of technical glass used by the solar industry and of pharmaceutical packagings." He foresees an unimaginably large number of possible applications, including windows never requiring cleaning, eyeglasses that are always crystal clear, casseroles never needing scraping, and…, and…, and… ■



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Simulation in motion

Robots that collide with adjacent equipment or whose cables get tangled can stop an entire production line. A new simulation program indicates where problems might occur, so that they can be eliminated during the planning phase. A number of prominent car manufacturers are already benefiting.

Text: Monika Weiner

IPS simulation of a car wiring harness with flexible cable components. The colors indicate the stress condition (blue = low, red = high) caused by cable deformation. © Delphi

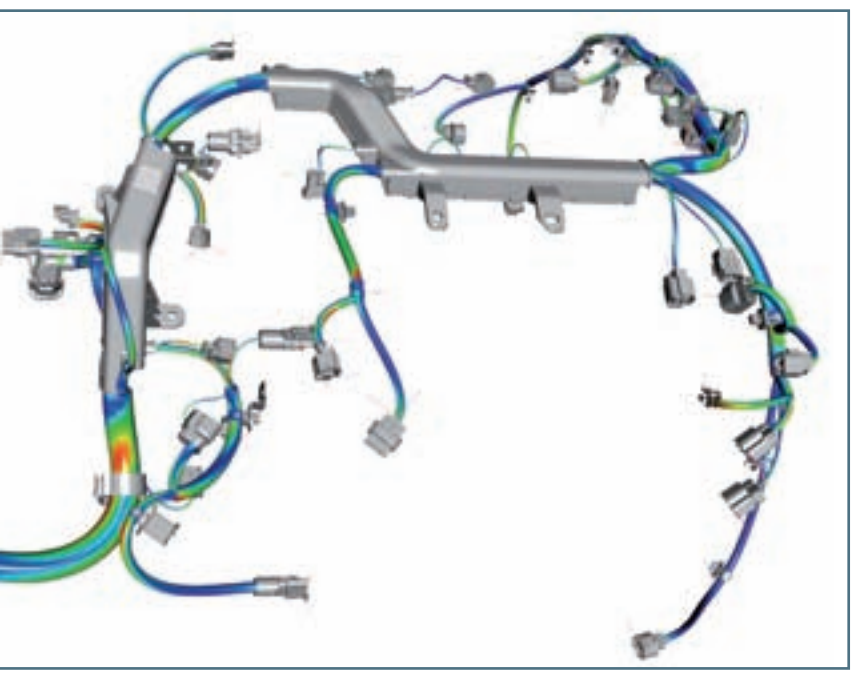
What stress loading will the hoses on the paint spraying robot have to withstand? Will the jerky movements of the robotic arm abrade the cables? Will the robot run over its power cable when moving to the next car body? How long do an excavator's hydraulic hoses need to be so that they do not rub against the bodywork but are not subjected to excessive mechanical strain when the boom extends? "Such questions used to be almost impossible to answer," states Dr. Joachim Linn from the Fraunhofer Institute for Industrial Mathematics ITWM. "Simulation models using virtual and augmented reality merely visualize assumed movements in the geometry of the cables and hoses without taking into account their material properties such as tensile rigidity, pliability and torsional rigidity. With such purely geometric modeling, however, it is impossible to correctly calculate the movement and deformation of the cable and hose structures in physical detail and thus predict them realistically." But these physical properties are enormously important. If the movements of the robot's paint spraying hose cause it to crack and have to be replaced, the entire production line can come to a standstill. A worn power cable can have similar consequences. A leak in the hydraulic hose of an excavator can mean expensive repair work. The German-Swedish research team is aiming to highlight such problems before they occur.

For six years Linn and his colleagues at ITWM have been working together with mathematicians from Gothenburg. At the Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC they are jointly developing a new generation of simulation tools. Almost a thousand kilometers separates Kaiserslautern and Gothenburg but the cooperation is extremely good. Two or three times a year the Fraunhofer research scientists fly to Sweden and in between the Swedish colleagues make trips to Kaiserslautern. The meetings usually start with a visit to a restaurant the evening before, where the latest scientific results are discussed. "The relationship is friendly, the cooperation intense," reports Linn. "As it is when you have known each other for some time."

Advanced mathematics for excavators, robots and the like

The FCC was established ten years ago as a joint venture between the Fraunhofer-Gesellschaft and Chalmers University. "The idea behind this cooperation was to make mathematics usable for industrial applications," recalls Dr. Uno Nävert, Director of the FCC. "All technical developments are rooted in mathematics. Our task is to apply it to the simulation and optimization of products and processes – for planning production plant and assembly tools, designing ergonomic workplaces, calculating how best to cut gemstones and modeling metabolic processes in living cells."

Over the years the FCC has blossomed into a sizable institute with about forty staff, located in the Technology Park on the campus of Chalmers University. This is a good address to have: The University is a recognized center of engineering science in Scandinavia, with a tradition of applied research, so Nävert and his team have never had to complain about a lack of demand for their work. Major companies such as Saab and Volvo followed the development of the new simulation tools with interest and have implemented them successfully.



