Fraunhofer magazine

2/15 special issue

Toward a sustainable future

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Prof. Dr. Reimund Neugebauer. © *Stefanie Aumiller*

Mission: Future

We live in a time of great challenges. By the year 2050, the world's population will have surpassed nine billion. The resulting increase in demand for water, food, raw materials and energy will be exacerbated by the ever-increasing scarcity of key resources such as crude oil and rare earths. Ensuring that we can provide future generations with food and products means we have to be more responsible about how we manage resources. We must develop sustainable production processes and better utilize renewable raw materials and energy sources. Research and development is already laying the groundwork. As Europe's leading applied research organization, the Fraunhofer-Gesellschaft is living up to its responsibility to secure our future by providing sustainable solutions. We were the first of Germany's four major non university research institutions to publish a sustainability report for our organization.

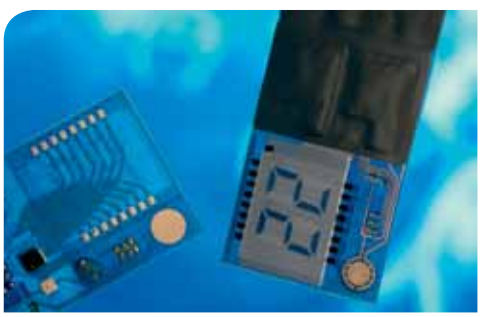
But what exactly do we mean by sustainability?
Hans Carl von Carlowitz coined the German term "Nachhaltigkeit" back in 1713 in his book "Sylvicultura oeconomica." As far back as three hundred years ago, he was campaigning for people to cut down only as many trees as could be replaced by organized reforestation. A key reason for his plea was that wood, a crucial raw material, was on the verge of becoming scarce.

In a research organization such as Fraunhofer, there are many aspects of sustainability. Our scientists are working on all kinds of solutions for managing ever-dwindling resources in a more responsible way. You can read about several of our projects here, both in our lead article and throughout this issue. Find out how wood can substitute for the finite resource crude oil in the chemical industry, which new technologies are being developed to use renewables efficiently, and how phosphate can be reclaimed from waste water.

Our job is also to improve the sustainability of research practices and to use available resources responsibly ourselves. That's why it's important to find many more levels on which to network basic and applied research with industry. With this goal in mind, Fraunhofer plans to set up national centers of excellence. Such collaborative ventures are a way to make the most of available funding. We are also placing even more emphasis on interdisciplinary collaboration within Fraunhofer, too. In the spirit of networking across institutes and focusing our efforts on the needs of industry, we have launched a series of lead projects, one of which is E^3 Production. Here, our researchers are working closely with industry partners to explore how the flow of resources, energy and information can be connected and controlled to create an efficient, emissions-neutral and ergonomic factory.

Since the Fraunhofer-Gesellschaft plans to continue providing excellent research results in the future, we will continue to rely on our well-qualified, creative and motivated employees as well as well-educated young talent. Fraunhofer takes an active role in a variety of projects aimed at getting young people to get excited about research and technology. We also depend on attracting sufficient funding – only then can we carry out the preparatory research needed to develop the technologies, methods and processes that appeal to industry and can be translated into innovations.

Applied research becomes sustainable when industry adopts our R&D results so that our work benefits society. This is one of our goals for the coming years, as is working hard on Mission: Future. The work we do will help shape the solutions we need to master the great challenges of our time.



Content

Anti-ice protection

Aircraft, ships, trains, automobiles, cooling units and wind turbines all have surfaces that are susceptible to the build-up of ice. Such icy coatings often pose a safety risk and incur additional costs due to increased energy consumption or downtimes.

This has led experts to work intensively on finding even better technological solutions for preventing the formation and adhesion of ice on surfaces. Paint technology specialists at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Bremen, for instance, are researching anti-ice layers that can be heated and made water-repellent.

The researchers are testing these and other developments in a newly constructed ice laboratory at the institute. Featuring an integrated ice-forming wind tunnel, the lab allows them to subject anti-icing technologies to realistic icing conditions of the kind encountered on aircraft wings or wind-turbine blades, at temperatures as low as minus 30 degrees Celsius and wind speeds of up to 350 kilometers per hour.

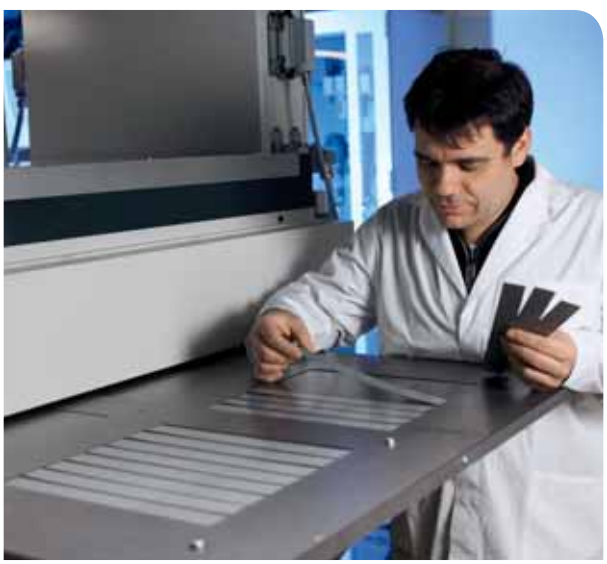
Test area with built-in wing profile. © *Fraunhofer IFAM*

Transformer steel

Transformers are found in almost every electrical appliance. And electrical steel is an important material used in every transformer. Researchers at the Fraunhofer Institute for Material and Beam Technology IWS in Dresden have found a way to make this special metal perform not only better, but also to produce it more efficiently. Their solution uses lasers to improve the magnetic properties of the steel.

The researchers also managed to integrate the flexible machining processes into existing production environments, which saves time and money. What's more, their method uses highly efficient fiber lasers instead of CO_2 lasers. There are plans to use the new process to make electrical sheets for engines, too.

A scientist removes samples of electrical steel from the test facility. Electrical steels are an important component of transformers. © *Fraunhofer IWS*



The perfect steak

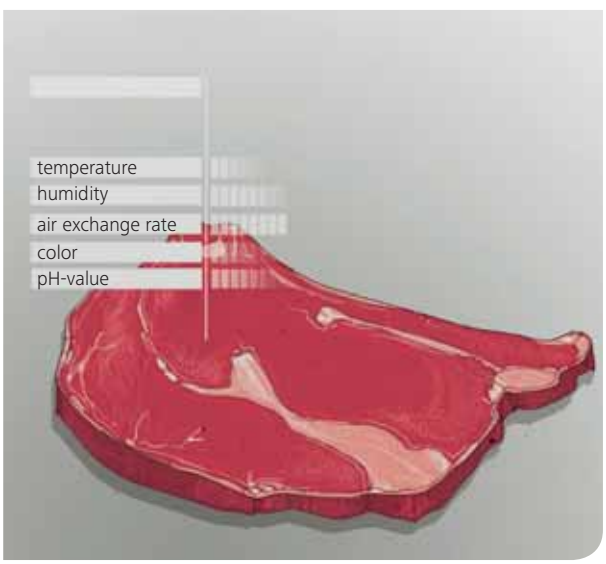
Achieving a perfectly tender steak on the grill has more to do with the quality of the meat itself than the cooking method. Only meat that has been properly stored and matured can become delicate, aromatic and easy to digest.

Dry aging is the oldest method for maturing meat. It involves hanging the meat on a hook and allowing it to dry on the bone, a process during which it loses up to 30 percent of its weight. Gourmetkreis GmbH, an online retailer of high quality meats, intends to use precision measuring technology to cater even better to its customers' requirements.

The aim is to increase the transparency of the meat maturation process by measuring various parameters and displaying these measurements online. This will let customers decide at what stage of maturity they would like the goods they have ordered to be delivered. Researchers at the Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT in Oberhausen are working up a concept with the help of a demonstrator room for monitoring the dry aging process.

Meat is hung in this cooling chamber for up to eight weeks at a temperature of between one and five degrees Celsius. The scientists use the setup to determine process parameters such as humidity, temperature and air exchange rates, and to develop measuring techniques that allow them to ascertain how mature the meat is. They create maturity profiles and analysis methods for this purpose.

By precisely controlling the parameters, scientists can guarantee a perfect meat-eating experience. © *Fraunhofer UMSICHT*



Secure smart homes

Heating, lighting and many other devices in the home can now be controlled via the Internet. Smart homes may promise efficient buildings, management, but in many cases such systems are not secure. The botnet, a phenomenon previously confined to the world of computers, is now an issue for buildings automation as well. Botnets are when attackers infiltrate several computers (bots) without the owners' knowledge, create networks (nets) linking them together and then misuse these 'botnets' to carry out computer attacks. This same principle can be applied to smart homes and their network of shutters, ventilation and locking systems that are interlinked via the Internet.

Researchers at the Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE in Wachtberg have developed protection software that can be easily interposed between a building's own IT network and the Internet. The technology filters out potential threats from communication protocols before they even reach the home or office building, irrespective of the technology used within the building.

Building management via tablet PC: In many office buildings, light, blinds and doors can be centrally controlled via the Internet. This is often more efficient, but also carries certain risks. © *Fraunhofer FKIE*

The needs of the ever-growing world population can only be met by sustainable development. © *shutterstock*

Toward a sustainable future

Important resources such as rare earth metals, clean water, copper, silver and gold are becoming scarce. If we want to continue to meet the needs of the ever-growing world population, we must become more accountable in how we manage raw materials. With its research, the Fraunhofer-Gesellschaft is making an important contribution to sustainable development.

Text: Birgit Niesing

We are living on borrowed time: by August 22, humans already have consumed the natural resources calculated for 2015 – in less than eight months, we used up more water, food, energy and raw materials than we can replenish in a year. What's particularly frightening is that this annual day of depletion, which the Global Footprint Network calls Earth Overshoot Day, arrives earlier each year. In 2000, it was October 1.

There's no question about it: we can't afford to be so wasteful with raw materials and energy in the future. But how do we do that when more and more people are living on the planet? One approach would be to produce more from fewer resources. This is especially important for countries that are poor in raw materials, such as Germany. That's why the German federal government has set some ambitious goals. One is to double resource productivity (compared to 1994 levels). Another is to increase energy productivity – that is, the overall economic performance per unit of primary energy used – 100 percent by 2020 (compared to 1990 levels).

Chemical products from wood waste

Fraunhofer began developing solutions for responsible resource use several decades ago. "The concept of sustainability permeates all areas of research at Fraunhofer: health and the environment, safety and security, communication and knowledge, mobility and transportation, raw materials and energy as well as production and services," says Prof. Dr. Thomas Hirth, spokesperson for the Fraunhofer Sustainability Network and director of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB. With its focus on sustainability, Fraunhofer is laying important groundwork for lasting, future-oriented development. Both the environment

Sustainability report

In recent years, the issue of sustainability has become an increasingly important part of the Fraunhofer-Gesellschaft's corporate strategy. As early as 2009, 20 Fraunhofer Institutes and facilities came together to form the sustainability network, a bottom-up initiative from which a structured process emerged. Just how important this issue is to the research organization is demonstrated by the sustainability report that was presented a few weeks ago. The report's more than 120 pages are based on the G4 guidelines of the Global Reporting Initiative (GRI). It presents the sustainability activities of the 2013 financial year and provides information about the objectives and measures which the Fraunhofer-Gesellschaft has voluntarily committed itself to.

www.fraunhofer.de/en/about-fraunhofer/sustainability.html

and the economy will benefit from the results. The chemical industry is a good example. Until now, the manufacturing of detergent, adhesives, paint or cosmetics has required petroleum as a key starting material. But this fossil fuel is becoming increasingly scarce and expensive. An alternative carbon source is biomass made from agricultural and forestry raw materials, such as plants that supply sugar, starch or cellulose. But to produce chemicals from renewable sources, new processes are needed that also work on an industrial scale. That's what the Fraunhofer Center for Chemical Biotechnological Processes CBP in Leuna is working on. The Center collaborates with various companies in the chemical industry as well as in the mechanical and systems engineering sectors.

Professor Hirth describes the Center's work: "If we are to use renewable raw materials efficiently and effectively, we need new and scalable processes that are closely networked with existing production structures." The CBP in Leuna has shown how this can be achieved through its holistic use of wood waste. First the scientists split the wood into its constituent parts, carbohydrates (cellulose and hemicellulose) and lignin. Anything left over is used in generating energy. Enzymes convert the carbohydrates into sugar. Then bacteria break this down into basic chemicals for plastic production or into isobutene, a hydrocarbon. The chemical industry can use this basic material to produce fuels, solvents, elastomers or even anti-knock agents for gasoline.

Researchers use the wood constituent lignin to yield aromatic compounds that they can use for producing adhesives or paint. In the Lignoplast project, researchers from three Fraunhofer Institutes are working with several universities and industrial partners to develop processes for this. The Fraunhofer team has already found a way to split the extremely robust and resilient lignin molecules into smaller units. These fragments contain a mixture of up to 30 different aromatics. To turn this mixture into adhesives or paint, it is chemically modified and adjusted for the respective application. "The CBP is laying important groundwork for the future manufacture of chemical products and is helping reduce the dependency on fossil fuels," Hirth emphasizes.

This dependency on fossil fuels such as oil, gas and coal also extends partially to our energy supply. One focus of Fraunhofer research is to create the technical requirements for an efficient and environmentally friendly energy supply. In Europe, the largest percentage of these fossil fuels is used for heating and cooling buildings – the International Energy Agency (IEA) in Paris estimates that this adds up to some 40 percent of all European energy consumption. This is to change: Fraunhofer researchers are working on converting buildings into suppliers of energy. Houses of the future will be turned into power plants thanks to state-of-the-art technologies built into the façade, such as high-performance insulation materials, vacuum insulation, ventilation systems with heat recovery, latent heat storage materials, fuel cells or photovoltaic systems.

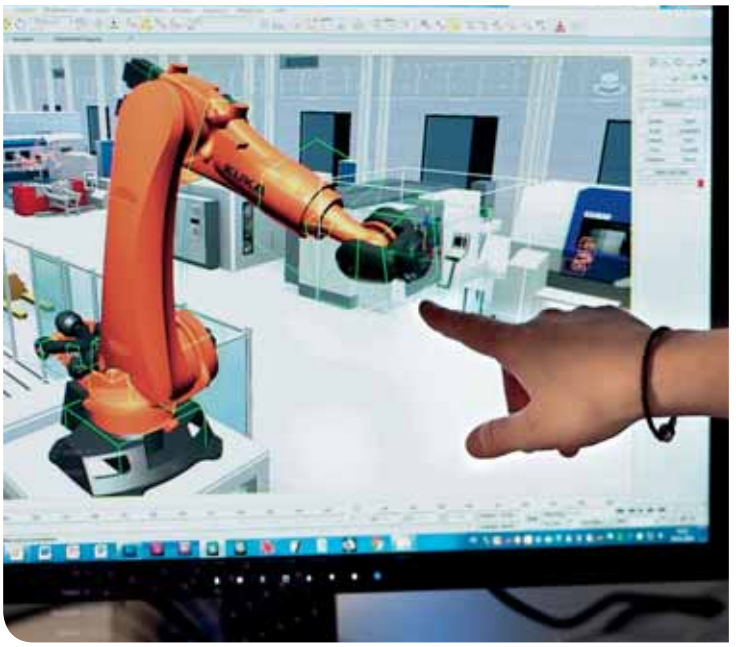
Regenerative energy

For Germany's transition to the new energy economy, the rapid development of photovoltaic and wind energy systems will play a crucial role. Fraunhofer has some key contributions to make to this process; one example was an achievement just a few months ago. In collaboration with Soitec, French research institute CEA-Leti and the Helmholz-Zentrum Berlin,

Renewable raw materials such as straw and wood waste yield important starting materials for the chemical industry. *© Fraunhofer IGB*

New components for electric vehicles. *© Thomas Ernsting / Fraunhofer*

New processes make manufacturing more resource efficient. *© Fraunhofer IWU*



the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg set a new efficiency record for solar cells: 44.7 percent under concentrated light. Although wind energy already makes up a large part of our power supply, the production of wind turbines is still performed partly by hand – in particular, the manufacture of blades. To automate and reduce the cost of production, 17 companies and research institutes have come together for the BladeMaker project, under the direction of the Fraunhofer Institute for Wind Energy and Energy System Technology IWES in Bremerhaven.

On the go with plug-ins

Even mobility is heavily dependent on oil – most cars and trucks still run on gasoline or diesel. The German government wants to change that. It wants to have one million electric cars driving on German roads by 2020. E-vehicles offer several advantages: they pollute the environment significantly less than comparable gas or diesel vehicles do, especially in cities. If more electric cars were used in cities, air quality could be greatly improved, and carbon dioxide emissions, particulate matter, hydrocarbons, carbon monoxide and nitrogen oxides could also be reduced.

As part of the Electromobility lighthouse project, 16 Fraunhofer Institutes are working on innovative technologies and components for hybrid and electric vehicles. Key focus areas include developing a fully electric wheel-drive unit, processes for bidirectional inductive charging, improved battery systems, lightweight construction and autonomous driving.

An important component for plug-ins are their electric motors and their powerful permanent magnets. These owe their excellent magnetic characteristics to the chemical elements neodymium and dysprosium, which belong to the group of rare earth elements. These raw materials are hard and dangerous to extract, and available in meaningful concentrations in only a particular part of the world – China. A consortium consisting of seven Fraunhofer Institutes has come together in the Critical Rare Earths lighthouse project. Its goal is to cut the need for these critical rare earths in the production of high-performance magnets in half by 2017, and to substitute them completely in the long term.

Environmentally friendly solutions are also needed in aviation. Twelve Fraunhofer Institutes are participating in the European joint technology initiative Clean Sky, where experts are working on reducing the amount of fuel consumed by aircraft. The goal is to reduce a jet's carbon dioxide emissions by at least 20 percent. Using small air nozzles, for example, should make this possible. They would be mounted on the wing and decrease air vortices that drain energy during climbs. The researchers also analyze the life cycle of an aircraft from manufacture to removal from service in order to develop methods that help recycle aircraft components.

Efficient car production

Germany is one of the nations with the most economic clout in the industrialized world. According to the Federal Statistical Office (Destatis), Germany's manufacturing sector accounted for 22.4 percent of gross domestic product (GDP) in 2012. Nearly one in five workers in Germany is employed in manufacturing. But the manufacturing of the future faces particular challenges: since Germany has almost no raw materials of its own, important resources such as oil, aluminum, copper

Vaccines can be produced at an automated tobacco farm (pictured above and below right).
© *Dirk Mahler / Fraunhofer*

A new renewable raw material for car tires – rubber made from dandelions (pictured above right).
© *Continental*

and so on must be imported at great expense. That's why, in many industries, the expenditure for materials and energy has a decisive influence on the price of the final product. For instance, in the manufacturing sector in 2012, spending on materials and energy already made up 58 percent of total cost. In comparison, personnel expenses totaled only 18 percent, as calculated by the German Federal Statistical Office. A study created by the Technische Universität Berlin on behalf of the Association of German Engineers suggested that resource-saving production processes offered major savings potential. For example, by applying targeted resource management and employing new technologies, the German metalworking industry alone could save up to 2.3 billion euros on materials and up to 600 million euros in energy costs.

How the manufacturing halls of the future will save on energy and materials is the subject of investigation by Fraunhofer researchers in the E^3 production lead project. Factories of the future require little energy – the first E – and few resources. They barely pollute the environment with emissions – the second E. As manufacturing processes are becoming more complex, the close involvement of people arise as a crucial requirement. Therefore, new concepts of embedding people – the third E – into the production are needed. At Fraunhofer, scientists develop solutions that companies can implement quickly. Recently, an E^3 research factory opened at the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz. Inside the factory, the concept of ultrashort process chains is implemented in an environment very similar to real-life production. The researchers are also testing a holistic energy and resource management system plus developing IT-supported planning and technical solutions for a flexible and intelligent car body manufacturing process.

Another possibility for becoming less dependent on resource imports is to make use of renewable resources produced in Europe. Dandelions, for example, can provide a replacement for rubber in tires. In the past few years, the Fraunhofer Institute for Molecular Biology and Applied Ecology IME has been working together with industrial partners and the scientific community to further improve cultivation and production techniques. Now the researchers are creating a pilot facility with Continental in order to yield enough dandelion rubber for tire production.

Renewable raw materials can even provide us with vaccines. At the moment, vaccines are produced mostly in chicken eggs, but should a global epidemic break out, this method would be pushed to its limits. Tobacco plants could deliver more vaccine in less time. When the genetic information for the vaccine protein is introduced into the plant using

a launch virus vector, the plant begins to produce large amounts of the desired biomass within a few days. The Fraunhofer Center for Molecular Biotechnology CMB in Delaware (USA) has perfected the production of the necessary biomass in tobacco plants. Researchers at a pilot facility in the U.S. produce some 2.5 million vaccine units per month.

Personalized medicine is another reason for a better use of resources in health care. Cancer treatment is one example of this. For many cancers, doctors rely on chemotherapy. But patients respond very differently to the various treatments. Even if the type of tumor is the same, the cancer cells in one patient react differently to the medication than those in another patient. It is possible to use an in vitro sensitivity test to search for the most effective drug for an individual prior to starting treatment; however, these manual procedures are expensive and therefore not covered by basic health insurance. This is where researchers at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA come in: they have developed a prototype for an automated test system. This new method enables cost-effective tumor analysis and helps reduce health care costs by avoiding ineffective chemotherapy.

Many illnesses and fatalities could be prevented through improved hygiene. In industrialized countries, one great challenge is infection by multi-resistant pathogens. Experts estimate that, in German hospitals alone, up to 800,000 people are infected with such germs each year – and several thousand of them die from it. In the Beyond Tomorrow project "Steri-Health", experts from six Fraunhofer Institutes are working on solutions that will reduce the number of new infections and lower costs at the same time. For example, they are developing a mini sterilizer that makes it possible to easily and safely sterilize medical products, instruments or cell therapy products on site.

Green electronics

Information and communications technology ICT is increasingly pervading every aspect of our life and work – computers, tablets and smartphones have become an indispensable part of our daily lives. Although the devices contain numerous valuable materials, many cellular phones and PCs end up in the landfill only a few years after purchase. Fraunhofer researchers are examining how electronic devices could be constructed to be more environmentally friendly, and are developing processes for recycling. For example, in cooperation with a private company, Fraunhofer scientists have developed a "green" laptop, which will soon be ready for market. The notebook's modular construction simplifies repairs and recycling. Another feature is that the housing is made of wood.

However, sustainability in information and communications technology means far more than just using environmentally friendly materials. Above all, responsible handling of our data and knowledge is key – the loss of important business information could drive a company into the ground, for example. But mobile end devices and the increasing degree of connectivity make it difficult to protect data from unauthorized access. Recent scandals show how susceptible IT infrastructure is: information is intercepted, computers are spied on and hacker attacks paralyze whole companies. Fraunhofer researchers don't develop just security solutions – they also drew up a seven-point program for Germany's national research agenda "Cyber Security 2020". This will supply the standards for information technology that is secure over the long term. Among other things, the program recommends establishing an application lab for cyber security. Technical solutions to combat cybercrime and industrial espionage will be tested there with help from industrial partners.

Making infrastructure crisis-proof

Usually, we notice how reliably technical systems function only after they fail during a natural disaster or due to a defect. That's why we have to create technologies today that can protect people in the event of a natural catastrophe. Researchers including Fraunhofer scientists are working on making infrastructures as crisis-proof as possible. The SENEKA project is one example; here, a mobile robot sensor network has been developed for disaster management. In an emergency, the robot network helps provide a better overview of the situation, which then cuts down on the time needed to search for victims and hazards. The network consists of mobile aerial and ground robots that communicate wirelessly and are equipped with various sensors, such as infrared, gas detectors, GPS, ultrasound, cameras and image intensifiers.

With the KATWARN system, authorities can warn people in a targeted way by mobile phone, for instance about keeping windows closed after a chemical plant fire. Registerd users receive notices by text message. KATWARN is already available for free to about ten million people in Germany.

City of the future

Cities are already home to half of the world's population – and the number of urban dwellers continues to increase. As these large cities grow, so do their problems. We need to lay the foundation now if we want to continue to live and work in hospitable and sustainable megacities in the future. Fraunhofer established the Morgenstadt initiative. Its goal is to develop system solutions today for the urban life of tomorrow. Science Year 2015 is also dedicated to the city of the future: in Germany, two out of every three people live in cities, where three-fourths of the country's energy is required and 70 percent of anthropogenic greenhouse gases are emitted. Megacities have a key role to play in meeting the major challenges of the 21st century, because that is where the major shift toward responsible production and business practices must begin. ■

Fertilizer from wastewater

Wastewater can be a valuable source for the raw material phosphate. © panthermedia

Wastewater and liquid manure include phosphorous, a raw material essential for life. With new processes, this valuable element can be retrieved and used as fertilizer.

Text: Birgit Niesing

No phosphorus, no life. The element is an essential nutrient not only for plants, but for people and animals too: phosphorus transports energy and is an indispensable building block of our DNA. Agriculture is especially dependent on phosphorus, which is used on the fields as phosphate fertilizer. Only through the intensive use of this fertilizer is it possible to supply nearly eight billion people with food.

Agriculture already uses more than 80 percent of the worldwide production of phosphate salts. With the growing world population and the increasing need for food, the demand will continue to grow. This is particularly problematic in places such as Europe that are entirely dependent on the import of the increasingly expensive phosphate salt. Additional challenges: while the overall supply dwindles, farmers and industry continue to use phosphate in such great quantities that surface and ground water is being contaminated.

The good news is that this vital raw material can be recycled several times. But to do so, it has to be recovered from wastewater, liquid manure and biowaste. Fraunhofer researchers are working on a range of processes for recycling this valuable resource. Phosphate is already being removed from wastewater in order to prevent an over-fertilization of bodies of water. For this purpose, sewage treatment plants are usually precipitated with aluminum or iron salts.

Recycling phosphorus

Unfortunately, the resulting phosphate salt cannot be used in agriculture. Experts speculate that worldwide, about 4.3 million metric tons of phosphorus are lost in this way each year. The E-Phos method, developed by researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart, offers an alternative. “Phosphate is recovered

from wastewater in such a way that it can be directly applied as fertilizer," explains Dr. Jennifer Bilbao from Fraunhofer IGB. The core of the patented method is an electro-chemical process: researchers use electrolysis to precipitate phosphate and nitrogen in the form of small crystals of magnesium ammonium phosphate. This compound, known as struvite, can be used as a high-quality fertilizer in agriculture. What makes the method unique is that, unlike traditional methods, the scientists do not need to add any salt or lye: the process is completely free of chemicals. The magnesium ions needed for the reaction are delivered by the magnesium electrode used.

But just how effective is this method? To find out, the researchers tested it with the help of a pilot plant. With the electrochemical process, the phosphorus concentration in the reactor could be reduced to less than two milligrams per liter. This meant that the scientists were under the limit set by Germany's wastewater ordinance (AbwV) for wastewater treatment plants serving up to 100,000 inhabitants. "This would enable operators to combine wastewater treatment with lucrative fertilizer production," says Bilbao, identifying the crucial advantage. The E-Phos method has already successfully passed its first practical test in a German sewage treatment plant. Now the system is to be tested abroad, and the researchers are already planning the next steps. "We're confident that the method will be implemented at a treatment plant on an industrial level within two to three years," says Bilbao.

Fishing for resources with magnets

Researchers at the Fraunhofer Project Group for Material Cycles and Resource Strategies IWKS at the Fraunhofer Institute for Silicate Research ISC are launching a new method to use when wastewater has low phosphate concentrations, a situation where other systems no longer work efficiently. They target the resource and fish it out using superparamagnetic particles. What makes this method unique is that the particles are magnetic only when an external magnetic field is applied. If it is removed, the particles "forget" their magnetic characteristics and can be finely dispersed in the water. "We've synthesized superparamagnetic microparticles and coated them with a layer that the phosphate anions can easily attach to," says Karl Mandel from Fraunhofer ISC. A magnet can then be used to pull the particles from the water along with the phosphate they carry. Once the particles have been magnetically removed from the water, the phosphate is separated from the coating on the particle. Now the valuable resource can be reused, while the magnetic particles, stripped of their cargo, can be redeployed.

"Because we can collect the phosphate ions directly from the wastewater with the magnetic particles and then use those particles again, the process is highly efficient – even at very low concentrations," explains project manager Dr. Carsten Gellermann from the IWKS Project Group. Together with their colleagues from the Institute for Sanitary Engineering, Water Quality and Solid Waste Management ISWA at the University of Stuttgart, the Fraunhofer researchers received the Re-Water Braunschweig Future Award for their technology. Currently, the project partners are scaling up the process in a project funded by the Baden-Württemberg Stiftung. It will then be implemented at the University of Stuttgart's large research treatment plant in Büsnau to purify wastewater from Stuttgart neighborhoods. ■

www.fraunhofer.de/en/press/audio.html

With a magnet, previously added superparamagnetic particles can be pulled from the water, along with their load of phosphorous. *© Knud Dobberke / Fraunhofer ISC*

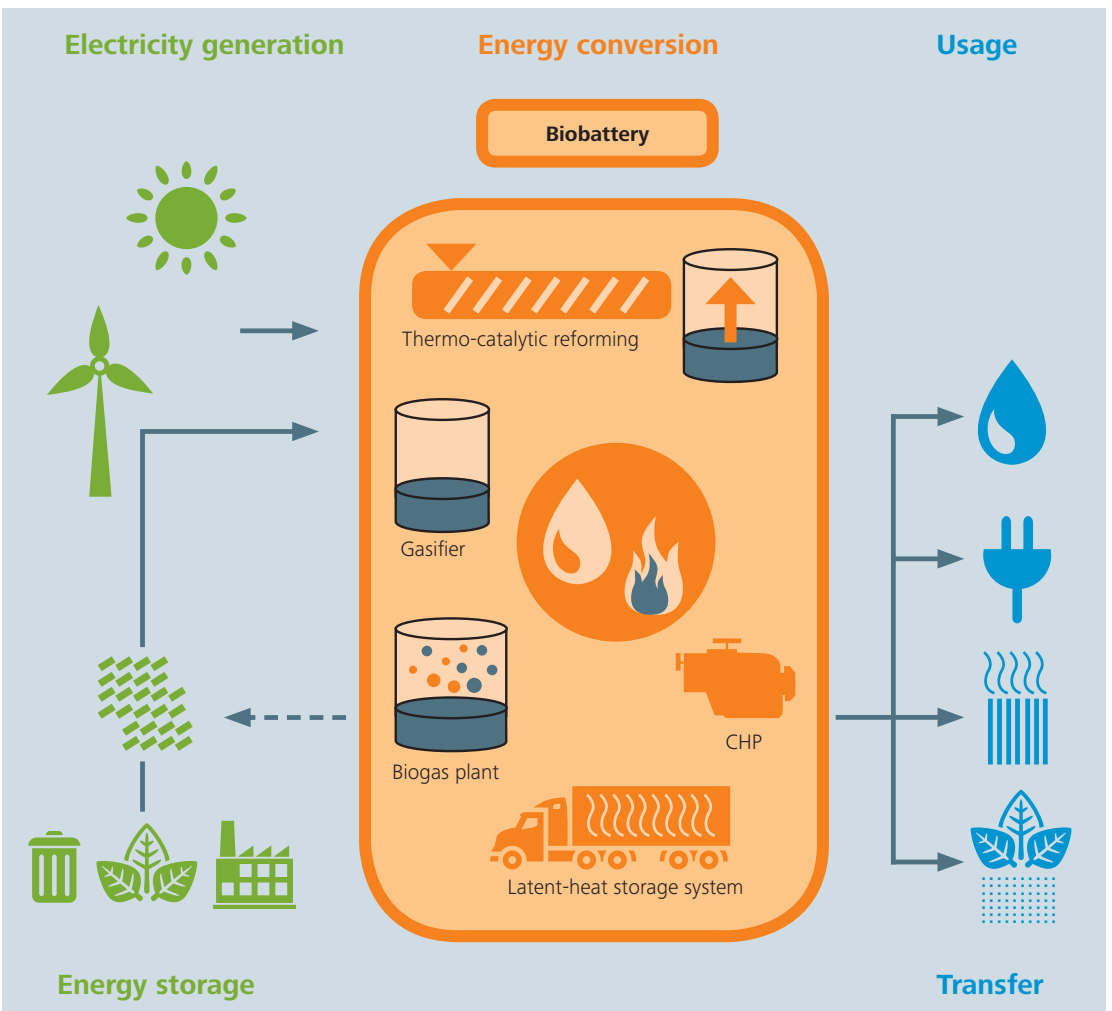
Making use of liquid manure

An additional source for recovering phosphorous includes agricultural waste, such as liquid manure. In the EU project PhosFarm, researchers from the Fraunhofer IGB are seeking to develop this organic waste into a source for the valuable material. The idea is to isolate the inorganic phosphate from liquid manure, digestate and other agricultural waste by binding special enzymes to suitable carriers. These catalysts react with the resource, forming a solid phase and a liquid fraction that contains the dissolved phosphate. This can be precipitated as magnesium ammonium phosphate or calcium phosphate, salts which can be applied directly as fertilizer.

The biobattery

Biobatteries are a way of exploiting the energy contained in biomass - materials such as sewage sludge, green waste, leftovers from food production, straw and animal excrements. Now a Fraunhofer spin-off is putting the biobattery concept into practice with large-scale pilot installations implemented with the help of partners in Germany and abroad.

Text: Marion Horn



The biobattery concept is ideally suited to establishing a decentralized supply of energy and raw materials. © *Fraunhofer*

Biogas plants are a crucial part of a decentralized energy supply, generating electricity from renewable raw materials and compensating for the highly variable yield obtained from wind and solar energy facilities. Germany already has 8000 such plants in operation, generating a total of 3.75 gigawatts – roughly as much as three nuclear power plants. They do have their drawbacks, though: They are capable of processing only a limited range of organic materials and have to compete with the cultivation of foodstuffs.

Producing electricity, oil, gas and biochar

Scientists at the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT have come up with a way to significantly boost the efficiency of biogas plants. Their biobattery solution supplies not only electricity and heat but also valuable products such as gas, oil and biochar. The materials can then be used as required: for electricity, marine transportation fuel, fuel additive or fertilizer. They even provide base materials for the chemical industry.

Modular in construction, the biobattery is the amalgamation of a range of environmentally friendly technologies including biogas plants, thermal storage systems, gasifiers and electricity-generating motors. At the heart of the concept is the thermo-catalytic reforming technique (TCR®), which the experts use to convert residues from biogas plants and bioethanol from staw production, industrial biomass waste, sewage sludge, straw, scrap wood or animal excrement and convert it into oil, gas and biochar. "The paticular advantage of the biobattery is that we can utilize a number of raw materials which would otherwise have to be disposed of, often at great cost," says Professor Andreas Hornung, Director of UMSICHT's Sulzbach-Rosenberg branch.

To demonstrate that the concept works in practice, researchers have constructed a pilot facility that processes around 30 kg of biomass per hour. First, the raw materials pass through a sluice into a screw reactor with inert atmosphere. There the material is heated up and broken down into biochar and volatile vapors. These vapors are heated up further and then cooled down again. In the process, they condense into a liquid that contains bio-oil and process water. Researchers extract the valuable oil for reuse, while the resulting gas is purified and collected.

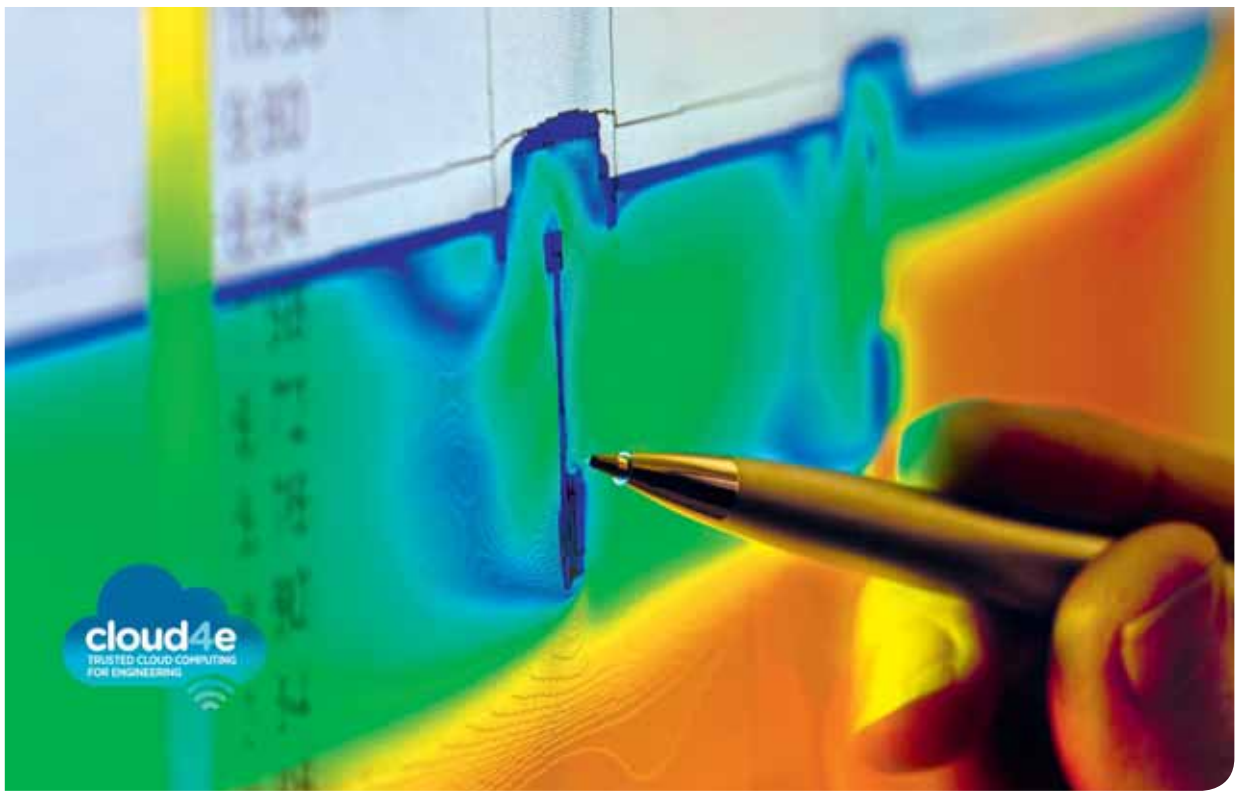
The liquid, gaseous and solid products obtained can be reutilized in a variety of ways. The oil can either be processed into marine and transportation fuel or used in a combined heat and power plant – as can the gas – to generate electricity and heat. The separated process water contains numerous short-chain biodegradable carbon compounds, and can be fed back into the biogas plant to increase the methane yield. The biochar is usable as a soil conditioner.

www.umsicht-suro.fraunhofer.de/en.html

But is the biobattery efficient? "The biobattery converts more than 75 percent of its energy input into high-quality energy sources in a robust, continuous process. And by using mobile latent heat accumulators, you could improve the energy efficiency even more," explains Hornung. One particular advantage of the biobattery is that the system can be expanded step by step. "That is extremely financially attractive to operators, since there's no call for big upfront investments, as our profitability analyses demonstrate," explains Hornung. Susteen Technologies GmbH, a spin-off from UMSICHT, is already putting the biobattery concept into practice with large-scale pilot installations implemented with the help of partners in Germany and abroad.