Fraunhofer-Chalmers Research Centre for Industrial Mathematics (FCC), Göteborg

In August 2001 the Fraunhofer-Gesellschaft and Chalmers University in Gothenburg established the Fraunhofer-Chalmers Research Centre for Industrial Mathematics FCC, which cooperates closely with ITWM in Kaiserslautern. The activities of the FCC focus on geometry, motion planning and multi-physical simulation, including flow dynamics and electromagnetics. In addition, the FCC engages in the modeling and simulation of biological systems. The work concentrates on problems arising in the design of innovative products and the virtual assembly of product parts. To check reliability, variation and quality, the research scientists develop modeling methods and calculation techniques from process data processing, bioinformatics and mathematical statistics.

www.fcc.chalmers.se

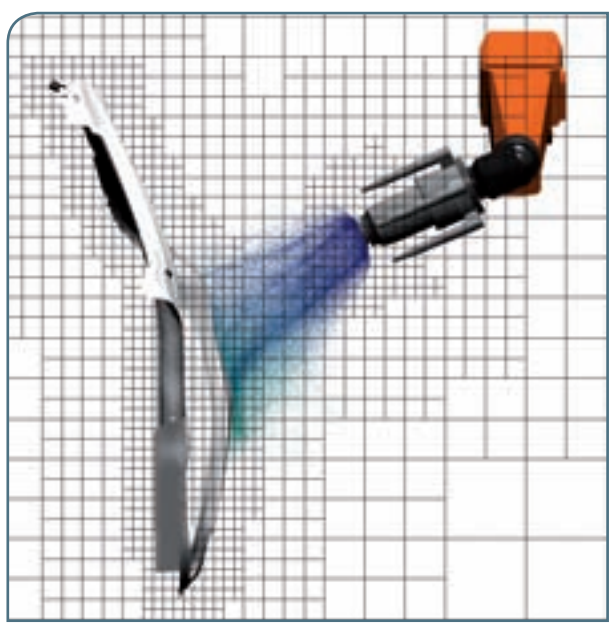
"We are now able to combine the high calculation speed of geometric simulation methods with corrective physical models from non-linear structural mechanics. Using our interactive and intuitive simulation software we can therefore precisely predict whether a hydraulic hose on an excavator boom will wear when digging a trench, whether the hoses on a robot will be subjected to excessive strain or whether a new instrument panel is flexible enough to be assembled manually," explains Linn. "Our answers to all these questions come very close to reality, and they are provided in real time." Not only in Sweden but also in Germany, car manufacturers are using the combined software tool to plan production processes, for example the installation of cable looms and the assembly of passenger compartments, including instruments, headlining and floor mats.

A new tool brings machines on a collision-avoidance course

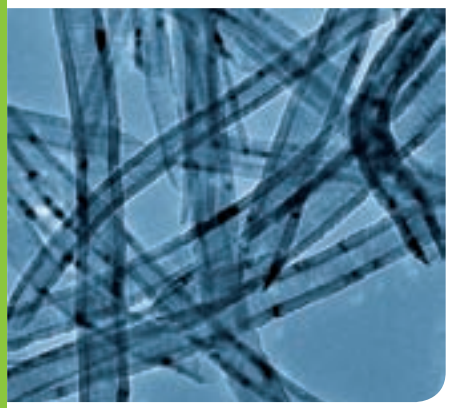
The new Swedish-German simulation tools can do even more. "One problem that remained unsolved for a long time was how to avoid collisions," states Linn. "Conventional simulation methods show what a production line will look like, where the machines will be located and what they will do. But they do not reveal what will happen when robots travel backwards and forwards or when robotic arms move in different directions at lightning speed when welding, drilling or paint spraying." To avoid collisions, the interdisciplinary and international team of research scientists developed the Motion Planning Tool, which is now being used by Volvo, Saab and ABB.

The next step is to simulate dynamic factory operation. Cables and hoses, the soft parts of a robot, move and are deformed when inertial forces act on them. Dynamic strain, for example, causes hoses to wear more quickly. Inertial forces also influence movement behavior. For instance, supply cables that hang relatively slack when the robot is moving slowly can knock against an adjacent machine or wall during operation at higher speed. In order to calculate such dynamic effects, the research scientists have developed an expanded simulation model, which is currently being integrated in the simulation software.

"It was a major challenge to simulate the mechanical properties of components and how they change under load," Nävert states, adding: "Our next objective is to automate and optimize the complete operation of a factory using purely mathematical methods. This will include process steps for painting and treating surfaces. Our software can, for example, be used to simulate robot-based paint spraying. The methodical basis for this is provided by new approaches to modeling, algorithms and calculation methods for multi-physical simulation. The latest component is a mathematical model of a factory worker with which we can study the ergonomics of workplaces." ■



Paint spraying the car body is the key process in the paint shop and at the same time the most demanding process in terms of modeling. The software enables all geometries to be painted.
© Volvo Car Corporation



Thick carbon nanotubes as seen through an electron microscope.
© *Fraunhofer ITEM*

Carbon nanotubes put to the test

Contact: Karola Neubert
karola.neubert@item.fraunhofer.de

Carbon nanotubes (CNTs) are of great interest for the manufacture of various products. As well as being light, they offer extremely high tensile strength and very high electrical conductivity. Tests have provided indications, however, that certain nanotubes could be as carcinogenic as asbestos fibers. The German Federal Ministry of Education and Research (BMBF) is funding the CarboTox research alliance for three years, aimed at developing a screening process that should enable early detection of a possibly carcinogenic potential. This alliance is made up of the Fraunhofer Institute for Toxicology and Experimental Medicine ITEM in Hannover, the Leibniz Institute for Solid State and Materials Research in Dreseden and Bayer MaterialScience AG in Leverkusen.