"We need a mix of different technologies if we are to make the transition to a new energy economy. Our biobattery concept is ideally suited to establishing a decentralized supply of energy and raw materials," says Hornung. ■

Security for cloud simulations



FEM simulations provide smaller companies with the chance to employ finite element methods (FEM) to solve complex problems. *© Fraunhofer IIS/EAS, photo: Jürgen Lösel*

By and large, small and medium-sized enterprises are still hesitant about using cloud services. Still, they could be particularly useful for engineers, offering them easy and secure virtual cloud access to expensive modern simulation software whenever they need it. Fraunhofer researchers are working hard on a solution.

Text: Chris Löwer

Lots of medium-sized businesses view cloud services with mistrust. They want to protect their expertise and innovation – the core of their business – and are reluctant to make themselves dependent on an IT provider. In the "Cloud4E – Trusted Cloud Computing for Engineering" project, researchers from the Design Automation Division EAS at the Fraunhofer Institute for Integrated Circuits IIS are working on a solution tailored to the needs of development departments in small and medium-sized enterprises (SMEs) that will banish these sorts of fears for good.

In the automotive and mechanical engineering industries, engineering departments in particular have come to rely on computer-aided engineering (CAE). "One of the most important CAE methods is computer-aided simulation, which demands a huge amount of hardware resources as well as configuration and administration expertise," says André Schneider from Fraunhofer EAS. He points out how it is already becoming apparent that future requirements will go well beyond individual simulations to include parallel variant simulations, such as statistically evaluating how a new gear component performs under stress or in different ambient temperatures. "Most SMEs simply don't have the massive computing power needed for these sorts of operations. Cloud services offer a solution to the problem, allowing you to access computing power and simulations when you need them," highlights Schneider.

In larger companies, it is standard practice to factor in more IT resources and personnel than are needed for routine requirements so the company can deal with peaks in demand. This is something that smaller companies cannot afford. Because of this, they are not in a position to exploit the possibilities of modern CAE tools to their fullest extent. The result: avoidable functional defects aren't uncovered until the prototype stage.

The hope behind the Cloud4E project is that soon smaller companies too will have access to significant computing power and professional simulation software at a relatively cheap price via the virtual data cloud. This will allow them to identify and remedy defects from their computer using a virtual prototype. The Fraunhofer researchers in Dresden have been joined on the project by a local computer center (GWDG), a provider of simulation software (ITI), a medium-sized FEM simulation service provider (ERAS) and researchers from the University of Erlangen-Nuremburg. Cloud4E is one of 14 research programs in the Trusted Cloud technology program initiated by the Federal Ministry for Economic Affairs and Energy. Its aim is to develop innovative, secure and compliant cloud computing solutions.

Fraunhofer has developed the framework that will allow developers to reliably access simulation software from a range of providers. "Launching a simulation will be no more difficult for engineers than using local resources," explains Schneider. Instead of running on the engineer's own computer, the simulation software is offered as software-as-a-service running on virtual machines (VMs) in the cloud. The VMs draw on the cloud's storage and computing capacity and can be tailored to individual requirements. The standardized OCCI (Open Cloud Computing Interface) and AMQP (Advanced Message Queuing Protocol) are used to configure the solution on the software, platform and infrastructure levels. A major advantage, says Schneider, is that by using these open standards, engineers can switch providers if they need to without losing their previous work. This puts an end to reliance on a single cloud or software provider. As such, Fraunhofer's "GridWorker" solution is the cement that holds the environments together.

Wide-ranging access to all necessary resources

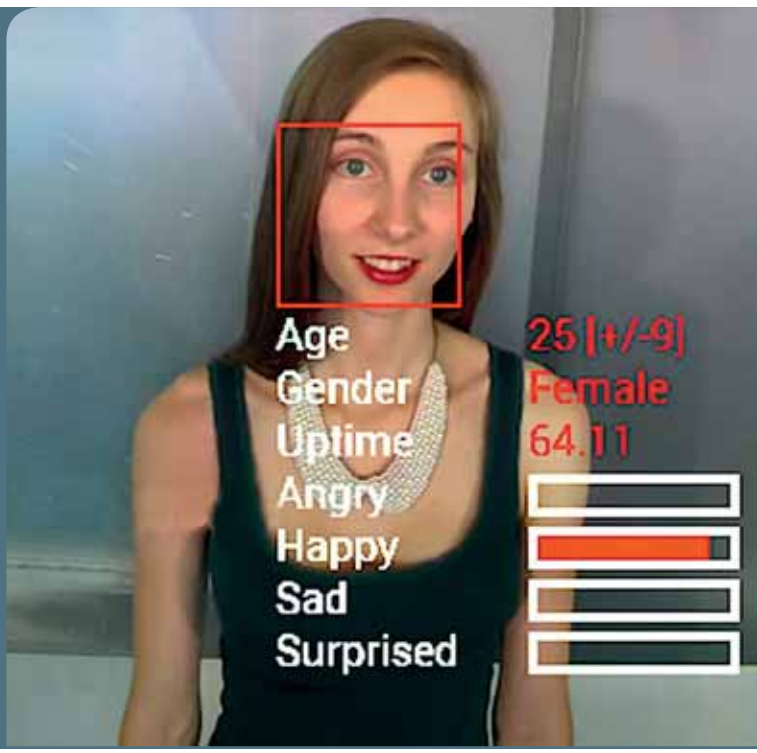
Initially, Cloud4E will provide access to Modelica and FEM simulations in the form of a model application that allows engineers to examine prototypes for defects. "The basic software is running solidly and we'll have a demo application to showcase at the end of 2014," says Schneider. In time the plan is to offer a choice of any simulation software solution via the cloud, in which the software can be reserved flexibly either by time or for a flat fee. This way, Cloud4E will provide engineers with wide-ranging access to all the resources they need. For Schneider, the advantages to companies are obvious: it means a reduction in the need for investment in hardware, software and staff while escaping the operating costs involved in installing and maintaining simulation software. Using the cloud also significantly improves system reliability without incurring large costs since the resources in the cloud operate on a redundancy concept and are quickly accessible. This is something that SMEs can seldom afford, purely for reasons of cost.

The flexible and cost-effective solution ought to be particularly attractive to high-tech start-ups. Schneider already knows of cases in which young companies use on-demand resources from a cloud provider for all their computer-intensive simulation and development work – a decision also motivated by the desire to save on energy costs. Servers and the equipment needed to cool them are real energy guzzlers. And yet most companies still hesitate to entrust their sensitive data to cloud providers. It's a state of affairs confirmed by Techconsult's IT Cloud Index market research study of medium-sized companies. Whereas at the beginning of 2013, medium-sized companies in Germany were more receptive to cloud data services than ever before. The Edward Snowden leaks precipitated a sharp slump, with a good two thirds of companies reporting that they once more had security concerns and just as many saying that they wanted to avoid the cloud because they were wary of losing control over their own IT systems. Since that time, analysts have seen only "slow erosion of medium-sized German business's hesitation to make use of cloud services."

A particularly high level of security

This mistrust is hindering the spread of the technology, at least as long as there are no binding data security standards. "The security and integrity of all sensitive development data during transmission, processing and cloud storage is at the heart of the solution," reassures Schneider. That's why Cloud4E combines various security methods – including techniques for identity management, authentication, and encrypted data transmission, processing and storage. The result is a particularly high level of security.

Another advantage is that while many SMEs can't afford to employ data security experts, cloud providers have their own specialists to protect data against external attacks. The Cloud4E infrastructure is also suitable for smaller computer centers aside from the U.S. industry giants such as Amazon, Google and Microsoft. That means that companies can easily make use of German providers – and the German data protection laws that come with it. ■



Man or woman? Sad, angry, surprised or happy? SHORE™ software detects faces and emotions. © *Fraunhofer IIS*

Always online

Google Glass, Google's smart eyewear, has already hit the U.S. market, while in Germany it has fueled a lively debate about data protection. Yet despite all the reservations, miniaturized computers have great potential. For instance, they could help autistic people recognize facial expressions - in line with data protection law, of course.

Text: Janine van Ackeren

A lot of people seem permanently attached to their smartphone, the computer that's always to hand. In the future, we won't need to reach into our pockets for the data that interests us; instead, it will appear directly in our field of view: data glasses. These glasses display information right in front of us, in what's known as augmented reality. But the very thing that delights technology enthusiasts has data protection groups squirming with unease, since the glasses rely on a camera that users can connect to the Internet via their smartphone. Basically, the glasses allow you to photograph and film people without their knowing. As a result, the release date in Germany is unclear and there is heated debate as to whether the product, which has been launched in the U.S. as Google Glass, ought to be sold in Germany at all. Those concerned about data protection see the glasses as an attack on privacy. On the other hand, many experts agree that smart glasses have huge potential.

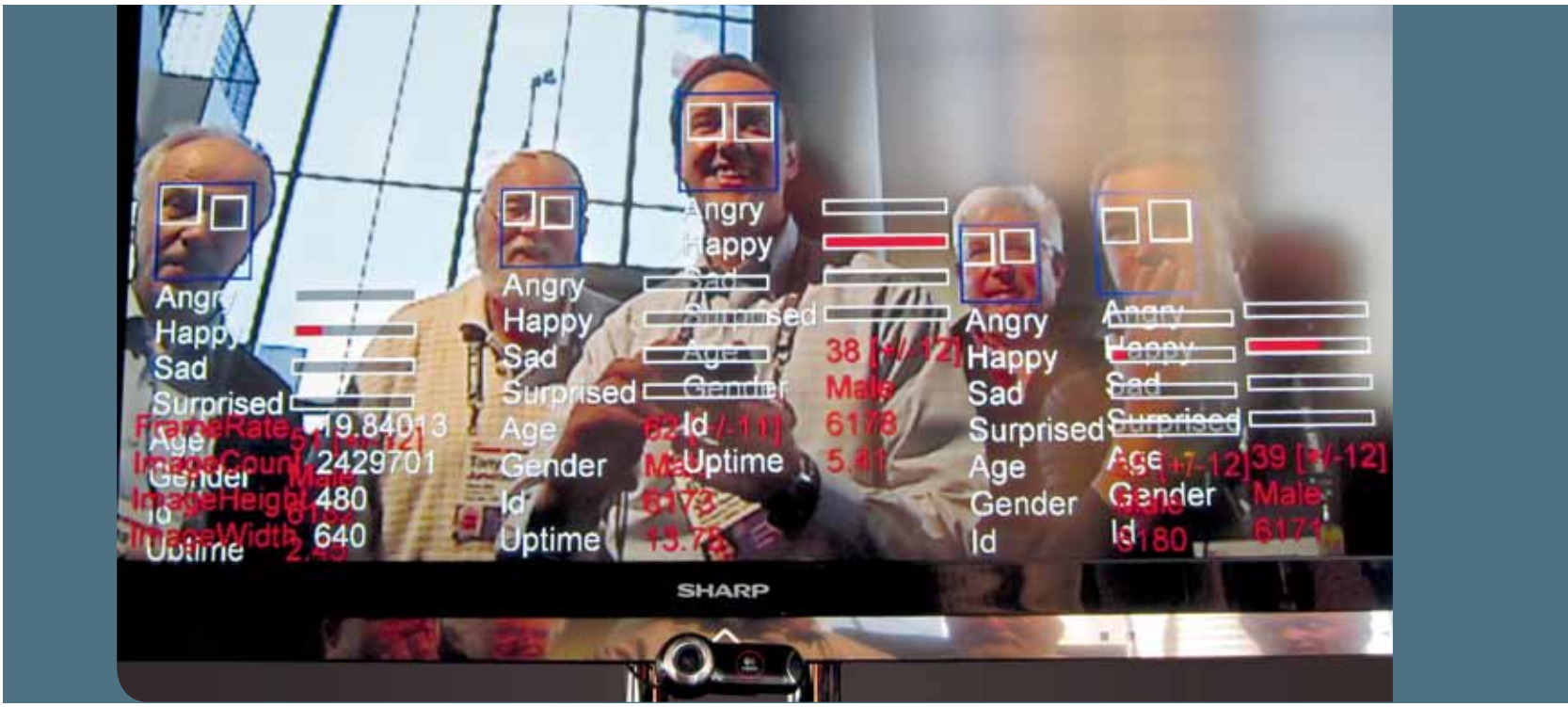
Getting rid of the paper

Data glasses have a range of uses in the working world. For instance, researchers from the Fraunhofer Institute for Applied Information Technology FIT teamed up with Bayer AG to develop a piece of software that helps chemists in their daily work. A chemist is a bit like a chef, in that they have a formula – or recipe – and have to collect various "ingredients" so that they can follow a process to create particular substances, often several at a time. So far, they have relied on paper aids in that process. "What we've done is make the whole process easier by calling up all the relevant information for chemists using smart glasses," says Dr. Leif Oppermann, head of department at Fraunhofer FIT. Instead of searching through the laboratory with a sheet of paper in hand, chemists get the information they need on their data glasses. When they are standing in front of a shelf of chemicals, they see the list of ingredients on the display in front of them. If they are working at the fume hood, they can see the chemical structure of the substance to be prepared at the edge of their field of view, in addition to instructions about the next steps in the process.

While Google Glass has reignited the debate over data protection, the truth is that similar devices by other manufacturers are already available in Germany. "Now we can actually implement the ideas we've come up with over the past years," says a delighted Prof. Wolfgang Prinz, who heads a research group at FIT. "The glasses are the hardware our research has been waiting for." What's more, this research is extremely diverse, ranging from computer games to security to construction. One example is machine maintenance. On-site technicians are often pushed out of their depth when it comes to repairing the many different machines, and they are required to call upon the manufacturer for support. Support experts frequently have to travel a long way to resolve the problem, while explanations given over the phone are easily misunderstood. Data glasses provide a solution to the problem, since when employees put them on, their colleague at the manufacturer can post the relevant information right on the employee's display. The picture from the camera integrated in the glasses can also be relayed straight to the manufacturer, so that the person on that end has exactly the same view of the machine as the on-site technician.

Smart glasses can also make life a lot easier in the construction industry. For example, CAD

Researchers have also made the face recognition and analysis software into an app for Google Glass.
© *Fraunhofer IIS*



technicians used to have to rely mostly on their imaginations; now they can use data glasses to browse through their designs, view planned buildings from inside and out, and even take a look from the roof. When they turn their head, so too does the view – just as in real life. "It's a case of applying experiences from gaming to architecture," explains Oppermann. In another project, the researchers are installing a 360-degree camera onto a car roof. If the passenger is wearing smart glasses, they can see the images from the camera as the background, along with planned buildings or information on existing ones perfectly overlaid on top.

Help for autistic people

Findings from the Fraunhofer Institute for Integrated Circuits IIS in Erlangen open up more exciting possibilities. "We've been able to integrate software into the data glasses that automatically detects faces," says Dr. Jens-Uwe Garbas, group manager at the IIS. The program informs the user about each person's sex and approximate age, while also interpreting their facial expression: are they happy, angry, surprised or sad?

This could be very helpful for autistic people, who often have problems understanding other people's facial expressions and have a hard time recognizing whether the other person is happy or annoyed. Yet facial expressions are an extremely important part of communication. Smart glasses could help those with autism by telling them what the people around them are expressing with their faces.

Users see their surroundings as normal, except that the software marks all the faces and displays a bar chart underneath that indicates how they are feeling. The researchers are at great pains to point out that "although the software detects faces, it is not capable of identifying the person. In other words, it doesn't know who that person is," emphasizes Garbas. Autism support groups and research organizations that work with autistic people are voicing significant interest in the concept. The researchers have also received inquiries from smartphone manufacturers.

The face recognition is thanks to Software Shore™, short for Sophisticated High-speed Object Recognition Engine. Whereas previously it had only run on PC and, more recently, on smartphones and tablets, the researchers have now been able to compact it to the extent that it can be run even on such a small device as data glasses. "This opens up a whole range of applications – smart glasses are just one example of a miniaturized camera," says Garbas. For instance, it would be entirely possible to couple this software with car assistance systems.

Combining camera and software

Presently, one of the things the researchers are working on is encapsulating the software within a smart camera. This camera then no longer relays a picture, but only the information relating to sex, age and emotion. "This camera-software combination would be a sort of sensor, and thus a completely different kind of tool when it comes to data protection. The key here is privacy by design," explains Garbas.

Potentially, data glasses could transform society as did smartphones before them – after all, they offer enough useful and data-protection-compliant applications. ■

Programming is child's play

"Anyone can program - with Open Roberta!" That's the motto of the new online programming platform Open Roberta Lab. Schoolchildren can interactively create their own programs for robots free of charge and share them with others. The open learning environment, established through a partnership with Google, is designed to interest more girls and boys in technology.

Text: Katrin Berkler and Marion Horn

Programming Roberta robots is child's play.
© *Fraunhofer IAIS*

Intelligent robots, self-driving cars, smartphones as assistants to people – digital technologies are omnipresent in our society. "We need fine minds to shape our digital world; young people who understand technology, can program software and come up with innovative solutions," says Prof. Dr. Alexander Kurz, Fraunhofer Executive Vice President for Human Resources, Legal Affairs and IP Management. For this reason, Fraunhofer and Google jointly launched the web-based programming platform Open Roberta.

The project extends Fraunhofer's "Roberta – Learning with Robots" initiative, which introduces children and young adults to the STEM fields through play. "Open Roberta combines the successful Roberta educational concept with an innovative technological learning environment, one that makes programming easy to learn and that is open to exciting, creative experiments," says Dr. Stefan Wrobel, head of the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS. IAIS experts have been developing Open Roberta with support from Google, which provided the project with a million euros for a two-year period. "Google has been promoting computer science in education and training as well as encouraging open source software for many years now and with several initiatives," explained Dr. Wieland Holfelder, engineering director at Google Germany, regarding the IT giant's commitment. "We're very pleased to further expand our activities with Open Roberta."

More than 30, 000 kids are taking part in the Open Roberta project each year. © *Fraunhofer IAIS*

Anyone can program – with Open Roberta

In the Open Roberta project, Fraunhofer researchers have developed a freely available, cloud-based graphical software that enables children and young adults to have fun programming without having to overcome technical hurdles. The platform starts with the first programming steps and continues on through to the development of intelligent LEGO MINDSTORMS robots with all kinds of sensors and skills. In the future, it won't matter if kids access Open Roberta from a computer, a tablet or a smartphone. The platform can be called up easily using an internet browser, stores the written programs in the cloud, and makes complicated software updates superfluous.

This is particularly beneficial to schools, where IT maintenance is often associated with massive administrative effort. Besides which, many schools simply do not have sufficient resources to acquire powerful computers. The web-based software makes it possible for kids to work on their own programs both at school and at home, share them with others and tinker away on them together, independent of time or place. Tutorials for teachers working with Open Roberta will soon be made available, which address the different interests of girls and boys.

Open source development tools

Currently in beta testing, the Open Roberta software will be developed as open source. The next step is for IT experts from IAIS to actively involve teachers and educational experts from the Roberta network as well as universities and their students in the development process. "Working with universities simultaneously strengthens the project and provides practical programming experience for the students," explains Wrobel. By mid-2015, the software will be available without restrictions to everyone, allowing for the programming of additional robot systems, for instance. Both the software and the open source developer tools will be available on the Fraunhofer server. In addition, students from all over Germany can actively shape the Open Roberta programming environment by holding idea workshops and competitions.

Open Roberta also makes it possible for Fraunhofer IAIS to continue its longstanding collaboration with LEGO Education. LEGO Education is making 160 Open Roberta building kits available for further distribution in the various Länder. In cooperation with the D21 initiative and "Anyone can Program" initiative by Start Coding e.V., the project partners presented their work to the public for the first time on November 4, 2014.