The aim is to use this screening process to identify toxicologically harmless CNTs in the development of new materials and to sideline harmful products and manufacturing processes at an early stage.

Test laboratory for solar power plants

Contact: Karin Schneider, karin.schneider@ise.fraunhofer.de

Solar power plants are increasingly helping to stabilize the power grid. Large photovoltaic facilities are now expected to meet similar requirements to conventional power plants. For instance, solar power inverters, which convert direct current into alternating current, can feed in additional output at specific times to support the grid. And brief fluctuations in grid voltage must not be allowed to cause the facilities to shut down.

The Fraunhofer Institute for Solar Energy Systems ISE has opened a megawatt laboratory in Freiburg for photovoltaic power inverters. It is the first and currently the only laboratory in Europe that enables manufacturers to test solar power inverters with an output of up to one megawatt in accordance with certification rules. A discrete connection to the 20-kV grid is provided via three medium-voltage transformers . In the laboratory a high-power solar generator simulator takes the place of a field of solar panels covering an area of up to two hectares.

To test the behavior of power inverters during brief outages, a testing unit connected at the 20-kV medium voltage level is used to induce real voltage dips without disrupting the public power grid.

The magawatt laboratory is the only lab in Europe enabeliing manufactures to test solar power inverters.
© *Fraunhofer ISE*

Water monitoring in real time

Contact: Dr. Thomas Bernard, thomas.bernard@iosb.fraunhofer.de; Dr. Iris Trick, iris.trick@igb.fraunhofer.de

Drinking water quality is strictly monitored, but only with regular random checks. Research scientists in the AquaBioTox project have developed a system that can monitor drinking water constantly in real time and warn of toxic substances in just minutes. The key aspect of the system is that the water is “tasted” by a biosensor. A sample of the drinking water is siphoned off and passed through the sensor, which contains bacteria and mammalian cells that produce a fluorescent protein. If they come into contact with toxic substances their fluorescence changes. The bacteria react within minutes, the mammalian cells are more closely related to the human body and make the result safer.

The biological sensor was developed by scientists at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart. The associated camera system with analysis unit is from the Karlsruhe-based Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB. The Berlin public water utility and bbe Moldaenke GmbH are also involved in the project .

When facades turn into foil

Buildings with plastic-cushioned facades project real eye-appeal. German companies lead the way in this technology, but there are only about a dozen specialist firms with the necessary expertise. Six Fraunhofer institutes have teamed up in a research project with the aim of optimizing the membrane structures.

Text: Tim Schröder

Can you imagine cladding the roof and walls of your house with plastic? Perhaps you can't, but actually buildings covered in plastic foil have been all the rage for quite some time. The Beijing National Aquatics Center, home to the 2008 Olympic swimming competitions, and the Allianz Arena in Munich are just two examples of what architects can do today with sheets of plastic. The material of which the airy structures are made is ethylene tetrafluoroethylene, ETFE for short. It can be used to produce robust and durable plastic foils which are translucent and permeable to UV light. ETFE is therefore the ideal material for light and airy architecture.

From the greenhouse to a new type of architecture

ETFE has been an established product on the plastics market for several decades, mainly used to make sturdy lightweight roofs for animal enclosures and tropical greenhouses. But for a long time the material rather lived in the shadow of other plastics and robust opaque membranes. This all changed in 2001 with the Eden Project, a cluster of futuristic greenhouse domes in South West England, and also with the construction of the equally striking Allianz Arena. The structures took the architectural community by storm, and since then the material has enjoyed growing popularity worldwide. German foil manufacturers and membrane processors play a leading international role, with about a dozen companies in the country possessing the necessary specialist knowledge. Given the worldwide enthusiasm for the transparent construction material, three years ago six Fraunhofer institutes decided to inject some impetus into the German ETFE market. They launched an initiative to make the requisite expertise available to numerous other companies in a cooperation project bearing the name Multifunctional Membrane Cushion Constructions. With the aim of further optimizing ETFE construction technology, the project focuses on membranes which are processed to form cushions and inflated with compressed air.

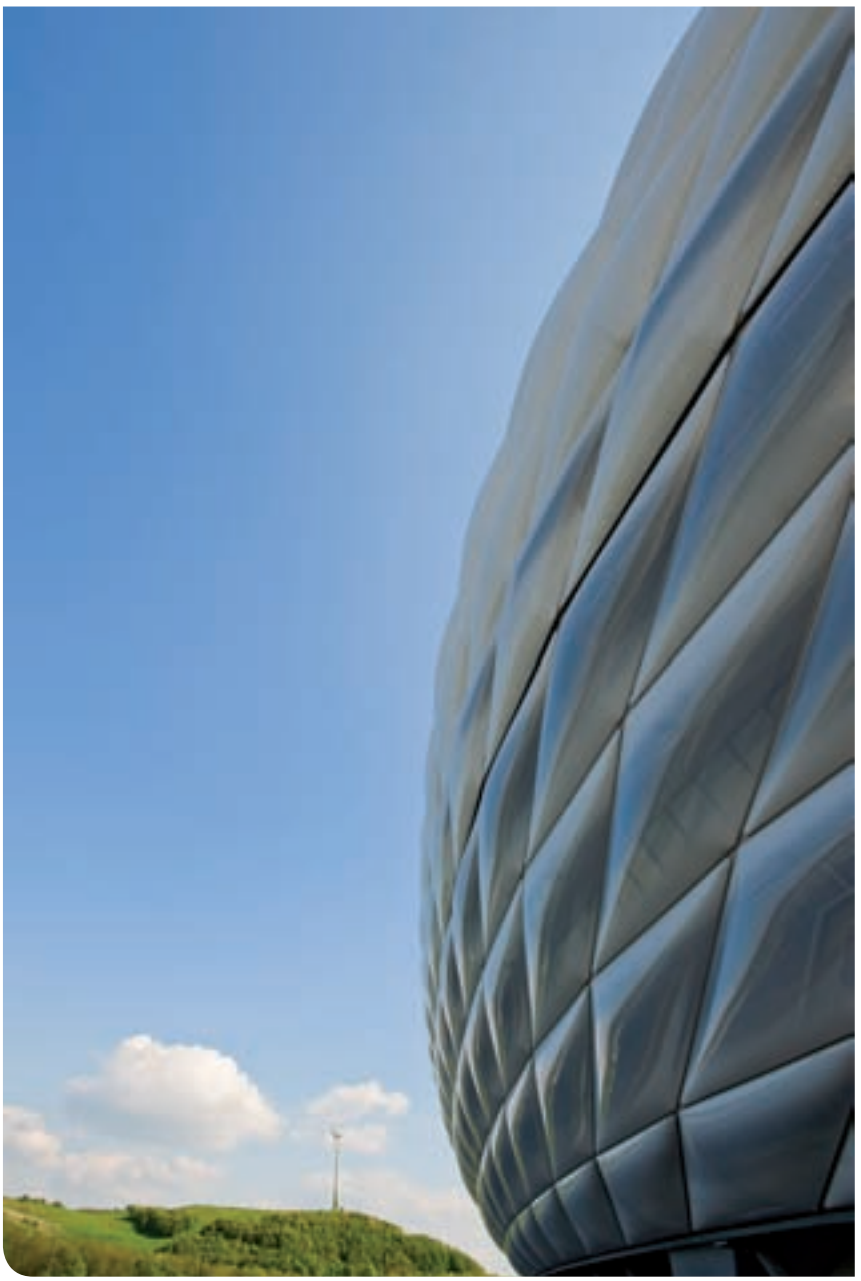
Although the material has been around for a long time, the Fraunhofer research scientists see plenty of potential for improving how it is used in large-scale applications. For instance, heat passes through the ETFE foil relatively easily. As a result, buildings can heat up like a greenhouse in the summer, while they lose heat in winter and on clear nights. "The heat retention capacity depends entirely on the outside conditions," says project coordinator Andreas Kaufmann of the Fraunhofer Institute for Building Physics IBP in Stuttgart. "Especially when a wind blows over the membrane, heat is lost. Weather conditions have a direct impact on the passage of heat through the cushions and therefore affect comfort." The research scientists found that no binding standards exist for measuring and assessing the thermal behavior of the curved membrane panels. Two large measurement systems were therefore built at IBP – a tunnel the size of a tennis court with an ETFE cushion roof and a tower the height of a house covered in two layers of ETFE. Kaufmann and his colleagues are currently working on a swivel-mounted measurement device as big as a garage which will automatically follow the position of the sun. Measurements were already being performed at IBP before the cooperation got underway. On the basis of the data collected, the IBP research scientists have developed their construction planning software so that the thermal behavior of a membrane cushion structure can be simulated for the first time. The system also takes into account whether parts of the structure will cool down to such an extent that condensation will form. This is a problem because it can lead to corrosion of load-bearing structures made of metal and rotting of wooden roof beams.

Moisture does not just attack the roof structure, however, it also promotes the growth of microorganisms. In the joint project experts from the Fraunhofer Institute for Silicate Research ISC in Würzburg have for this reason developed an antimicrobial ceramic paint coating which combats the growth of the Aspergillus niger mould as well as bacteria and yeast fungi, which form ugly black patches. In cooperation with the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising a pilot plant has now been built for the bulk coating of ETFE foil. Also, IVV has developed a method for coating the foil with aluminum to reflect thermal radiation. This layer reduces both overheating of buildings and heat loss, whilst being thin enough for the foil to remain transparent. ETFE is related to Teflon non-stick material and hardly shows any chemical reaction with other substances. Before being coated the foil's surface therefore has to be chemically pretreated or activated. Then the aluminum is applied by vacuum vapor deposition. To prevent it from corroding, the aluminum is also covered with a very thin coat of lacque. The IVV research scientists have demonstrated that the layers adhere to the membrane in a stable bond which does not spall. The intention now is to further optimize the coating process with partners from industry.