Roberta – Learning with Robots initiative

Roberta – Learning with Robots is an educational program that has been helping to spark interest in the natural sciences and technology among children and adolescents for more than ten years. Launched in 2002 by the IAIS, the initiative receives funding from the German Federal Ministry of Education and Research (BMBF). Each year, the Roberta initiative reaches more than 30,000 young people through more than 800 documented Roberta courses. A comprehensive training concept as well as gender-appropriate teaching and learning material support teachers as they impart topics related to the natural sciences or technology in a playful manner. Regional Roberta centers and certified Roberta teachers make up a European network for sharing experiences and further developing the Roberta concept. ■

Getting viewers involved

In the future, TV will offer wide-ranging additional information, opportunities to interact with your TV and much more.
© *shutterstock*

TV is dead, long live TV! In the EU-funded "LinkedTV" project, 12 partners are working on developing new concepts.

Text: Bernd Müller

Once upon a time entertainment had its structure. In Germany on work days at 6 p.m. on the dot, the children's program Sesame Street was on and the 11:30 a.m. Sunday slot was reserved for "Die Sendung mit der Maus". Many of us still remember how this fixed programming used to shape our daily and weekly routines. But the linear TV schedule, where programs are broadcast only at a set time, is a thing of the past. Today four-year-old Julia is free to watch programs whenever she wants – or at least when her parents allow her to. She finds a knowledgeable helper in her mother, Heike Horstmann, since each day at home the researcher from the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS in Sankt Augustin is working in some way on ending the reign of linear TV. At the institute, Horstmann's work helps broadcasters tread the line between traditional TV broadcasting and the mighty Internet.

Horstmann is an expert on the second screen – the smartphone or tablet that an increasing number of viewers use while the TV (the first screen) is on. The second screen is a threat to TV broadcasters since it attracts attention away from the TV and negatively impacts advertising revenues. Broadcasters can't do anything about viewers surfing the net on a mobile device while watching TV, and that makes it all the more important for broadcasters to couple the second screen as tightly as possible to the first. If they don't, anyone with a tablet in front of them will quickly wander off onto Facebook or Amazon and will no longer be engaging with the show. The companies paying broadcasters for advertising don't want TV to become background noise, and that's why broadcasters bring out apps that are tightly interconnected with the show currently on the TV, offering extra information or prize competitions. As far as content goes, broadcasters already have enough, including old programs that sometimes go back decades in addition to the content on their own websites.

Automatic searching of TV content

Still, producing this kind of connection presents TV stations with sizeable challenges. Preparing the content so that an editor could select older videos relevant to the topic a few minutes before a program goes on air would require a huge editorial team dedicated exclusively to looking through material. At the same time, the

sheer amount of content keeps on snowballing – making for an impossible undertaking.

There's only one solution: the content has to be automatically processed, which is exactly what "LinkedTV," a project funded within the EU's Seventh Research Framework Programme, is working to achieve. Twelve partners, including TV broadcasters such as Rundfunk Berlin-Brandenburg (rbb) and research institutes such as the University of St. Gallen, are developing a platform to automatically "enhance" TV programs under the leadership of Fraunhofer IAIS. The software uses speech and text mining algorithms that search through huge stacks of video, radio and website content at lightning speed to recognize people, places, and themes in videos, articles and websites, and then makes suggestions as to what older material might fit in with planned new shows.

These algorithms are even able to locate specific objects or people within a video. To take an example: a TV broadcaster is planning a news piece on the resignation of Klaus Wowereit, the Mayor of Berlin. The software finds all of the past news stories that mentioned Wowereit, including those dealing with the problems in the construction of the new airport that precipitated his demise. It can also search external sources, notably Wikipedia. What's more, as soon as Klaus Wowereit appears in a story with a graphical insert displaying his name, his face is remembered for all further stories and will be marked with his name.

No substitute for human editors

LinkedTV is a great aid for editors – but it isn't designed to replace them. The software has its limits because only a human can assess a story's ultimate relevance. To return to Klaus Wowereit: one of the results the software returns in its search is the Wikipedia page for Berlin.

For viewers of Rundfunk Berlin-Brandenburg, the LinkedTV pilot user, this page is of little interest, since it's fair to assume that people living in Berlin are unlikely to have to visit the Wikipedia page for extra information. The editor is free to go into the LinkedTV editing system and move the page down the priority list – or even remove it altogether.
Editors define a "white list" to help them – a list of all the resources the software is authorized to search. In case of rbb the program is free to search through TV and radio pieces from ARD (a consortium of public broadcasters in Germany), and Wikipedia too, but not items from commercial broadcasters, since you don't want to end up directing viewers to the competition!

LinkedTV is enormously useful for editorial teams, but how do viewers benefit? Horstmann plays a demo, a British piece about whistleblower Edward Snowden's exile in Russia. A QR code pops up on the TV screen, which the IAIS expert photographs using an iPad. Immediately, the TV report begins, and the iPad displays information about Edward Snowden. Each time the scene changes, so too does the information on the tablet. If it's going too fast, a picture bar allows you to jump back to an earlier display, and the video on the TV screen jumps back in tandem. Alternatively, you can bookmark the page and review the chapter later. In other words, the first and second screen are tightly connected – which is exactly what broadcasters want.

What broadcasters don't want is for viewers to concentrate all their attention on the second screen and ignore the first. Still, that appears to be where it's going, says the IAIS expert. After all, having the TV show on one screen and just web content on the other is hardly a hard and fast rule. Zattoo and Horizon-TV have made it possible to watch TV on your tablet. And then Netflix recently made the jump into the German market; the powerful player is in the process of transforming itself from an online video rental shop into a full-blown online TV broadcaster. The only remaining advantage of the first screen is its size, which comes in handy when several viewers want to sit on the sofa and watch a film together. More and more often, though, they will use an online media player to do so. The old rituals, where the whole family would gather around the TV as they might gather around a campfire to watch "Wetten, dass…?" on a Saturday night are dying out. "In short, broadcasters are losing their unique selling point," summarizes Horstmann.

Smarter TV

What can we expect of TV in the future? Will we have TV on demand? Yes. Will second screens become commonplace? Perhaps, though not so fast, says Stephan Steglich of the Fraunhofer Institute for Open Communication Systems FOKUS in Berlin. He agrees with his colleague at the IAIS about the future of TV, though he places a different emphasis. The head of the FOKUS competence center for Future Applications and Media agrees that the amount of additional information provided in complement to TV programs will increase, but argues that this will also work to the benefit of the first screen. This is because of the Hybrid broadcast broadband TV standard (HbbTV) supported by many smart TVs. HbbTV is much more than a successor to the anachronistic teletext with its block-like lettering. The new standard transforms the TV into a personalized information device, in which TV programs play a prominent but by no means exclusive role. Broadcasters have the opportunity to display additional information not just on a small external screen but also on the big TV. Researchers at Fraunhofer FOKUS are currently developing a toolbox that allows small providers to create content for HbbTV as well. The number of broadcasters will continue to grow, and content and advertising will be tailored toward increasingly specific target audiences.

Other FOKUS's projects also center in on the first screen. For instance, the Berlin researchers are working on a technology that detects when a TV within a Wi-Fi network is turned on. If the user happens to be surfing the net on their tablet, this can automatically be made into the second screen and linked with the first. "It's our way of getting the Internet onto the primary screen," says Steglich. The plan is for the TV to become more than just a central media player; it will go on to act as the control hub for automated home functions, including the lights, washing machine and heating.

3D TV

Not that long ago 3D TV was the next big thing, though the hype has died down a bit since then, given that even benevolent technology enthusiasts have to concede that 3D glasses are uncomfortable and that the animated images are too dark and pixelated. "3D will find acceptance, but only once we get rid of the glasses," says Ralf Schäfer confidently. Schäfer heads up the department of Image Processing & Interactive Media at the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut,

Words like "Smart TV" and "second screen" represent the vision of networked and device-independent access to content whenever you want it. Now, Fraunhofer researchers are making their contribution to developing the standards needed to achieve that vision. © *Matthias Heyde / Fraunhofer FOKUS*

HHI. Key to the breakthrough are autostereoscopic displays catering to multiple viewers – technology that enables 3D TV without the need for glasses. The way this works is that the TV simultaneously provides each viewer with two views – one for the right eye and one for the left.

These sorts of displays have been around in prototype form for years. The transmission technology was a major hurdle. More images means more data – and sending up to 30 simultaneous projections of independent views would mean 30 HD channels, beyond the capacity of any satellite and TV cable provider. Fraunhofer HHI's solution was to develop the MVD standard. MVD transmits just one 3D image consisting of two independent stereo views plus information relating to depth. This contains the position in space of each pixel in the image. A specially designed set-top box then uses this information to calculate as many views as required, thus creating a glasses-free 3D image. If viewers tilt their heads, they see a different pair of images, and are able to look around objects in the picture from their sofa as if they were moving in a real-life space.

Ultra-high-definition TV

Still, MVD is just half the story. The stereoscopic partial images battle on the screen for the available pixels, which are always in short supply. If we imagine that a HD TV has to display 16 different images concurrently, the picture quickly crumbles away to a pixel quality not seen since pre-HD. Ultra-HD TVs boasting 4K or even 8K resolution can improve the situation dramatically, and as soon as 8K displays are introduced we can expect to enjoy 3D TV without glasses and in full HD. That's why Ralf Schäfer has no doubt that the trend towards higher and higher resolutions will continue – even without 3D.

Starting in 2016, soccer fans will be able to see the technology in action at the new International Federation of Association Football (FIFA) soccer museum in Zurich. Or they can see it at Fraunhofer HHI today. On the invitation of FIFA, the Fraunhofer experts from Berlin recorded the final of the soccer World Cup in Brazil with their own Omnicam. An Omnicam consists of ten HD cameras that work together to provide an impressive 360 degree panoramic picture with a resolution of 10,000 x 2,000 pixels. Once you've been to the HHI and seen the result for yourself on a 180-degree panoramic screen with seven HD projectors, you wouldn't want to watch soccer any other way. Adding to the experience is a wave field synthesis sound system from IOSONO, a spinoff from the Fraunhofer Institute for Digital Media Technology. The system has also come into the picture for live transmissions of Bundesliga soccer. At the last Internationale Funkausstellung IFA, Fraunhofer showcased a trimmed-down version with a 4K display, in which a tablet was used as a remote control that you could use to pan around a 360 degree panorama and zoom into the field. Whatever form TV takes in the future, the increase in the volume of data will be enormous. "That's great for us," says Ralf Schäfer of the HHI with a smile, "since our job at the institute is ultimately to develop techniques to compress video data." For instance, the HHI was at the forefront of the development of H.264 and also High Efficiency Video Coding HEVC – the standards that are used to broadcast HD and Ultra-HD content.

Idea catalysts

The Internet is slowly taking over the TV industry, too. "FIcontent" is a project that aims to bridge the gap between the two and unite research experts with the potential users of their technology. It is a flagship project within the Future Internet Public Private Partnership (FI-PPP), an initiative by which the European Union wants to drive the Internet of the future forwards in a variety of sectors, including health, energy and TV. FI-PPP has three phases; FIcontent is a phase-2 project set up to identify and develop TV technologies, and will run on until 2015. Meanwhile, phase 3 is already up and running. This is an opportunity for start-ups and medium-sized companies to submit their business ideas, which if successful, will receive support from backers in the form of expertise and funding amounting to up to 250,000 euros. One of these 16 backers is "EuropeanPioneers," which counts Fraunhofer IAIS in Sankt Augustin as a technology partner. Five start-ups are currently receiving backing, addressing the topics of smart-city services, social connected TV, pervasive gaming and e-learning. In 2015 they will be joined by ten more start-ups in two more rounds of applications. ■

Air cargo security check

Security has top priority in air cargo logistics, in which Johnson Controls are supposed to prevent hazardous substances from being smuggled on board. Screening procedures, such as x-ray scanning, are time-consuming and costly however. Easily verifiable features that can be used to cross-check the security status of cargo items are lacking at present.

Researchers from the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg are working with development partners and users, such as Panalpina, on a new approach.

In the joint project ESecLog they compile features such as 3D contours or RFID identifiers for every item of cargo in a shipment profile. In addition a marker has been developed that can be used to trace whether an item of cargo has already been x-rayed. An RFID seal is intended to make subsequent tampering with a shipment detectable during transit. This works by furnishing transponders with an ultra-fine safety wire. All the data collected can compiled in a shipment record. The experts plan to install the system in test environments this year.

Partners collaborating in the joint project are working on a digital fingerprint for security-sensitive air freight. © *Fraunhofer IFF*

Examining sewers

Are our sewers actually sound? A radar system detects the weak points in pipes – inside and out. © *Karl Thomas/dpa*

Pipes are usually checked only once there's a problem or when a building's walls are wet through. This means that wastewater can be seeping out unnoticed for years, polluting groundwater and damaging the soil. In order to help avoid such damage arising in the first place, experts plan to put Germany's public sewer system under the microscope.

Researchers at the Fraunhofer Institute for Nondestructive Testing IZFP in Saarbrücken are doing their part by developing a miniaturized radar system which works in the interior of the pipe. While an optical camera which is integrated into the system is inspecting the sewers for cracks, leakages or other hidden defects in the pipes, this radar system can additionally see the zone outside the pipes. It detects outflow, rocks or other hazards, all potentially problematic for the sewer system. The work is being funded by the German Federal Ministry of Education and Research.

Central stem cell biobank

Together with 26 industry and research partners, experts from the Fraunhofer Institute for Biomedical Engineering IBMT have launched a project to establish a central "European Bank for induced pluripotent Stem Cells (EBiSC)." This biobank will house cells collected from people suffering from a specific set of illnesses (http://ebisc.org).

With the help of human stem cells, scientists can gauge how people are likely to react to new drugs and examine the disease's progress. A new technique makes it possible for instance to reprogram adult skin or blood cells so that they behave in a similar way to embryonic stem cells and can become any type of cell.

By its three-year mark, it is hoped the new biobank will be in a position to offer over 1000 defined and characterized cell lines comprising a hundred million cells. Such quantities are needed because a single drug screening involves testing several million cells. The main biobank facility will be set up near London, and an identical "twin" that will contain a backup of all cell lines will be set up at the IBMT's Sulzbach location in Germany.

Food from lupines

German Future Prize

The German president's award for technology and innovation is presented to members of the research community in recognition of outstanding technological, engineering or scientific innovations. The prize, which is worth 250,000 euros, has been awarded annually since 1997. In 2014 German Federal President Joachim Gauck honored scientists from Fraunhofer IVV with the award.

www.deutscher-zukunftspreis.de/en

The prizewinners: Dr. Peter Eisner, Katrin Petersen and Dr. Stephanie Mittermaier. © *Ansgar Pudenz/ Deutscher Zukunftspreis*

From liver pâté to ice cream: Lupine proteins make food healthier. Newly developed processes supply flavor-neutral products that can be added to many foods without negatively affecting the taste. For their work on the subject, Fraunhofer IVV researchers were awarded the German Future Prize.

Text: Brigitte Röthlein

Red, pink, yellow, white and blue – lupines flower in all sorts of different colors. They flourish even in sandy ground, and their ability to fertilize soils has been common knowledge since ancient times. This capacity to enrich their environment comes from the symbiotic nodule bacteria attached to their roots, which fix nitrogen from the air. Thanks to their extensive tap roots, which can grow up to 2 meters long, they can also mobilize phosphate from deep underground and make it available for later plants.

Now scientists at the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising near Munich are working to ensure that, in addition to being pretty to look at and good for the soil, the lupine can take its place as an important nutritional component in the human diet. They have developed new methods for extracting proteins and fiber from the seeds of the plant so that they can be incorporated into people's diets. "When added to other foods, lupine proteins can lower fat and boost fiber content, thus helping to reduce consumers' blood cholesterol levels," says IVV researcher Dr. Peter Eisner, one of the pioneers in this field.

Food production uses special lupine varieties that do not contain alkaloids, the toxic substances responsible for their bitter taste. Scientists at the IVV focused their research on the sweet lupine, a plant that is rich in protein and that has the added advantage of flourishing in German soil. Their goal was to develop new methods for extracting proteins and fiber from the leguminous plant so that they could be incorporated into people's diets. A particular challenge they faced was finding a way to improve the taste of lupine products, and here it was food technologist Dr. Stephanie Mittermaier who achieved the decisive breakthrough when she identified the chemical bonds that give rise to the plant's bitter and "beany" flavors. "Armed with this knowledge, we were then able to develop processes for removing these unwanted substances from the products," she explained.

So how do you obtain flavor-neutral proteins from lupines? First, the seeds are shelled and processed into very thin flakes. Then they are de-oiled using supercritical CO_2, which behaves like a liquid at pressures above 74 bar and temperatures above 31 degrees Celsius. The majority of oils and their accompanying substances dissolve in the CO_2 without leading to products of lipolysis that taste rancid or of grass. Several aqueous extraction steps then follow to remove water-soluble bitter compounds and any other undesirable flavors. Only once these stages are complete do the scientists isolate the proteins. These high-purity proteins can be used to make more than just milk, cheese, ice cream and pudding. They are also an ideal base for cakes, mayonnaise, sausage products, creams and froths. This makes lupines excellent all-purpose plants that are suitable for flexible use in all kinds of different foods, especially vegan or vegetarian products. "Using lupine proteins in place of milk proteins enables us to make tasty vegetable milk, yogurt and cream cheese products that not only taste similar to conventional dairy products but also have the same mouthfeel," explains Peter Eisner. The process has now reached industrial maturity, and Dipl.-Ing. agr. Katrin Petersen is implementing it in practice. She is the CEO of Prolupin GmbH, a Fraunhofer IVV spin-off that manufactures and markets food ingredients made from lupine seeds.

For this groundbreaking research and their work on the subject, Dr. Mittermaier, Dr. Eisner and Katrin Petersen jointly received the German Future Prize 2014, a technology and innovation prize worth 250,000 euros that is awarded by the German president. "The award is very special for us, as it recognizes the excellent research work that our scientists do," says Professor Reimund Neugebauer, President of the Fraunhofer-Gesellschaft. "It proves yet again how our innovative spirit enables us to turn outstanding scientific findings into marketable products in a range of fields – while benefitting society as a whole."

Healthy lupine proteins have already found their way into a number of foods available on the market. These include Lupinesse, a newly developed ice cream available in several flavors that was launched back in 2011 by the IVV and German supermarket chain Edeka. Backstube Wünsche, a Bavarian bakery chain headquartered near Ingolstadt, Germany, also added a protein-rich "Lupinenstangerl" (lupine bread stick) to its product range in 2013. "More lupine-based products are set to follow in the future, among them additional milk substitutes, vegan yogurt, vegan cream cheese and gourmet food such as mayonnaise and curry sauces," Stephanie Mittermaier reveals.

Besides the health benefits, there is another advantage to using lupines as an ingredient in food that researchers consider even more important in the long term: It takes significantly less land to cultivate plant protein than it does to produce animal protein. Currently, the world's agricultural land is one-quarter pasture and one-third animal feed crops. Only a small proportion of the agricultural land goes toward the cultivation of plant-based foods – just seven percent in the U.S., for instance. Were one to reduce the amount of meat produced in the United States by a mere 25%, it would save enough grain to feed around one billion people.

"Our method for creating flavor-neutral plant proteins could improve the global food supply situation," says Dr. Stephanie Mittermaier. This is why Prolupin, based in the Land of Mecklenburg-Western Pomerania in northern Germany, is also looking to supply its lupine-based protein powder to food markets beyond Germany. Katrin Petersen has already built up a network of various contacts outside the country to promote the ingredients internationally – with the aim of benefitting not only global health, but also the world food supply. ■

Combatting periodontitis pathogens

Bleeding gums when biting into an apple could be a sign of periodontitis.
© *panthermedia*

In Germany alone, 12 million people suffer from periodontitis, an inflammation that can lead to the loss of teeth if left untreated. But that's not all: Periodontal disease is also suspected of causing other health problems such as cardiovascular disease. A European research network is studying the links and developing drugs to combat the pathogens.