Pillows that can change color permit shading

The cooperation partners from the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg have also developed a coating which changes the light and heat permeability of the ETFE foil. Like photochromic sunglasses, the ETFE foil can be darkened thanks to a tungsten trioxide coating. If hydrogen is pumped into the ETFE cushion, the coating turns dark blue. If oxygen is pumped in, the cushion turns clear again. The tungsten trioxide coating has been shown to reduce the light permeability of the foil by a factor of 10 – providing ideal solar shading during summer.

Although ETFE has been used on buildings for years, there are still considerable problems to be overcome. Little is known, for instance, about whether and to what extent the foils change over the course of time under permanent internal pressure or with the effects of wind



The Allianz Arena sparked the enthusiasm for membrane architecture. © alimdi.net/ Günter Lenz

and snow. Up to now the mechanical properties have been examined in simple tensile tests, in which strips of foil are clamped into a testing machine and pulled lengthwise until they are torn apart. However, as Jörg Lucas of the Fraunhofer Institute for Mechanics of Materials IWM in Halle explains: "These tests don't recreate the conditions the material has to endure in actual use, where the forces act in several directions." Lucas and his colleagues have therefore studied the ETFE foil in a testing device which simulates the stresses and strains encountered on a daily basis. The results are clear. The ETFE cushions may stretch over the course of time. On a building such as the Allianz Arena, where the cushions are not enclosed, that is not a critical factor. "Often, however, the cushions are installed close to other building structures, and that could lead to problems," states Lucas – for instance on roofs which can be opened and closed. Here the cushions could tear. IWM has been approved by the German Institute for Construction Technology (DIBt) as a certified testing body for membrane materials. What's more, the institute is developing new welding techniques for ETFE membranes.

"We believe that ETFE will develop a strong market of its own," says Robert Hodann, Managing Director of foil manufacturer Nowofol and industrial partner of the research project. "The transparency and high strength of ETFE foil are particularly impressive – much better than any other plastic membrane." In the future it will be possible, for example, to construct LED facades using ETFE foil to cover thousands of light-emitting diodes. House walls could thus be converted into huge video screens.

Specialists at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Bremen are working to make this vision a reality. They have developed several adhesive-bonding techniques for ETFE foil – which, given the non-stick character of the material, is quite a challenge. Among these, the hot-melt technique has proved particularly reliable, and a prototype plant has been installed at IFAM which bonds the foils so firmly together that they can even withstand the tensile tests conducted by the colleagues in Halle. ■

Fraunhofer Building Innovation Alliance:

Two years ago the Fraunhofer-Gesellschaft created the Fraunhofer Building Innovation Alliance to pool the expertise of 16 institutes. The objective of the Alliance is to address important construction research issues completely within the Fraunhofer-Gesellschaft. The Alliance is an interdisciplinary partnership forming an interface between industry, research and politics. Its main focus is on sustainability, conservation of natural resources and the health compatibility of buildings. In addition, the research scientists are working to optimize products, systems and processes. The six institutes involved in the Multifunctional Membrane Cushion Constructions project are also members of the Alliance. In future the joint project will be conducted as the Membrane Construction Cluster.

Attractive heat storage solutions

In the years ahead, solar thermal power plants will be able to supply electricity even at night - thanks to an innovative hydride-carbon composite material created by Dr. Lars Röntzsch and his working group, supported by the 'Fraunhofer Attract' program.

Text: Bernd Müller

Scientists around the world are working on storage media for energy – so that photovoltaic power stations, for example, can supply electricity even when the sun is not shining. But solar thermal power plants, like those the DESERTEC consortium intends to build in the Sahara, work in a rather different way. They use concentrated sunlight to heat a liquid that, via a heat exchanger, produces steam to drive a turbine. So the big question is: How can they operate at night? The idea is that they will then discharge heat from a storage unit that has been charged up during the day.

There is a good chance that such storage units will one day be based on a storage material developed by Dr. Lars Röntzsch and his team of co-workers at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Dresden. In cooperation with the Fuel Cell Research Center ZBT GmbH in Duisburg, this working group works on nanostructured metal hydrides that can be used to oscillate a chemical process to store large amounts of heat in confined space. Energy suppliers are clearly impressed with the performance that can now be achieved with the new storage method, and none more so than E.ON. In September 2010, the joint endeavor was bestowed with the coveted E.ON Research Award, which boasts an endowment of 660,000 euros over a three-year period.

The highly promising project owes its very existence to the Fraunhofer Attract program – and a little bit of luck. Dr. Röntzsch, who studied physics in Dresden and Boston before completing his doctorate, became acquainted with Professor Bernd Kieback, head of the Dresden branch lab of the IFAM, in 2007, just as the first call for applications for the Attract program was announced. Through this program, as the name suggests, the Fraunhofer-Gesellschaft seeks to attract young scientists with new research ideas, and gives them the opportunity to form their own working group. Together, Röntzsch and Kieback drafted a research proposal and submitted an application to work on 'Hydrogen Storage in Nanostructured Materials'. Röntzsch admits: "I was lucky that the Attract program had just been launched, and that our ideas really dovetailed with what they were looking for."

For the last three years, Dr. Röntzsch and his working group at the Dresden branch of the IFAM have been researching metal hydride materials. These can be used to store heat, among other things. Over the next two years, the group intends to develop storage tank demonstrator models which will be used as the basis for industrial implementation. The heat storage concept that so impressed E.ON involves two tanks filled with different metal hydrides, between which hydrogen flows back and forth – "rather like a seesaw effect," explains Röntzsch. No hydrogen is consumed, the circuit is closed. The hydrogen simply serves to trigger hydrogenation and dehydrogenation reactions in the two metal hydrides in an alternating day/night cycle.

Special magnesium alloy hydride

The first material is the hydride of a special magnesium alloy, which becomes totally dehydrogenated during the day at temperatures of between 350 and 400 degrees Celsius, using

up the concentrated solar energy. The hydrogen that is released in this dehydrogenation process flows into the second tank. It contains a hydride-forming alloy of various transition metals that stores hydrogen safely at room temperature in confined space. At night, the hydrogen flows back in the direction it came from. Once it has been released, still at room temperature, it reacts with the magnesium alloy once again. The resultant reaction heat is released between 350 and 400 degrees Celsius, and is sufficient to ensure continuous steam production in the power station until the sun rises again the following day. There are many teams of researchers working on metal hydrides

In future, new storage units should help make better use of the energy collected by solar thermal power stations. © *siemens*

all around the world, and competition is fierce, even in Germany. But the system developed in Dresden offers clear advantages over other concepts. Its secret lies in the production of the nanometals involved: Where rivals use complex milling techniques, the team at the IFAM in Dresden has opted for a process known as 'melt spinning', in which the molten metal alloy is dripped onto a cooled, rotating copper cylinder and solidifies extremely quickly. This process can be used to create several metric tons of the alloy every hour. "Industrial implementation is important, and ultimately that's what Fraunhofer does," says Röntzsch. One major advantage of melt spinning is the tiny crystals which form during the 'shock freezing' process. These are only a few tens of nanometers in dimension and their size can easily be controlled during production. Diffusion causes the hydrogen to penetrate the spaces between the crystallites at a tremendous rate: Depending on the size of the crystals, the hydride material becomes completely saturated within minutes, or at most hours, prompting its chemical reaction with the hydrogen. In pure form, however, hydrides have the major disadvantage of being poor heat conductors. The IFAM researchers get round this problem by mixing small quantities of graphite (an extremely efficient conductor) into the hydride. Their storage capacity is impressive, too: Approximately 100 grams of hydrogen fit into a 1-liter metal cube. Although this doesn't sound like much, it represents a huge step forward, as evidenced by comparison with the Andasol I solar thermal power station in southern Spain. Andasol I generates 50 megawatts of electricity and, for the last two years or so, has been equipped with heat storage units containing a massive 57,000 metric tons of liquid nitrate salt. This salt enables the plant to generate sufficient heat at night for the turbines. By contrast, a comparable metal hydride storage unit produced by the IFAM would easily fit into the space of a single-family home.

Storing heat from car engines

Automobiles, too, could benefit from this high energy density. Heat from the engine could be stored and utilized in a heat booster that would warm the engine and interior within seconds in the winter – without consuming any fuel as conventional independent vehicle heaters do. But that's not all: Not only can metal hydride units be used to store up heat, they can also be used for hydrogen storage – for example in electric vehicles powered by fuel cells. Such vehicles are currently being fitted with pressure tanks that are filled to 700 bar yet contain only 39 grams of hydrogen per liter. The IFAM solution almost trebles the amount of hydrogen stored in the same physical space. Although heat is of course needed to extract the hydrogen from a metal hydride, this poses no real problem in a fuel cell-powered vehicle, since around 45 percent of the energy it consumes is generally lost as heat.

The funding for all Attract projects is reduced after the first two years, to encourage the scientists to seek alternative sources of money to finance their work independently when the five-year endowment grant comes to an end. This is unlikely to pose a problem for Dr. Röntzsch and his working group. Supported by the E.ON award, by other projects financed through third-party funding, and by close cooperation with Dresden's University of Technology, Dr. Röntzsch is in no foreseeable danger of having to cut his present payroll of six full-time and six student auxiliary team members. "We've made good progress," says Röntzsch, "and I definitely want to keep working in this field of research." ■

New record for electric car

Vehicles that run on electricity have to be both lightweight and safe. Researchers have developed an innovative framework comprised of aluminum. A single charge of its battery enables the car called “Schluckspecht E ” to traverse more than 600 kilometers.

Text: Brigitte Röthlein

Researchers at the Freiburg-based Fraunhofer Institute for Short-Term Dynamics, Ernst Mach Institute EMI and students and professors at the University of Applied Sciences in Offenburg are not used to standing in the limelight of public attention. They normally conduct their work in laboratories or at computers. Last October, the “Schluckspecht E” meaning “Thrifty E” took part in the South African Solar Challenge. Staged by the Federation Internationale de l’Automobile FIA, the Challenge featured a course covering the 1443 kilometers – and more than 1,000 meters of elevation –between Pretoria and Durban and back. The researchers managed to set a new record with their prototype vehicle “Schluckspecht E”. Confirmed by FIA and cheered on by the spectators, the vehicle traversed 626.6 kilometers of public roads on a single charge of its battery.