Text: Britta Widmann

Bleeding gums during tooth brushing or when biting into an apple could be an indication of periodontitis, an inflammatory disease of the tissues that surround and support the teeth. Bacterial plaque attacks the bone, and deepening periodontal pockets gradually form that can cause teeth to loosen over time. Poor dental hygiene and smoking often trigger the inflammation, but unhealthy eating habits and psychogenic factors such as stress can also play a role.

If the disease remains untreated, the patient runs the risk of losing teeth. Once periodontitis has been diagnosed, the problem is treated by cleaning the surface of the tooth root and disinfecting the pockets. If the disease is particularly advanced, doctors will often also prescribe broad-spectrum antibiotics.

Periodontitis, formerly known as periodontosis, also acts as a focal point from which disease can spread throughout the entire body: If the bacteria, which can be very aggressive, enter the bloodstream, they can cause further damage elsewhere. Medical studies have proven the link between periodontitis pathogens and various systemic illnesses such as cardiovascular disease, rheumatoid arthritis and chronic obstructive pulmonary disease (COPD). It has been shown that sufferers are at increased risk not only of developing narrowed coronary arteries, but also Alzheimer's disease.

Researchers investigate aggressive bacteria

According to the World Health Organization (WHO), about 60 percent of adults suffer from gum disease requiring treatment. This worryingly high number is what led eleven European research organizations from nine countries to come together as part of the TRIGGER EU project to devote themselves to tackling the widespread disease. The project examines how periodontitis pathogens influence the systemic diseases mentioned above. The aim is to determine the relationship between periodontitis and other inflammatory diseases. Furthermore, the scientists are exploring whether effective oral hygiene and treating periodontal disease can positively impact overall health.

A special task within the joint project has gone to scientists in the Project Group for Drug Design and Target Validation, an external department of the Fraunhofer Institute for Cell Therapy and Immunology IZI based in Halle. The group is responsible for developing pharmaceutical agents for the effective treatment of periodontal pathogenic germs, and has been allocated one-tenth of the 7.8 million euro total funding budget to do so. The group, which specializes in identifying pathological mechanisms at protein level, will use these findings to develop and optimize the active ingredients. (For more information about the project group, see the "Well connected" box).

Primary pathogen colonizes periodontal pockets

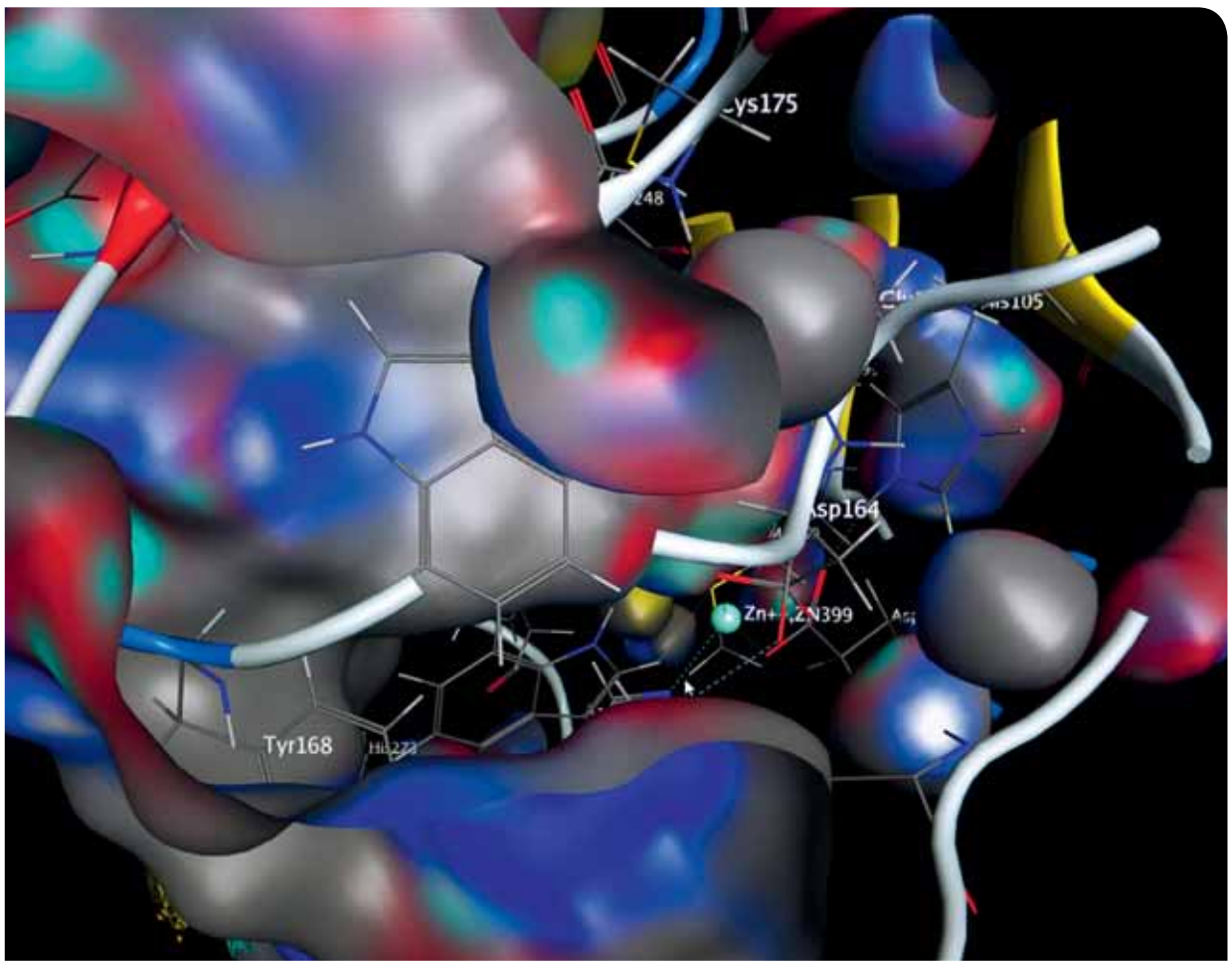
"We're looking for drugs to combat the highly toxic Porphyromonas gingivalis bacterium," explains Professor Hans-Ulrich Demuth, initiator and head of the project group in Halle. This aggressive primary pathogen lives in the periodontal pockets in the mouth and is responsible for gingivitis, the gum disease from which periodontitis can develop.

The pathogen thrives on the degradation of oral collagen. Porphyromonas gingivalis destroys gum tissue using protein-degrading enzymes – proteases – which it activates just before they are released in the mouth. To trigger this mechanism, the bacterium uses a specific enzyme involved in protein maturation called bacterial glutaminyl cyclase. This is what researchers are focusing on, as they hope to combat gingivitis by blocking this key bacterial enzyme and thus starve the pathogen. Professor Demuth and his

Well connected

The Project Group for Drug Design and Target Validation at the Fraunhofer Institute for Cell Therapy and Immunology IZI was opened in Halle 2013. Initiator and head of the project group is Professor Hans-Ulrich Demuth, an expert in protein research. For a long time, he headed a drug research working group at Martin-Luther-Universität Halle-Wittenberg, and later at the Leibniz Institute for Natural Product Research in Jena. During his time as CEO of the biotechnology company Probiodrug AG, his team developed a concept for the treatment of adult-onset diabetes that is available on the market today. The Land of Saxony-Anhalt and the European Regional Development Fund (ERDF) are financially supporting the project group's five-year development phase. Meanwhile there are already 40 employees working in the project group, a team that comprises biologists, biochemists, bioinformaticians, pharmacists and technicians as well as postgraduate and undergraduate students from Anhalt University of Applied Sciences and the universities of Halle and Leipzig. They are developing new drugs and test systems for drug research on behalf of or in collaboration with partners from the pharmaceutical and biotechnology industry.

TRIGGER, an EU project that aims to develop anti-periodontitis drugs, was launched shortly after the project group was founded. It is one of several projects that were able to raise a total of more than 750,000 euros of funding in the first year. Over the next few years, the project group also intends to complement the research work by expanding its regional network. "Our aim is to play an important role within the Halle-Leipzig metropolitan region for universities, higher education facilities, our sister institutions and industrial partners in Saxony and Saxony-Anhalt," says Professor Demuth, revealing the plan for the coming years.



The active center of the bacterial glutaminyl cyclase enzyme. © *Fraunhofer IZI*

team are therefore looking for an inhibitor that can reduce the enzyme's activity.

The Halle-based researchers characterized glutaminyl cyclase in mammals a few years ago, and discovered new properties of the enzyme. "It plays an essential role in immune overreaction in diseases and is involved in inflammatory conditions such as rheumatoid arthritis, COPD and Alzheimer's disease. Evidently there is a fundamental link between certain bacterial infections and various inflammatory diseases that still remains unclarified," explains Professor Demuth. "We believe that in Alzheimer's patients, for instance, human glutaminyl cyclase forms an amyloid beta-peptide variant that is particularly harmful to nerve cells." A treatment approach for Alzheimer's based on this idea is currently undergoing clinical trials.

The group has already achieved some initial successes. From a pack of 20 compounds, the scientists were able to filter out several highly effective substances that inhibit the growth of the pathogen Porphyromonas gingivalis by up to 95 percent when tested on a cell culture model. Animal testing is due to start soon.

New compound with no side effects

However, before a new product for treating periodontitis can enter the market, it still has to undergo a series of investigations and studies. The first step is to optimize the selected substances, followed by clinical trials to test in which form and amount the drug is administered best.

"This is a long, drawn-out process. But good oral hygiene alone is not enough to combat periodontitis. Additional medicinal intervention is necessary in order to prevent the Porphyromonas gingivalis bacterium from causing further inflammatory diseases," says Professor Demuth. Unlike conventional antibiotics, which dentists often use to treat advanced periodontal disease, the new product has hardly any side effects. "It's applied locally and does not pass through the liver. It targets only the affected area," Professor Demuth adds, describing the benefit of the concept. The research consortium aims to have completed all animal-based studies by 2016. The search for a partner to help market the drug is then planned to take place from 2017 onwards. ■

New Clinical Research Center

In the new Center, the Fraunhofer Institute for Toxicology and Experimental Medicine ITEM, the Hannover Medical School (MHH), and the Braunschweig-based Helmholtz Center for Infection Research (HZI) are offering their medical expertise in early-phase clinical and epidemiological studies for the first time under one roof.

Text: Tobias Steinhäußer

Seen from the outside, the new stair-shaped, four-story building looks more like a hotel than a clinical facility: patios and courtyards, terraces and a nice garden, in addition to natural daylight and a diversity of pastimes such as cinema and gym in the interior. Yet the CRC Hannover is no hotel. It provides an important interface between basic research and marketing authorization of new drugs and medical devices – "translational research" is the technical term for this. The focus is on novel concepts for early-phase clinical trials of phases I and IIa. In these phases, new drugs and medical devices are used for the first time in healthy volunteers and patients, to test them for efficacy and possible side effects in humans. The results of these trials are decisive in whether or not a new drug or medical device receives approval from the authorities. The CRC Hannover excels particularly in its size, the quality of its services and equipment, and the pooling of scientific, medical and epidemiological know-how.

The CRC Hannover has a floor space of 6000 square meters, located next to the Fraunhofer ITEM buildings and in direct vicinity to the MHH. It includes an outpatient section for screening visits and studies that do not require study participants to stay overnight, and a total of 50 beds for accommodation and monitoring of patients and healthy volunteers. First studies have already been initiated: In July, the Fraunhofer ITEM began to test a new nasal spray for treating allergic seasonal rhinitis. The institute's Environmental Challenge Chamber is also used for these tests. In particular in the context of respiratory diseases such as seasonal rhinitis, asthma, and COPD, the ITEM scientists are at the forefront.

Research activities of the MHH

The MHH has begun a study in the CRC Hannover that was initiated by its Institute for Clinical Pharmacology, aiming to investigate the effects of a novel diabetes drug on cardiac function. Further clinical trials in close cooperation with the MHH Clinic for Ophthalmology and also studies in the early development phases I and II in cooperation with the MHH Clinics for Neurology and for Immunology and Rheumatology are about to be started.

"This cooperation of excellent research institutions and a leading medical university allows us to perform a large diversity of clinical studies and to offer a broad spectrum of diagnostic and imaging techniques," said Professor Norbert Krug, Coordinator of the CRC Hannover and Fraunhofer ITEM Medical Director.

On 400 square meters of floor space, the MHH is setting up one of the most modern biobanks in Germany in the CRC Hannover. Biomaterials from patients and healthy volunteers will be stored there under high quality and safety standards. In another part of the CRC Hannover, a 500-square-meter imaging center is being set up under the direction of the MHH radiology departments. A first magnetic resonance imaging (MRI) scanner was already installed in April, further equipment will follow. "The CRC provides a perfect basis for top-quality, science-based and safe performance of clinical studies. In the first place, the CRC enables testing of drugs and medical devices in the early stages of the development process. It thus sets the stage for urgently needed innovations in the field of medicine, under optimal structural conditions. At the same time, it symbolizes the strength of the MHH's cooperation with two important non-university research institutions, Fraunhofer ITEM and HZI," said Professor Christopher Baum, MHH President.

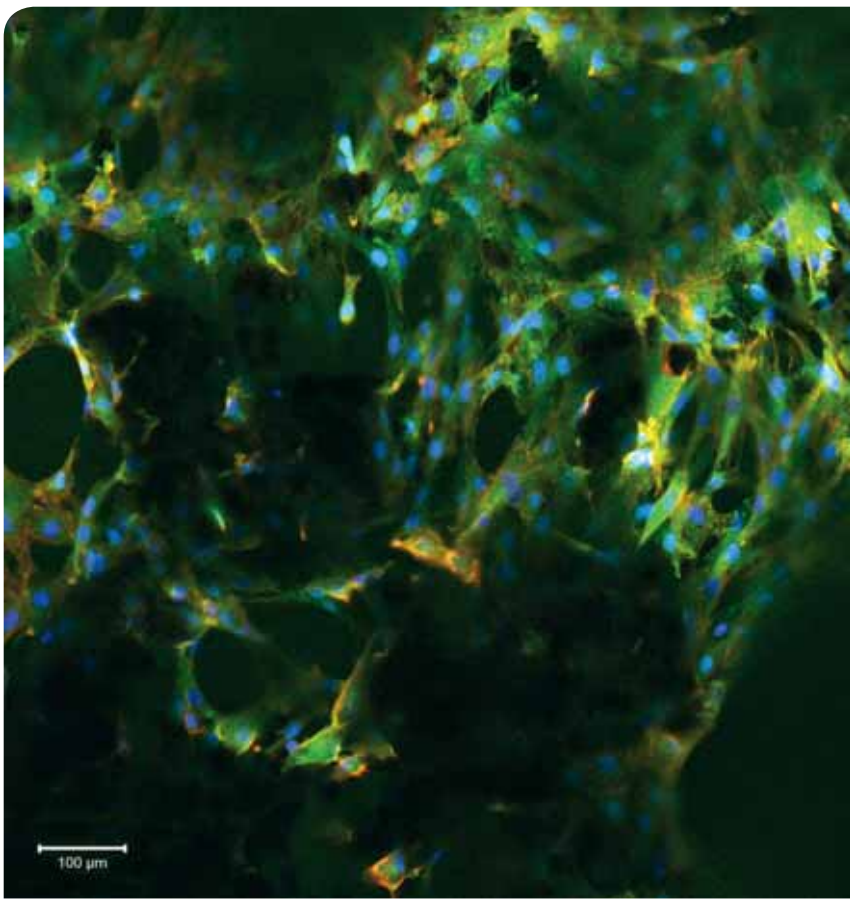
In May, the HZI started examining the first study participants of the "National Cohort" study in the CRC Hannover. Germany's most comprehensive epidemiological study is intended to provide data facilitating early detection, prevention, and treatment of wide-spread conditions such as cardiovascular diseases, cancer, diabetes, dementia, and infections. In addition, HZI scientists will perform studies in the CRC Hannover to investigate infectious diseases and disorders of the immune system. "The CRC is a good example of the close dovetailing of the different research institutions based in this region: HZI, MHH, and Fraunhofer ITEM will do research for human health together here in the future," said Professor Dirk Heinz, HZI Scientific Director. ■

The new Clinical Research Center Hannover provides an interface between basic research and marketing authorization of new drugs and medical devices.
© Fraunhofer/CRC Hannover

Toolbox for new bones

As part of an EU-funded project, researchers have developed a toolbox concept for making bone implants.

Text: Monika Weiner



Time heals all wounds, or so the saying goes. And the truth is that nature's healing powers are amazing. If you break your shin bone or cut your finger, chances are you'll be good as new in just a few weeks. But the body's powers of regeneration do have their limits. If in the course of removing a tumor surgeons also have to remove part of your jaw bone, if your bones are badly damaged in an accident, or if your bones have degenerated due to poor circulation, waiting for the damage to heal is not the answer. Restoring form and function to bones calls for implants. In the past, surgeons would replace missing material with metal or tissue harvested from your pelvic bone.

Ferrari or Range Rover?

"Both of these approaches have their disadvantages: metal remains a foreign body and no new bone will ever grow over it. Pelvic bone material happens to be ideal, but here we have the problem that we can harvest only a very limited amount," explains biologist Heike Walles. As well as being professor of Tissue Engineering and Regenerative Medicine at the University Hospital of Würzburg, Walles is also head of the Regenerative Therapies for Cancer and Musculoskeletal Diseases at the Würzburg branch of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB.

In collaboration with 19 scientific teams from four countries, Walles spent five years researching alternative treatments as part of a 12-million-euro EU-funded project – VascuBone.

What the project has come up with is not a bone substitute, but rather a collection of different components – a toolbox for regenerative medicine.

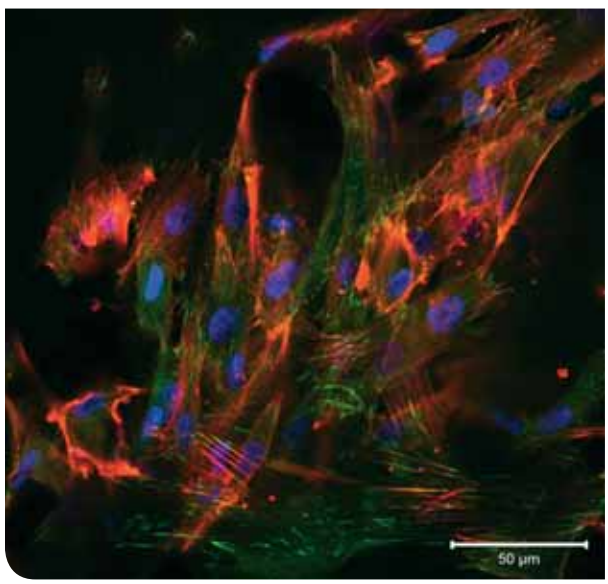
"It's impossible to find a universal bone substitute – one that works in every case," says Walles. "Just as you wouldn't use the same car to race in Formula One as you would to cross the Sahara, surgeons can't use the same materials to treat any patient with any condition." Thanks to the toolbox developed as part of the VascuBone project, in the future surgeons will have the components they need to custom-build the right implants.