Led by Professor Ulrich Hochberg, teams at the University of Applied Sciences in Offenburg had been working for more than ten years on a series of experimental vehicles, each bearing the name “Schluckpecht”. In 2009, the university’ researchers launched a working relationship with scientists at EMI. One of the institute’s research thrusts is automotive safety. The researchers and scientists joined to build the Schluckspecht E. This electrical automobile weighs only 326 kilograms and is certified for limited use on public thoroughfares. The vehicle’s propulsion system is comprised of hub motors placed on the rear axles. Their power comes from 2184 lithium ion battery cells arrayed into twelve modules. These are placed into two lines. The main objective of this vehicle is saving weight. The fact that the batteries are relatively heavy – 126 kilograms – means that the structure of the automobile has to be as lightweight as possible – and has to offer the driver, at the same time, the greatest possible security. “We decided to go with a bow string structure, which works like a suspension bridge. Arched sheets bear the batteries and the driver in the same way that the bridge’s structure carries the roadway,” states Frank Huberth, the head of the project’s work at EMI. “Made from aluminum, the longitudinal sheets convey the weight to the chassis. This is a combination of the principles deployed in bridge-building and aluminum-based light gauge systems.”

The structure is surrounded by a material made out of fiber-reinforced woven plastics and a honeycomb structure serving

The Schluckpecht E making its record-setting voyage in South Africa
© *Fraunhofer EMI*

as the chassis. "The design is based upon the principle of relying upon composite materials. This stems from aviation," explains the engineer. "This sector has been for a long time incorporating such materials and light gauge metals to pare weight. This sector was also where the shell-string construction method was developed of which we have been availing ourselves."

Crash tests and numerical simulation

One of the Schluckspecht's most extraordinary and innovative features is the distribution of its battery blocs: most E-mobiles place them behind the seat or in the vehicle's front, where conventional cars generally have their internal combustion motors. Not the Schluckspecht E. Its batteries are arrayed in two long chests – one on each side of the driver – in the so-called "longitudinal beams". This arrangement yields an optimal balancing of weight. How safe is the car? Since no structure had yet been developed for testing, Frank Huberth and his team put the batteries through crash tests and through numerical simulations of the vehicle's behavior in such situations.

"The critical load case stems from a crash from the side," explains Huberth, adding, "that's why that was the first thing we precisely investigated." To be determined is how batteries – both on individual and bloc bases – respond, and whether or not the driver would be endangered by a crash from the side. The cells contain a large amount of energy – theoretically 20 times as much per volume unit of active materials as TNT. The good news is that, in contrast to this high explosive, the cells are not capable of releasing their energy within split seconds, but rather over considerably longer periods of time. This even applies to crashes. This peril is thus controllable, but should not be underestimated. The researchers were made aware of this fact when it came time to load their batteries on board the airplane taking them to South Africa and the attempt to break the record. "While doing such, we had to fulfill the high international standards of operating security placed on hazardous goods being air-freighted," relates Jörg Lienhard, who is studying engineering, and who was responsible for running the technical side of the expedition. "The project very nearly came to grief at the last moment because of this."

Tough trials in the laboratory

The tests conducted by the researchers in EMI's laboratory started with the using of nails to pierce a variety of models of lithium ion cells. They then observed what happened. It turned out that even structurally-identical cells showed a great variety of responses. Some experienced only minor losses of electrolytes; others, larger amounts. Temperatures of more than 300 °C were reached and gases were expelled. The analysis of the latter revealed that the gases were a variety of hydrocarbons, sulfur compounds and traces of hazardous hydrogen fluorides. Also found in the absorber materials in the test chamber were small amounts of acids. These results showed the need to protect vehicle passengers from such a case.

And what happens when the entire battery modules are rammed from the side by a wedge-shaped stake? "All of the cells remained undamaged, only the cell bloc structure didn't do its job," reports Huberth, who ran the tests. "The advantage of this special-purpose design is that it enables battery cells to evade a crash by relocating into open areas."

The Schluckpecht E is a one-of-a-kind prototype. As such, the whole vehicle could not be subjected to a crash test. To make up for this, the researchers used their computers to simulate such a test – a procedure that it is nowadays used by all car manufacturers to save time and costs. And saving time was also of the essence in the Schluckpecht E project, as only three months remained until the Schluckspechts's start in South Africa. For that reason, the researchers decided to go with a simplified model. They treated the batteries as being homogenous cuboids whose mechanical properties were adapted to account for the data from experiments. By doing such, modeling-related expenditure and computer time were reduced.

www.schluckspecht.net

The results of these procedures revealed a strong deformation the battery module in the area that was struck by the stake, but that the protective casing did withstand it. "In case of a collision, a damaging of the cells can not be excluded," summarizes Huberth, "but margins of safety still exist for passengers." One way of optimizing this system is by incorporating T-profiles into the exterior covering of the vehicle. These locally-placed reinforcements would serve to brace the vehicle longitudinally and laterally. The increase in crash protection and thus passenger safety would come at a moderate addition of weight. The researchers working on the Schluckpecht E want to take closer looks at all these topics. The procedure using numerical simulation provides them with a way of researching a larger variety of models, of structures and of arrays of batteries in the underbody of the vehicle.

What remains with them and what motivates them are, the stress notwithstanding, are the positive memories of the setting of the world record: Miss South Africa's conferring upon them the prize, champagne, and, especially, the enthusiasm shown by the spectators lining the race course. ■

Cooperation with Indonesia

During a trip to South-East Asia Fraunhofer-President Prof. Hans-Jörg Bullinger signed a Memorandum of Understanding with Indonesia. The document states the decision of close cooperation between the Fraunhofer institutes and the Indonesian Agency for the Assessment and Application of Technology (BPPT). The focus of the cooperation will be bioindustry, renewable energy, production and materials, and traffic and transportation technology.

On the same occasion a cooperation agreement between the Indonesian Bioindustri-Deputy Technology Centre Agro Technology and Biotechnology and the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT was signed. Both institutions plan a project on Integrated Production of bio-based Fuels, Products and Chemicals in a multi-feedstock process. The goal is to develop an integrated concept consisting of a combination of several integrated processes for the full utilization of several crops. Those integrated processes will produce energy, chemicals, fuels and materials for technical applications. The project will show the feasibility in terms of technical, economic, ecological and social aspects.

Mobile lab starts rolling

To reach groups at risk of HIV-1 infection and tuberculosis in rural areas of developing countries represents an enormous challenge in view of the lack of medical support infrastructure. For these groups basic medical care, medical consultations or medical diagnostic care as well as sampling hardly exist and often are completely absent. However HIV-tuberculosis co-infections and resistant tuberculosis (TB) pose an increasing risk, for which adapted and optimized diagnostic and therapeutic approaches are imperative. Therefore, there is an urgent need for mobile and self-sufficient facilities, preferably including a biosafety level 3 laboratory (BSL-3) fully equipped with diagnostic and cryo-storage facilities.

In the South African province of Western Cape such a mobile lab starts operating now. It was supported by the German Consulate in Cape Town. The project is based on a public-private partnership between the Western Cape Department of Health, the University of Stellenbosch, the Npational Health Laboratory Service and the Fraunhofer Institute for Biomedical Engineering IBMT.

Since suitably adapted vehicles barely exist anywhere in the world, the Fraunhofer Institute for Biomedical Engineering IBMT has developed a mobile laboratory that conformes to with German standards for mobile laboratory units and the Infection Protection Act (IfSG) at their location in Sulzbach/Saar together with a company specializing in the production of special-purpose vehicles (Bischoff & Scheck Fahrzeugtechnik GmbH & Co. KG).

A medically equipped admission and treatment unit offers the doctor and his nurse as well as his patients comfortable and suitable surroundings. The samples taken will be analyzed in the BSL-3 laboratory unit which is accessible through a hermetic gate, thus guaranteeing gradual negative pressure between all rooms.

The basic equipment of the laboratory is designed to treat HIV and TB patients. However, the setup of the systems is designed for easy interchange of devices as required and deemed necessary. An expansion to malaria or other germs is possible.

"The mobile laboratory will finally give our people in rural areas, especially those working in agriculture, access to a facility that up till now they had to travel to Cape Town for. Beneficiaries will be now tested in their region, receive the results on the same day and be referred for treatment. In the long term, this also means that up-to-date statistics on the status of the people of the Western Cape will be at our fingertips. This mobile unit, together with the world-class equipment that we have in Health Services, will also be able to assist in cases of outbreaks such as H1N1", states Theuns Botha, Western Cape Minister of Health.

The mobile laboratory containing all the equipment was shipped from the port of Hamburg to South Africa. © *Fraunhofer*

Joint research for future aeronautics

Less noise, less exhaust, less refuse – air travel of the future is expected to be environmentally friendly. To reach that goal researcher are closely collaborating in the EU Project Clean Sky coordinated by the Fraunhofer Institute for Building Physics IBP in Holzkirchen. In future the Fraunhofer researchers will also cooperate with the British BRE Group. Just recently the research establishments have determined the key points of their future cooperation in a Memorandum of Understanding. Within the coming months a joint Governing Board will produce an Operations Agreement, which will set out in detail the rules for collaborative activities.

"At both research establishments we have frontline experts, therefore we are happy to cooperate with BRE", said Prof. Dr. Ulrich Buller, Senior Vice President Research Planning, Legal Affairs of the Fraunhofer-Gesellschaft, at the signing of the Memorandum of Understanding in Munich. Prof. Dr. Gerd Hauser, head of Fraunhofer IBP, confirms: »As BRE is a strong partner this Memorandum of Understanding is very important to us."

The goal is to create a new kind of research community to face the new international demands in applied research engineering. Besides environmental issues a stronger return to people and their individual needs will increasingly influence future research. One response to that shall be to focus on human centered engineering. The collaboration agenda includes aeronautics space and defence, communication and information technology, low energy buildings and renewable energy systems and health and environment issues.

In the Fraunhofer test facility researchers can simulate the climatic conditions during a flight.
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Advice for Korea

Prof. Hans-Jörg Bullinger, president of the Fraunhofer Gesellschaft, is now an official adviser of the Korean Ministry of Knowledge Economy. Only recently the Ministry has founded an Office of Strategic R&D Planning. The goal is to integrate industry into the national research and development planning. The Head of the office is Dr. Chang Gyu Hwang , the former CTO and Vice President of Samsung Electronics. To get a second opinion on the national planning the office has founded a new advisory board with foreign experts, among them the president of Fraunhofer.

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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:
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Monika Weiner (Senior Editor)
Janine Drexler, Stefanie Heyduck, Marion Horn, Beate Koch, Birgit Niesing, Isolde Rötzer, Britta Widmann, Christa Schraivogel (Photography and production),

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