As easy as one, two, three

Centerpiece of the surgical toolbox is a new material that is easily accepted by the human body and integrated into bone tissue. Walles reports: "We experimented with a variety of materials, but we got the best results with a diamond-coated, large-pored ceramic granular material. It's biocompatible and stimulates bone-cell growth." Next to this material in the

Cells growing on calzium phoshate: sceleton of the cell (red), connecting material (green) nuclei (blue)
© *Fraunhofer IGB © Fotonachweis*

Cells growing on diamond coated granular material. sceleton of the cell (red), connecting material (green) nuclei (blue) © *Fotonachweis*



The project partners

- Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB, Germany
- Royal Institute of Technology KTH, Sweden
- DiaCoating GmbH, Austria
- University of Uppsala, Sweden
- University of Bergen, Norway
- Julius-Maximilians-Universität Würzburg, Germany
- University of Innsbruck, Austria
- Medical University of Innsbruck, Austria
- MRB Research Center, Germany
- nanoPET Pharma GmbH, Germany
- PP-Polymer AB, Sweden
- Medicyte GmbH Heidelberg, Germany
- Topass GmbH Berlin, Germany
- Evonik Industries, Germany

toolbox are proteins, which promote bone growth and are harvested from the individual patient's blood.

The third component is made up of cells from the patient's blood or spinal marrow, which ensures that the body does not reject the implant. These cells are cultivated in a bioreactor at temperatures similar to those found in the human body. The cells thrive in this familiar warmth, multiply and ultimately cover the granules entirely. The scientists developed a special delivery system for the treatment made out of a piece of sterilized pig intestine. They fill this with the granules and use the tissue's tubular veins to supply blood.

In the future, these three components are to afford surgeons greater flexibility – small defects could be repaired by sprinkling just the granulated powder, but should it be necessary to reconstruct larger sections, the toolbox provides surgeons with everything they need to custom-build biocompatible implants.

To find out whether the new bone substitute materials really are as good as they sound, the researchers held preclinical trials. Experiments carried out in Austria, Sweden and Norway indicate that the implants do not accelerate tumor growth. And to ascertain whether the new material would also be suitable to help regenerate bones that have weakened due to old age, Christoph Rückert from the IGB took the three components and the bioreactor to Australia. "Here we had the opportunity to test the implants on particularly old sheep," says Rückert. "What we learned was that our implant works well for older subjects whose bone growth has slowed."

Supporting innovations

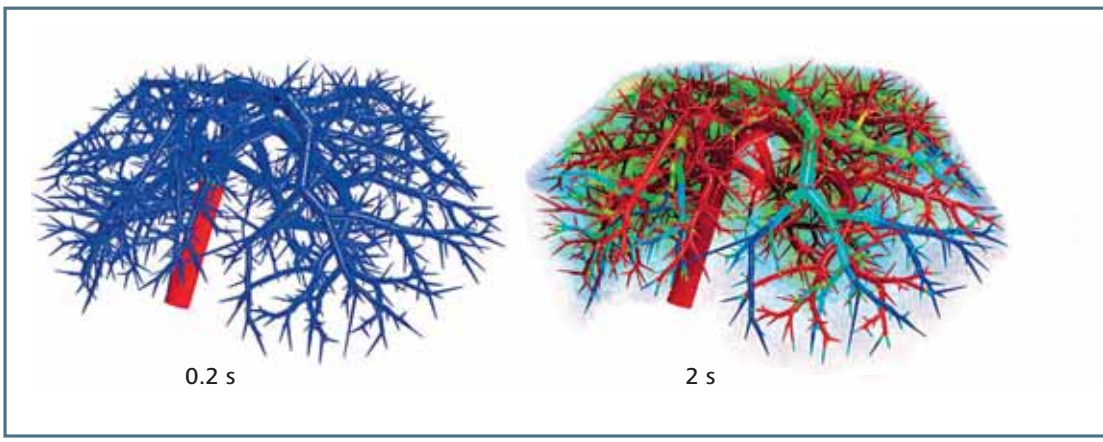
While the scientists were refining their toolbox, engineers and technicians at various companies were working on product development, production processes and imaging techniques. Medicyte GmbH in Heidelberg, for example, optimized cell cultivation. Experts at the MRB Research Center in Würzburg developed new coils for MRI visualization. And a spinoff of the VascuBone project has the expertise to custom-manufacture the implant materials.

By now the toolbox has successfully completed all preclinical trials and the granular material has received CE certification. This marks the conclusion of the VascuBone project and heralds the start of clinical trials. As soon as these are complete, people will start to benefit from this new bone substitute. ■

Virtual blood flow

A new computer process simulates liver metabolism.

Text: Frank Grotelüschen



Simulation of contrast injected into a liver.
© *Fraunhofer MEVIS*

Picture a bare, thorny treetop – a trunk splitting off into ever finer branches. All of it is deep blue at first, when a glowing red suddenly shoots up from the bottom and within seconds has reached the tips of almost all the branches. The trunk begins to change color again, with blue regaining the upper hand. It gradually reconquers the thorny tangle, and after 30 seconds, everything is as it was.

This colorful ballet is being played out on a screen at the Fraunhofer Institute for Medical Image Computing MEVIS in Bremen. Mathematician Ole Schwen explains what just happened: "The branch-like system represents the blood vessels of a mouse's liver. We injected a dye for two seconds and saw how it is distributed through the liver before being flushed out."

What is remarkable here is the computer simulation that allows Schwen and his colleagues to realistically simulate blood flow in the liver. Though still a prototype, the simulation software could someday help both to design new drugs and to plan treatment for people with liver disease. Experts at Fraunhofer MEVIS developed the underlying model in collaboration with Bayer Technology Services and RWTH Aachen University as part of Germany's national Virtual Liver research network.

From airplanes and cars to life sciences

Computer simulations have been established tools in industry and technology for quite some time. Airplane manufacturers use them to help analyze airflow around wings, automakers to improve crash performance of car bodies, and chemical companies to model entire process chains. This can save these businesses from having to carry out expensive series of tests using miniature or full-scale models. When it comes to medicine and life sciences, however, the use of such simulations remains much less widespread. Biological metabolic processes tend to be considerably more complicated than technical ones, which tends to make them more difficult to model digitally.

Although pharmaceutical companies are already using computer models of the human body to develop new drugs, according to project manager Professor Tobias Preusser, "these models are still rather basic. An organ such as the liver is treated as a kind of black box in which only a handful of mathematical equations are used to describe what goes in and what comes out." Obtaining a realistic picture of the complicated and diverse metabolic processes remains the exception rather than the rule.

The liver performs several important tasks – it stores vitamins, produces essential proteins and cleans the approximately 90 liters of blood that flow through it every hour. To simulate this blood flow in detail, Fraunhofer MEVIS experts start with a high-resolution 3D computed tomography image of the liver. They use that to create a detailed reconstruction of its vascular system: the trunk that splits off into finer and finer branches. The researchers then divide this image into 50,000 virtual blocks, each one mapping the behavior of several thousand cells.

10 s

Concentration

The Virtual Liver Network

The goal of the Virtual Liver Network is to better understand the liver in order to develop new options for diagnosis and treatment. A total of 70 working groups at 41 hospitals and research institutions are working on computer models that can provide detailed simulations of the processes at work inside the liver. For the first time, the full spectrum of scales is being brought together –molecular, cellular, organ and body. The Fraunhofer MEVIS method for simulating blood flow is a key component of the project. The German Federal Ministry of Education and Research (BMBF) began funding the network in April 2010 and has committed 43 million euros over a five-year period.

www.virtual-liver.de

Now the researchers can run the simulation. Each virtual block becomes a model not only of blood flow, but also of the exchange of materials between blood and cells, including certain metabolic reactions. Once all this has been mapped, the software collates the data from all 50,000 blocks to produce a complete simulation. "By splitting the virtual liver into these small blocks, our process can simulate what's actually going on inside the liver," explains Preusser. "This is particularly useful for livers that have suffered damage in places."

What happens in diseased parts of a liver?

Take the example of a fatty liver, which is most commonly a result of overeating. Fat building up in the liver can lead to the dreaded condition of cirrhosis. "But often only certain areas are affected and not the entire liver," explains Schwen. "That's exactly what our simulation software can show." What you see is that some of the 50,000 virtual blocks are "healthy" and work exactly as they're supposed to. Others are fatty and have limited function, which can be seen in the simulation by injecting a contrast agent. The MEVIS software can also simulate metabolic reactions triggered by medication, in healthy and fatty livers as well as in those that have already been damaged by an overdose of common painkillers (paracetamol).

How can we know the picture is accurate?

But how can we guarantee an accurate picture of the complex processes going on in the liver? "To ensure we're on the right track, we have to perform tests on real livers. This involves injecting an agent and observing what happens as closely as possible," says Schwen. "We can then see how realistic our simulations are by comparing them with these physical experiments."

During this validation process the MEVIS researchers are also working on adapting their software to simulate human livers. Since these work differently in some respects from a mouse's liver, the experts are having to adjust several parameters in their algorithms.

Blood flow simulation has the potential to become a valuable research tool. "When a pharmaceutical company is developing new drugs, simulations could help estimate how they perform," says Preusser. "Further testing would then be reserved for the most promising new drugs." The hope is that this would lessen the need for animal testing and for expensive clinical trials.

The new software could find its way into doctors' offices and hospitals. Preusser describes the idea: "We could show how each patient's liver is likely to change over time, and discover if a patient with a fatty liver is primed to develop cirrhosis or even liver cancer." And once a diagnosis has been made, the simulations could also facilitate treatment by indicating the right drug and dosage for a given patient. ■

www.fraunhofer.de/en/press/audio.html

Researchers investigate ways to minimize energy consumption at Roma-Fiumicino airport.
© *mauritius images/Alamy*

Saving energy before take off

How can we make airport terminal buildings more energy efficient? An international team of researchers is working to find the answer.

Text: Monika Weiner

Cascade project partners:

- The Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany
- Projects in Solar Energy PSE AG, Freiburg, Germany
- D'Appolonia S.p.A., Genova, Italy
- National University of Ireland, Galway, Ireland
- Enerit Limited, Galway, Ireland
- Sensus Mi Italia S.r.L., Italy
- Societa per azioni Esercizi Aeroportuali SEA Spa, Milan, Italy
- Institut Mihajlo Pupin, Belgrade, Serbia
- Aeroporti di Roma Spa, Italy

Glass façades, marble flooring, elevators that glide silently up and down, lighting that is bright but never brash: 21st century airports are palaces, designed to handle hundreds of thousands of people a day without making them feel like they are being processed en masse. Architecturally pleasing spaces with a constant climate ensure passengers feel comfortable 24 hours a day, every day of the year. A plentiful selection of shops, lounges and restaurants make unavoidable delays a pleasant experience.

Behind the luxury of the modern airport building lies an elaborate logistical and technological concept. "But the amount of thought that has gone into planning the energy balance of such structures still leaves a lot to be desired," explains Nicolas Réhault of the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg. "An average-sized airport consumes as much energy for heating, cooling and lighting as a small town with a population of several hundred thousand people." The scientist knows what he's talking about, since he spent three years collecting data and working with partners from four countries to develop concepts for reducing energy consumption.

A look at the statistics demonstrates just how important this is. Air traffic in Europe has increased steadily in recent years and is set to continue growing, with experts predicting about 20 million flights a year by 2030 – more than twice as many flights as there were a few years ago. This will inevitably lead to an increase in energy consumption, and – assuming we continue to rely predominantly on fossil fuels – a rise in carbon dioxide emissions as well. But this is not compatible with the EU's climate objectives. Conclusion: Savings must be made. Not only in terms of aircraft weight and engine technology, but also where buildings are concerned. That's why the EU is supporting the CASCADE project coordinated by Mr. Réhault.

Quest for the ideal solution

Nicolas Réhault was aware from the outset that there was no cure-all solution to the problem: "Every airport is different. Most have developed over decades, with new buildings being added all the time, so energy management is usually a piecemeal affair. We need to identify a wealth of details in order to analyze the situation and be able to make recommendations."

Quite how complicated that can be became apparent to the engineer on his very first trip to Italy. Together with a team of specialists, he visited the airports of Milan-Malpensa and Rome-Fiumicino – two bustling hubs of the Italian aviation industry that have to handle hundreds of thousands of passengers on a daily basis. The delegation of experts received a friendly welcome at both airports, where they were shown around and given explanations by helpful facility managers. "There were mountains of plans, schematic drawings and descriptions of the technical systems, but a lot of important information, such as the technical data for fans, pumps and motors, couldn't be found," Réhault recalls. He wasn't surprised to discover that the documentation was incomplete. "These days, missing paperwork is more the rule than the exception. Constructing a building is a very complex business. It's not unusual for information that is important for evaluating the building's energy consumption to get lost along the way between the design, planning and operational stages of the construction process."

Whatever information could be collected was collated and analyzed at the ISE in Freiburg. The computer scientists used the documentation to develop algorithms that could automatically detect operational errors and pass these on for processing by higher-level energy management software. "Our first objective was to establish and automate these links, while at the same time developing immediate strategies for ways to resolve any defects," says Réhault.

In the airport terminal buildings in Milan and Rome, researchers installed hundreds of sensors that document the operation of ventilation systems, cooling units and heating systems around the clock. The data is transmitted to Freiburg via the internet, where the computer scientists use the measurements to test and optimize their algorithms. This allows them to identify areas in need of improvement, for instance by spotting if one part of a building is being heated while another is being cooled. Or by identifying instances where ventilation systems are running at full speed because the sensors for monitoring and controlling the climate are providing false information. Energy is also wasted when air conditioning sytems are cooling and heating simultaneously. "The devil is in the detail here," says Réhault. "Unfortunately, more than anything it tends to be the little defects that get overlooked for years during routine operation, as there are currently hardly any centralized systems for capturing and analyzing all the data."

In the future it will be easier for the operators of airport buildings to prevent this waste of energy. A software manufacturer involved in the CASCADE project has developed an ISO 50001-compliant energy management program that is currently being tested at Milan and Rome airports. The software allows users to identify energy-saving measures, and helps work out how these can be implemented, planned and monitored. The new computer program was linked to an online tool developed at the ISE that visualizes the operation of the building. A quick glance at the screen allows facility managers and handymen to see if a sensor has failed anywhere or if a pump is defective. The system then also provides an immediate diagnosis, which helps simplify the maintenance work required. But this is only the beginning, as the team of Fraunhofer researchers are also working on new algorithms that will allow users to improve the way a building operates with even greater speed and ease. "Our calculations show that the energy consumption of individual systems can be reduced by up to 20 percent if their operation is continuously monitored and optimally regulated," says Réhault.

It will take more than just a reduction in energy consumption, however, if air travel continues to boom at the current rate and the EU still wants to achieve the climate goals set out in the Kyoto Protocol. A 20-percent reduction in greenhouse gas emissions by 2020 is possible only if the use of renewable power sources goes up. A survey conducted by CASCADE researchers indicates that many airports have already begun transitioning to new energy policies. Some operators, for instance, are already using waste heat generated during bio-diesel production to heat buildings, and photovoltaic systems to generate electricity. In the next few years, there are plans for numerous investments in renewable energy sources.

With its ability to facilitate maintenance and help users save energy, the new software fits very well into this overall concept. "Basically, the methodology developed as part of the CASCADE project allows users to reduce energy consumption and optimize any building," explains Réhault. There's a simple reason for the experts' decision to begin by focusing on airport buildings: as buildings, they send a clear message. "Airports are the beacons of building technology, visited and seen by millions of people. There is no better place to publicly showcase successful energy saving concepts, innovative buildings technology and building management systems," says Réhault. "If Europe wants to protect the environment, then airports are the best place to show people what we're currently able to achieve." ■

Substance with a future

Japan has been considered one of the world's largest industrialized economies for several decades now. To stay competitive in the future, Japanese companies are searching for new and efficient manufacturing technologies. "Above all, networked product development and production, what's known in Germany as Industry 4.0, has attracted a great deal of interest," said Ivica Kolaric from the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart.

Recently, the Fraunhofer Project Center for Electroactive Polymers opened in the Japanese city of Kansai. Together with scientists from the National Institute of Advanced Industrial Science and Technology AIST, Fraunhofer researchers at the center are developing a new and very promising material for producing inexpensive electronic components. "Electrically conductive polymers that contain carbon nanotubes are ideal for creating electronics components for energy conversion and energy storage systems, for example," explains Kolaric, the new Project Center's deputy director. He believes the low material costs to be the greatest advantage offered by the electrically conductive polymers: carbon is present on the Earth in nearly unlimited quantities.

Lightweight and stable

Innovative technologies are the only way to ensure that Europe remains a premium industry location in the long term. Lightweight construction concepts look particularly promising. Thanks to new materials, cars, machines and the like can be built to be slimmer and lighter – saving on resources and energy without having to compromise on safety.

But such light and thin materials – high-strength steels, for example – must be extremely tough. However, the testing of material properties, best done during the manufacturing process, has thus far not been possible.

Now, researchers at the Technical Center for the Mechanical Industry CETIM, one of the Carnot institutes in France, have been collaborating with experts from the Fraunhofer Institute for Nondestructive Testing IZFP in Saarbrücken to develop a new kind of testing system. MAGNUS makes use of two methods for investigating material properties – a micromagnetic method and an ultrasound technique. "The micromagnetic method allows us to determine properties such as hardness, tensile strength and internal stress. Ultrasound testing informs us about the material's texture, a critical factor governing the material's deformation characteristics during the deep drawing process," explains Dr. Klaus Szielasko, who is leading the MAGNUS project at IZFP. The German-French research team has already put the first three testing systems into operation.

Train station security

Train stations can be difficult to navigate – not just for travelers, but also for security and emergency services personnel. Although state-of-the-art surveillance and emergency call technologies are helpful for planning and carrying out operations, the various security technologies have so far often proved incompatible. The EU project Secur-ED is intended to remedy this and make European train stations safer.

Secur-ED stands for SECured URban transportation – European Demonstration. With 39 partners and a budget of 40.2 million euros, it is one of the largest demonstration projects in European security research.

"Most large cities already use a lot of sensors – video cameras, for example – and have control centers for mass transit security. So we started off by analyzing where the tasks for participating partners as well as the existing IT systems are," said Dr. Wolf Engelbach, project manager at the Fraunhofer Institute for Industrial Engineering IAO. "Then we created a concept that describes how participants can best exchange information in critical situations." To that end, they developed a table with a multi-touch screen that the various players can use to select data, make it available to the partners and evaluate the information together.

The new solutions from Secur-ED have already been tested by the researchers in ten train stations including ones in Berlin, Madrid, Milan and Paris.

Decentralized energy

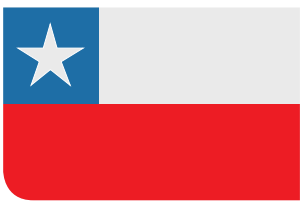
China's economy is growing. To meet the country's rising energy needs, the government is relying more and more on renewable sources. Small hydroelectric plants with a capacity of 1 to 10 megawatts have been built in rural areas since 2003 to guarantee an environmentally friendly, decentralized power supply. The first pilot plants are already in operation, and over a thousand hydroelectric plants in 24 provinces are to be built by 2015.

The environmental, economic and social impacts of the new energy supply system are being examined by the German-Chinese research project HAPPI, coordinated by the Advanced System Technology AST branch of the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB. Also joining the fun are the Fraunhofer Institute for Systems and Innovation Research ISI as well as three small or medium-sized companies from Germany. Together, the project partners are studying ways to minimize negative effects on the flora, fauna and landscape. Engineers are also developing new technical concepts for the hydroelectric plants.

Logistics without borders

Gelderland is the biggest province in the Netherlands and has traditionally been a hub for the transportation of international goods: cargo from the port in Rotterdam passes through the region on its way to buyers in Germany and Eastern Europe. It's also the place where native and imported foodstuffs – from Dutch tomatoes to cheese – are packaged and dispatched. For food-chain managers and agricultural logistics specialists, this is an enormous challenge.

Now they are to receive support from researchers at the Agrarlogistics Support Center. Here, researchers from the Fraunhofer Institute for Material Flow and Logistics IML are working together with Dutch colleagues from the Universities of Arnhem, Nijmegen and Wageningen to develop new, efficient and rapid logistics solutions tailored to the needs of the food industry. The experts offer the latest expertise in addition to technical and business consulting to companies that process and transport food products.



Mining special

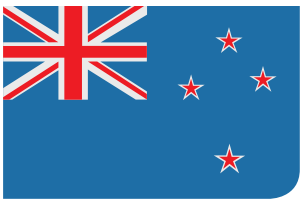
Chile is one of the leading exporters of raw materials in South America. Not only does the country boast the biggest copper reserves in the world, it also has access to iron, manganese, lead, zinc, molybdenum, gold and silver. Even so, natural resources are finite and at some point they will run short. In a bid to achieve long-term sustainable growth, the Chilean government is currently funding new and efficient exploration and processing techniques in addition to renewable energy systems. These are areas in which European expertise is very much in demand.

A memorandum of understanding has now been signed at the third German-Chilean Raw Materials Forum in Berlin, attended by Chile's President, Michelle Bachelet. In it, Chile's energy minister Máximo Pacheco and director of the Fraunhofer Institute for Solar Energy Systems ISE Prof. Eicke Weber have agreed to found a second Fraunhofer Center in Chile. The new "Center for Solar Energy Technologies" is to develop technologies for the use of solar power and solar heat and for water treatment. The second Fraunhofer Center will be based at the site of the Chilean Fraunhofer subsidiary Fundación Fraunhofer Chile Research, as is the existing Center for Systems Biotechnology.

The price of change

Transitioning to renewables costs money – but is making the investment going to jeopardize a company's ability to compete? That's the question Dr. Barbara Breitschopf from the Fraunhofer Institute for Systems and Innovation Research ISI set out to investigate. Together with the research company Ecofys, she has studied the breakdown of energy prices in selected EU countries and examined to what extent big energy consumers receive favorable treatment.

The findings suggest that the price of energy depends primarily on the stock market energy prices in that country. In Germany, the price is comparatively low, since the main source of energy is cheap coal, while the significant market share for renewables also puts pressure on prices. France has even cheaper prices due to the prominence of nuclear energy, while prices in the Netherlands and the UK, which rely heavily on natural gas, are correspondingly higher. In Germany, large-scale consumers are largely exempt from transport, distribution and transfer costs, as well as the renewable energy levy and taxes. This means energy-intensive industry obtains its power at prices that are not necessarily higher than those of competitors in other European countries. Levy relief for energy-intensive operations is something that exists in other countries as well – though these special conditions are not always regulated to the same degree and set out as transparently as is the case in Germany.



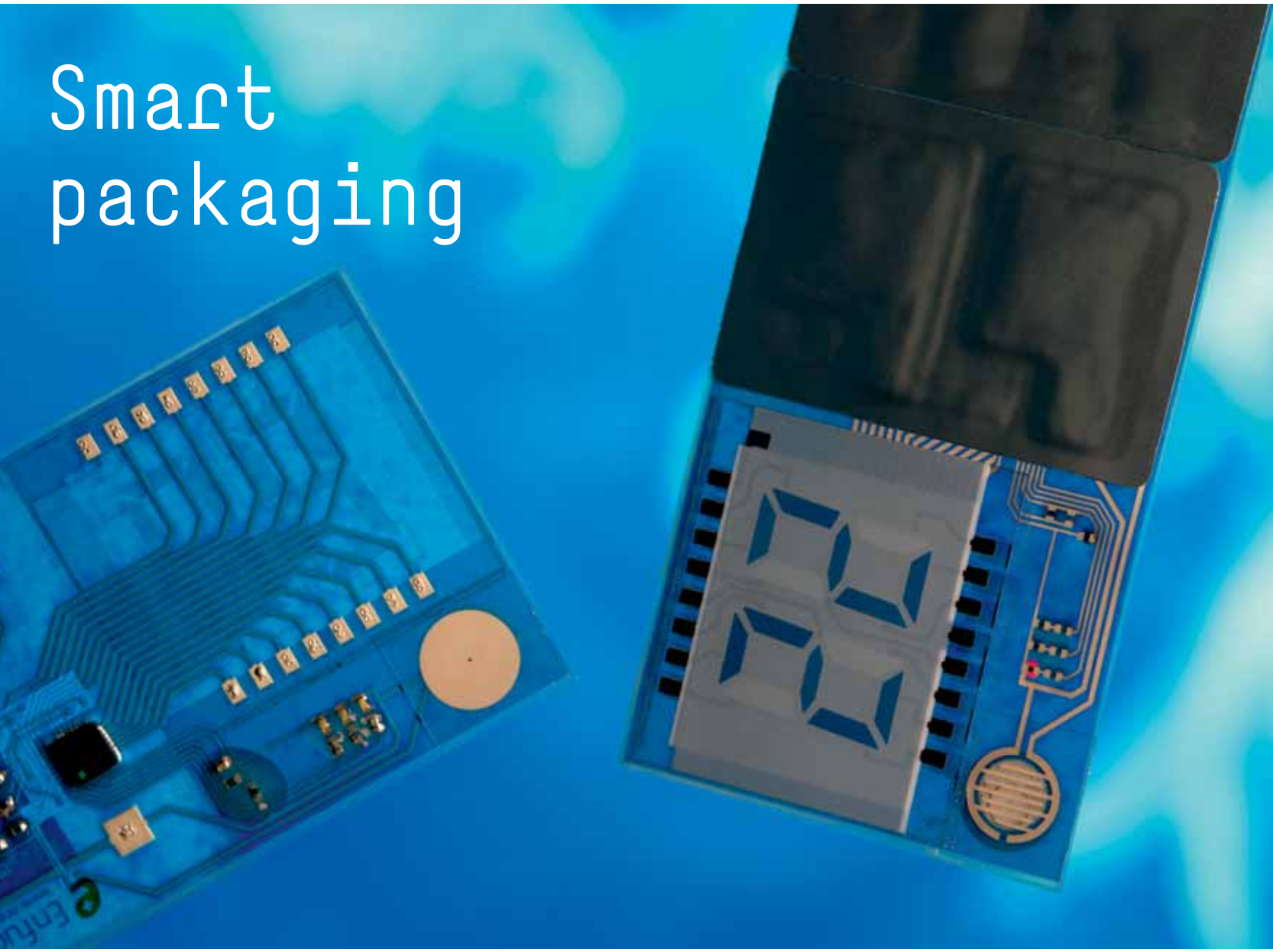
Bionics for humans

People are living longer. As medical care has advanced over the past decades, life expectancy has shot up in most countries around the world. One of the results of this development is an increase in age-related afflictions such as worn-out joints.

"To combat the problem, we need to first understand the loads placed on the human body, and provide it with active support. At the same time, we need to develop exoskeletons that help patients in their daily lives," explains Dr. Urs Schneider, head of department at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA.

Together with a team of researchers from New Zealand, he wants to give real impetus to the development of this new technology over the next three years. The goal is to develop a sensor-equipped bandage that evaluates movements as well as a motorized exoskeleton to help in getting around. "Both products must be small, light, intuitive to operate and well-adjusted to people's movements," says Schneider. "We still haven't seen a market-ready arm orthosis, for instance," says Professor Peter Hunter from the Auckland Bioengineering Institute of the University of Auckland, New Zealand. "Our project ideas for developing market-ready othosis would also be a milestone for bionics."

Smart packaging



Film system for measuring and displaying temperature. © *Bernd Müller/ Fraunhofer EMFT*

Until now, it's mainly been about mechanics – a protective layer. But in the future, packaging will also give consumers additional information about the product and its condition. To do this, researchers are integrating ultra-thin, flexible electronics into packaging materials.

Text: Katja Lüers

"Find the moo" was a novel competition run by a large Bavarian dairy to attract more customers. The company added a special sound effect to some of its bottles of milk that made them moo loudly when opened. This promotion was a hit with customers and increased the dairy's turnover. Another winner among customers is the box that lights up – as soon as someone picks up the box containing a particular spirit, for instance, several areas on the box glow blue. These are just two examples of how packaging can do so much more than simply protect a product. But as we know, mooing bottles and boxes that light up are still rare occurrences on supermarket shelves.

Wanted: Protection with added value

"What the packaging and printing industry is looking for are ways to create packaging that offers added value," says physicist Gerhard Klink, head of the Polytronic Technologies Group at the Fraunhofer Research Institution for Modular Solid State Technologies EMFT in Munich. According to Klink, there are two way to go. One involves special packaging along the line of boxes that light up or "talking" bottles, which are designed to draw consumers' attention to the product. The other goes much further, with packaging being used to give consumers additional information about the product. This may include temperature and special offer displays or even interactive labels.

Both strategies call for new technologies and this is where the expertise of Fraunhofer researchers comes in. They are busy developing ultra-thin components such as sensors, integrated circuits and displays, which are then combined with the likes of solar cells, LEDs or batteries to form complete film systems. What you get are pliable electronic components and systems that can be easily applied even to curved surfaces. This opens up entirely new possibilities for the packaging and printing industry.

That the researchers can get ultra-thin, flexible electronics onto or into the films is thanks to a key technology – printed electronics. Special printing processes are used to integrate several layers of functional materials onto a layer of film. Fraunhofer EMFT has its own roll-to-roll setup that offers its researchers a reliable large-scale production facility matching industry requirements. It starts with a substrate, generally a plastic film, which comes on a roll. This is fed continuously through between the dispensing and take-up rolls where it is coated, structured, printed or processed in some other way. Depending on the application, a range of materials with a variety of functions can be printed onto the film, including conducting or insulating materials, as well as sensitive layers, fluorescents or semiconductors. Finally, a cover film is laminated onto the top layer of film to guard against physical damage, for instance.

Need for smart packaging

"What we have to do is to integrate the entire flat and flexible electronic system – display elements, batteries, sensors – into the film. Since packaging isn't really supposed to cost anything, the big hurdle is doing this on-budget," explains Klink. A common approach is to use organic semiconductors, which theoretically should make for easy processing. The trouble is that these materials are still rather expensive and circuits made using them tend to perform less well than conventional electronics. "One option is to use the well-established silicon chip, where the only variation in price depends on the degree of miniaturization involved. We're in a position to make these chips thin and flexible enough that they can be integrated very well into film systems," Klink continues. But actually embedding these tiny circuits into a flexible system requires elaborate integrated circuit packaging technology, which drives up production costs.

What consumers find particularly appealing is smart packaging that provides specific information about any perishables and covers all the other relevant points, such as: How long has this product been stored in the chiller cabinet? What temperatures has it been exposed to? Under what conditions was it transported? To make this kind of smart packaging, the researchers integrate thin and flexible sensors into packaging materials, which provides a way of monitoring what condition the product is in at any time.

"Integrating sensors into packaging can help avoid food scandals," says Klink. Improperly stored food that has gone bad, but still has a valid best-before date, would never make it onto the shelves. What is more, this kind of monitoring could see to it that products that are past their sell-by date, but are still good, don't always get thrown away.

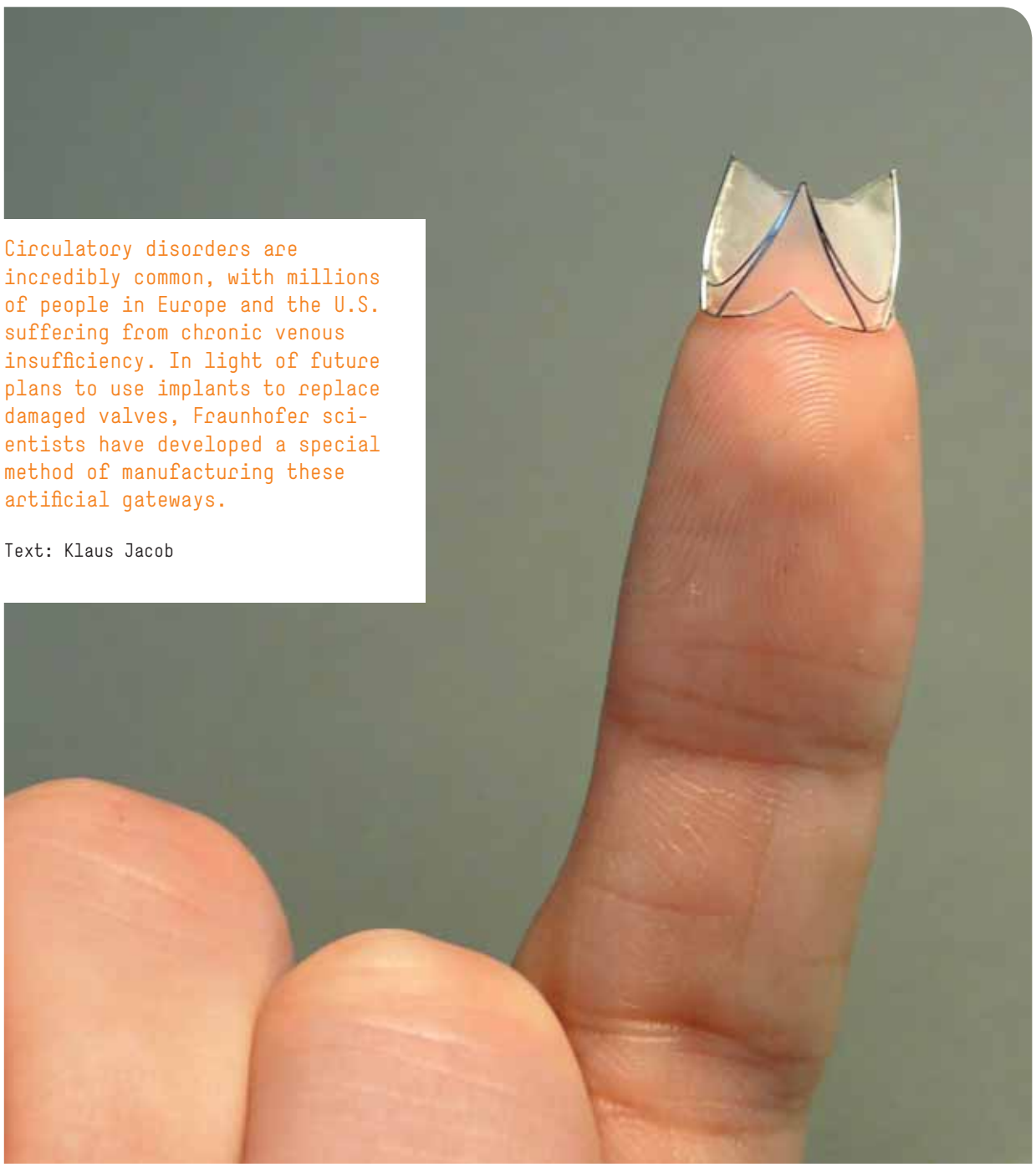
How to produce smart packaging that provides added value for the manufacturer and the consumer for a very low price – this apparent contradiction is one Fraunhofer EMFT researchers will be working on for some time to come. Klink is convinced that "the key to mastering this challenge lies in selecting the right mix of materials, technologies and processes." ■

www.fraunhofer.de/en/press/audio.html

Open and shut case

Circulatory disorders are incredibly common, with millions of people in Europe and the U.S. suffering from chronic venous insufficiency. In light of future plans to use implants to replace damaged valves, Fraunhofer scientists have developed a special method of manufacturing these artificial gateways.

Text: Klaus Jacob



A new manufacturing method for making thin-walled, highly durable artificial venous valves from polycarbonate-urethane plastics.
© AME – Institute of Applied Medical Engineering.

Most healthy people wouldn't give their venous valves a second thought. It's not until the vascular non-return valves fail that we realize how important they are: Blood no longer flows unobstructed back to the heart, feet and legs swell up, water is retained and open venous ulcers can form. In very severe cases, surgeons may even have to amputate a leg. These kinds of circulatory disorders, which experts refer to as chronic venous insufficiency (CVI), are a common occurrence. In the U.S., CVI is the seventh most common chronic disease, affecting 10 to 35 percent of adults (depending on ethnicity). In Germany, some 100,000 people suffer from the most severe form of CVI, resulting in an annual cost of treatment amounting to 1.2 billion euros.

Customized venous valves made of plastic

Despite the widespread nature of the disease, there is currently no available solution for replacing defective venous valves. While surgeons have been replacing heart valves with artificial implants for a long time now, patients with ailing venous valves have to find other ways to get by. These include putting their feet up regularly, wearing support stockings and taking tablets – measures that certainly don't remedy the cause of their suffering. A group at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart has now achieved the breakthrough that might change all that. Working together with a consortium of companies and the Institute of Applied Medical Engineering at RWTH Aachen University, they have found a way to produce customized plastic venous valves.

There are several reasons why scientists have struggled to make artificial venous valves in the past. One is that these small, delicate structures are only around five to eight millimeters in diameter, and are difficult to replicate. What's more, these tiny little in- and outlets work in an amazing way. To properly understand their function, we need to take a closer look at blood circulation in the human body. Blood is pumped from the heart into strong arteries that actively help carry the blood away. By contrast, the veins in our circulatory system have no such mechanism for moving blood along – they are, in effect, just passive tubes. In their case, it's the muscles around them that help blood to flow, which is why we call it the skeletal-muscle pump. Whenever a muscle tenses, it presses the veins together. Blood contained in the veins could then theoretically flow in either direction, but the valves make sure everything works in the way it should. Their design is such that they only open one way, preventing blood from taking the wrong route by allowing it to flow only in the direction it is supposed to go – towards the heart. If these valves fail, blood simply heeds the laws of gravity and flows downwards, which can cause problems in the legs especially.

An artificial venous valve has to be able to perform all these functions. This means it has to close tightly and make a reliable seal, even when strong muscle impulses cause a lot of pressure – while still opening easily in the other direction. What's more, blood cannot be allowed to idle or pool at any point, as stagnation brings with it the threat of thrombosis, or clumping. Natural valves are so cleverly designed that their shape ensures that these sorts of high-risk "dead water zones" are regularly flushed through. Last but not least, the implants must be made of materials that the body accepts as part of its own tissue, else patients would have to take anticoagulants their whole life, as is the case with arterial stents and artificial heart valves.

This interdisciplinary project's success rests on groundwork done by the company "be innovative", which developed a method for manufacturing biocompatible and bio-stable polycarbonate-urethanes (PCUs). Hemotec GmbH's contribution was a surface coating that is based on natural venous linings. It tricks the body into thinking the foreign body is made up of its own tissues, thus preventing thrombosis. The aerodynamically optimized design of the valve was developed by the Institute of Applied Medical Engineering at RWTH Aachen University. It goes without saying that the biggest challenge was creating such a delicate valve out of PCU plastic – here it was Oliver Schwarz and his team who pioneered the way.

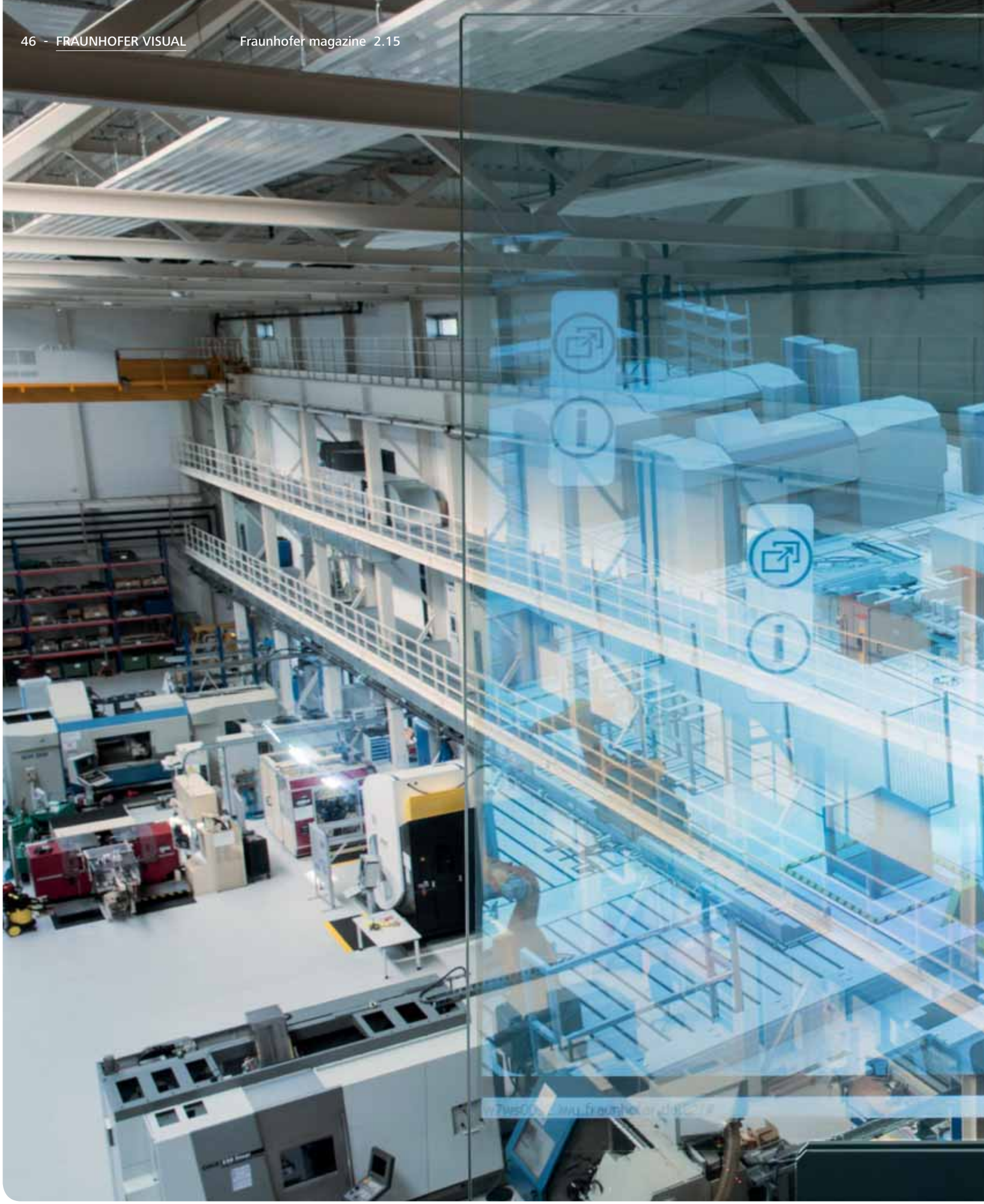
Special production technology: Additive manufacturing

To make the implant, the research team developed a special kind of 3D printer that builds up the component one layer at a time using tiny droplets of dissolved PCU. A special drying hood helps shorten the hardening phase. The 3D printer is incredibly precise: A nozzle delivering 100 droplets per second gradually builds up the shape by placing each droplet individually with an accuracy of 25 microns. What's really clever is that the printer can work with several different PCUs of varying degrees of hardness. They are kept in different tanks that are housed in a tool station, just like the color cartridges in a conventional inkjet printer. By expertly altering the degree of hardness, the printer can achieve smooth transitions to replicate the way natural materials are constructed, creating components that have both relatively stable parts and very soft delicate structures. Experts refer to these as gradient materials. This allows the artificial venous valves to closely approximate the real valves they are modeled on. It's also easy to adjust their size to suit each individual case. Another benefit is that the method is suitable for producing more than just venous valves. It can also print heart valves or intervertebral discs of a quality far superior to the products currently available.

Inserting such artificial venous valves is unproblematic, involving a routine procedure that is minimally invasive as it is conducted through the skin. The valve is held in place inside the vein using a fine wire made of nitinol, a material that is also used for stents. An alloy of nickel and titanium, this material has amazing properties that allow it to be bent and manipulated pretty much endlessly without breaking. In addition, nitinol always returns to its original shape, a property that is called the memory effect. These nitinol supports mean the implant doesn't have to be sewn into the vein, which would otherwise cause scarring that could encourage thrombosis.

There's definitely a need for artificial venous valves. Not only are doctors and hospitals in desperate search of implants, but the researchers are even being contacted by patients directly. "Every week I receive one or two emails from all over the world," says Oliver Schwarz. CVI sufferers write describing their discomfort and asking if the implant is available. But it will still be a few years before doctors can work with the new technology. First, a company must be found that is willing to finance the costly approval procedure – and that in itself is expected to take around five years.

But Schwarz is convinced the investment would be worth it, not least because of the great benefits it would bring to patients. Schwarz reckons there are about two million patients in Europe and the U.S. alone for whom this outpatient procedure would mean an astonishing end to an ongoing ordeal. ■



Sustainable manufacturing: the E³ Factory

Data on all required resources flows together in the glass-sided control center to form a factory-level picture. This includes pressured air and electrical power statistics as well as machine and process data. Scientists can visualize the information in real time on dashboards and optimize the processes to save more energy and resources. The transparent glass monitors can be operated using gesture control.

Photo: Sven Döring/Fraunhofer

Inventory takes flight

In the future, autonomous flying robots will be able to navigate independently and carry out inventory. © *Fraunhofer IML*

Standing on a ladder at a dizzying height, paper and pen in hand… just to count boxes? Inventory in large warehouses could look very different in the future - and, in the truest sense of the word, be done on the fly. Locating and tracking stock automatically with the help of flying robots is the aim of the InventAIRy project.

Text: Franziska Kopold

"Dear customers, we are closed today for inventory. We'll be open again tomorrow. Thank you for your understanding." Anyone who has stood before this or a similar sign tacked to the front door of a business knows that a little patience is required while the many people inside are busy counting. After all, although business operations appear to have ground to a halt, those inside have plenty to do.

Manual warehouse checks are an integral part of the annual inventory required by law. Not only is the traditional method time consuming, but a large part of warehouse operations are brought to a standstill.

Even today's wide use of barcodes and RFID chips offers little help. All in all, the entire process is relatively prone to error and requires resources that those in charge would likely prefer to deploy elsewhere. Not surprisingly, the interest in automated, continuously applied solutions is considerable.

Inventory today and tomorrow

When it comes to inventory, Marco Freund is quite familiar with the problems companies face. The logistics specialist is leading the InventAIRy project at the Fraunhofer Institute for Material Flow and Logistics IML in Dortmund. His notion of an optimized inventory looks like this: "The employee sits at his or her desk. There's not much happening at that moment, so with the press of a button, the employee can check stock status or search for a particular item without involving any further employee or logistical effort."

In order to make this a reality in the not-too-distant future, Freund and his colleagues are developing a "dynamic-motion tracking system" that differs from solutions currently in use in one crucial way. "Right now, goods and pallets can be automatically catalogued, say, via radio. Chips are located on the products, and an antenna – usually in a fixed location – reads the chips as they pass by. But in our project, it's the other way around. The chips stay where they are on the products, but the antenna is in motion." And not just a little bit; the inventory helpers envisioned by the scientists are autonomous robots that fly through the warehouse.

Giving wings to hardworking helpers

It's already a reality in unmanned transportation systems, and InventAIRy intends to take it to the air: the project aims to develop autonomous flying robots that can freely navigate and carry out inventory tasks by themselves. The idea is for the flying helpers to find objects located either inside warehouses or in outdoor storage areas and record them using bar codes or RFID chips – an exciting challenge for the participating researchers. Robots provide an advantage in that they can respond independently to obstructions on the ground as well as move in all directions and look in hard to reach places, for instance in high bay warehouses.

As a smart flying object, the individual service robot can dynamically perceive its environment on two levels: for instance, with help from motion and camera sensors, it recognizes how the warehouse is set up and can orient itself within the space. GPS determines its exact position outdoors. The robot can also record the contents of stored objects. For this purpose, researchers have equipped each robot with optical sensors, such as bar codes or radio sensors.

Freund's team has set itself lofty goals. "We want to build flying robots that are robust and light and can reliably identify their surroundings. What's more, they will be equipped with smart software for route planning and coordination," says Freund. "To keep the solution attractive for small and medium-sized companies, we deliberately avoided installing expensive local infrastructure for the robot to orient itself with." Instead, the researchers are relying on the help of intelligent algorithms. The flying objects are to autonomously create maps of the warehouse and adapt them to changes without prompting. Ultrasound sensors, 3D cameras and a laser scanner facilitate this ability. According to the researchers, combining these technologies allows the robot to complete its work by itself, even under difficult environmental conditions.

Although current solutions cannot automatically integrate collected inventory data into existing inventory management systems without additional software development, InventAIRy researchers are working on smart interfaces for seamlessly transmitting the information to existing infrastructure. This saves businesses a lot of time and money – and even significantly reduces documentation mistakes. Furthermore, the flying robots can monitor stocks continuously. "This would enable manufacturers to recognize material bottlenecks in time to resolve them before production downtimes occur," says Freund.

Legal considerations

The team's interim results are promising. "Starting in mid-2015, we plan to launch semi-automatic flights in which the robots – equipped with identification technology – are to remain in one position and avoid collisions with obstacles," explains the project leader.

Yet amid all the euphoria, the scientists still have to master a few challenges before their technology can really take off. The legal situation regarding the commercial use of flying robots in warehouses or manufacturing halls has not yet been adequately clarified. After all, in the case of unmanned aerial systems, it is unclear how aviation regulations, including aviation by-laws, apply in an Industry 4.0 context, especially when it has to do with an autonomous flight in outdoor areas. Freund is not overly concerned. "The German Federal Ministry for Economic Affairs and Energy (BMWi) has recognized this need and integrated the appropriate accompanying research about legal challenges into the project."

Back in 2010, the law school at the University of Würzburg set up the Research Centre Robot Law, which focuses on the legal requirements of technical innovations. What happens with InventAIRy will provide the legal experts with a precedent for appropriate legal guidelines and standard operating procedures, since practical applications that facilitate the elaboration of the legal framework are still lacking.

Equipped for every contingency

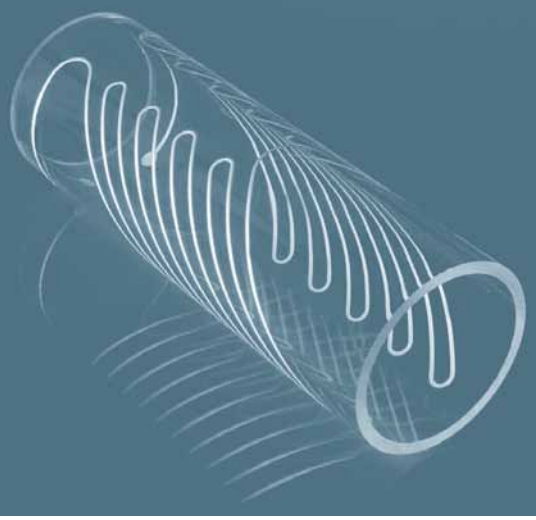
The InventAIRy team wants to tackle particular challenges with their solution: they are intimidated by neither the heterogeneous warehouse structures nor the robot's combined operation indoors and out. The Federal Ministry for Economic Affairs and Energy supports the research project as part of the AUTONOMIK for Industry 4.0 technology program. When it is completed, InventAIRy shall also facilitate automatic inventory in the automobile, spare parts, steel and freight forwarding sectors.

Logistics expert Freund is convinced. "Once established, automatic inventory with autonomous robots can be carried out over the long term in a cost-efficient and highly reliable way." ■

Printed electronics

Current processes for mounting circuit paths, transistors and resistors onto electronic components such as car ECUs are too time-consuming. A much more flexible option is to use a robot-assisted production line in which electronics are simply printed on. With this method, you can add functions to components in the best way possible.

Text: Tim Schröder



Digitally printed circuit paths on a 3D substrate.
© *Fraunhofer IFAM*

Everyone knows that printers today can do much more than just put ink on paper. Even 3D printers have become quite established, allowing architects to create whole components or home mock-ups from plastic powder. And thin-film solar cells are also printed using electrically conductive semiconductor materials. Now researchers from the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Bremen have taken it a step further and developed a robot-assisted production line that combines a number of printing techniques. It is now possible to print a wide array of electronic components directly onto a workpiece in quick succession, including wafer-thin circuit paths, flat-panel sensors and resistors. "The printing facility is extremely flexible. It can print on formed components – even on rounded components and the labyrinthine interiors of housings," says head of department Dr. Volker Zöllmer.

The production line makes use of screen and inkjet printing as well as dispensing and aerosol jet printing techniques. Screen printing, in which a printing paste is pressed through a fine mesh using a sort of squeegee, is good for quickly covering large areas. Aerosol jet printing, on the other hand, is able to print fine structures just ten micrometers thick – or five times thinner than a human hair. In this technique, the printing liquid is atomized into a vapor and then applied onto the substrate using a nozzle. This aerosol jet is much finer than in inkjet printing, where the printing liquid is applied in droplets.

A combination of various printing techniques

"Each technique has its own advantages. By integrating various technologies, we make sure we have the right one for every occasion," explains Zöllmer. The production line allows for a variety of structures, whether flat, thick or delicate, to be printed onto the substrate. This extends even to multilayer configurations and coatings of varying thicknesses. "For instance, you can equip a board not only with circuitry but also an additional layer that protects it against corrosion," says Zöllmer.

What's more, there's almost no limit to the materials the experts at the IFAM can use: metals, ceramics, electrically conductive polymers, even biomaterials such as proteins and enzymes can all potentially be used as inks. That's because each application calls for very different properties. For example, materials for LEDs have to convert energy into light as efficiently as possible. Printed circuit boards have to conduct

A manufacturing cell for direct-write technology integrated in a production line for functionalized components. © *Thomas Kleiner / Fraunhofer IFAM*

electricity extremely well. And solar cells require materials that convert as much light as possible into electricity.

Developing new inks

You can't just buy inks for every application. "Quite a few sensors require very specialized alloys that aren't available as printing pastes or liquids. In such instances, we have to rely on our creativity," says Zöllmer. This means the IFAM researchers develop their own new printing materials. Another important area of research for the scientists is setup and connection technology. Zöllmer explains, "We have to make sure our system for printed electronics is linked with the rest of the world."

The new production technique offers certain advantages. For one thing, it saves time. Electronics components are usually built in only once the housing has been made, and doing so is an intricate and laborious process. However, printing the electronics is a step that can be integrated directly into the housing manufacturing process. Printed electronics also unlock new design possibilities: until now, common practice has been to attach soldered electronics components such as capacitors to flat, rigid boards and incorporate them into all sorts of electric appliances. Because the board is rigid, it requires a certain amount of space to fit – and a car has to fit dozens of ECUs and sensors to control the motors for the electronic windows or to measure the temperature. By printing electronics, in the future it will be possible to manufacture components that are significantly more compact and robust. The result is systems that require less space.

Applications for a variety of sectors

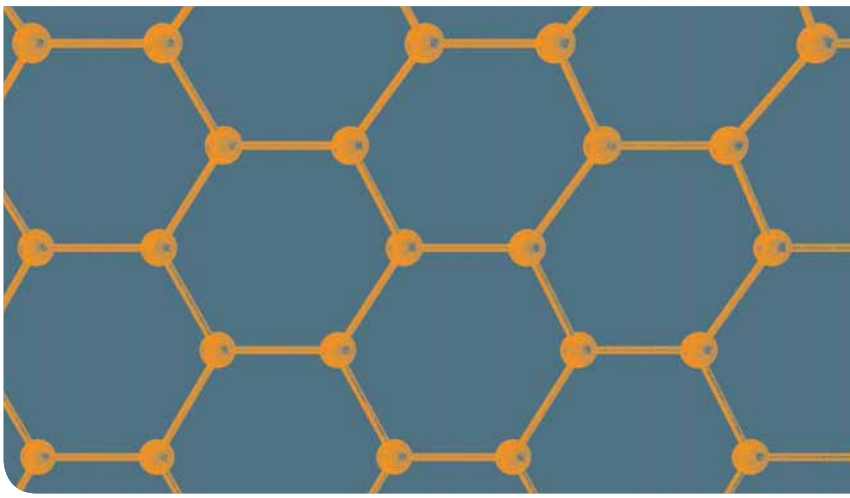
Printed electronics are of interest to many industries, and the scientists at IFAM are already working with partners from the automotive, electronics and medical technology sectors. For instance, the researchers have teamed up with a company to develop sensors that can be printed directly onto prostheses and continuously monitor the effects of the prosthesis on the patient's body.

"Many companies these days mass-produce electronics. The advantage of our facility, however, is that it allows companies to print individual pieces with speed and precision straight from a computer model," says Zöllmer. "In my view, this production customization is a strength that German industry can use to set itself apart from the mass-production hotspots of Southeast Asia." ■

All aboard the flagship

Fraunhofer researchers take part in billion-euro Graphene Flagship project.

Text Monika Weiner



Graphene is made of ultra thin graphite layers. These are extremely hard and robust. © *iStockphoto*

Stronger than steel, lighter than silk, more conductive than any wire, graphene displays such an amazing set of properties that it's no wonder researchers and engineers have such high expectations of the material. Over the next ten years, the EU intends to put a billion euros into researching graphene and developing graphene applications. The Graphene Flagship project, as it's called, brings together 140 organizations from 23 countries – including three Fraunhofer Institutes.

Graphene offers almost unlimited possibilities: featherweight yet robust vehicle and aircraft components; indestructible displays; powerful batteries; rechargeable cells that charge in seconds; and wafer-thin electronics you can integrate into a jacket or a T-shirt. The magic material that can do all this isn't even hard to obtain: graphene is pure carbon, an element that can be found anywhere in the world – in our atmosphere, as a building material for organisms, as graphite, diamond, coal or soot. Its wide range of properties – volatile like a gas, hard like a diamond and soft like graphite – is due to the fact that the atoms can bind together in a variety of ways. None of this is new. What we didn't know before, however, is the importance of thickness: incredibly thin graphite layers are extremely hard and robust.

A momentous Friday afternoon in the lab

Ten years ago, physicists Andre Geim and Konstantin Novoselov succeeded for the very first time in isolating individual layers of graphite just an atom thick, in which the carbon atoms form a honeycomb lattice. Their discovery earned them the 2010 Nobel Prize in Physics.

"Today we are able to obtain graphene not only with graphite ablation, but also with vapor deposition on metallic layers in a vacuum, growth on other crystals and direct chemical synthesis," explains Dr. Thomas Reiß. Dr. Reiß, who coordinates the roadmapping process for the Graphene Flagship project at the Fraunhofer Institute for Systems and Innovation Research ISI, goes on to say: "We are in the process of identifying potential applications and examining what material, process and product developments are necessary to make graphene viable for use in European industry."

The scientists involved in the graphene project are already working on specific solutions. For instance, experts at the Fraunhofer Institute for Applied Solid State Physics IAF are looking at how to manufacture almost weightless and therefore extremely efficient electrodes for piezoelectric resonators, used for instance as radio filters in mobile phones.

Meanwhile, experts at the Fraunhofer Institute for Chemical Technology ICT are developing a technique that allows graphene flakes to be manufactured cost-effectively in large quantities.

As is the case for all of the researchers involved in the Graphene Flagship project, the Fraunhofer researchers and engineers are working in close collaboration with industry partners: "European industry is already heavily involved in graphene research," says Dr. Tapani Ryhänen, laboratory director at Nokia's Sensor and Material Technologies Lab, which is also participating in the Graphene Flagship project. "I'm sure that the project will provide further entrepreneurial impetus and help commercialize research findings in Europe." ■

A KIC for Fraunhofer

Fraunhofer and Helmholtz jointly kicked off the start of Knowledge and Innovation Community on raw materials. The European Institute of Innovation and Technology EIT has asked two consortia to establish "Knowledge and Innovation Communities" KICs focusing on innovation in the sector "healthy living – active ageing" and in the field of "raw materials." In the latter field the EIT selected the consortium "EIT RawMaterials," a pan-European partnership with more than 100 partners from 21 countries of the European Union, including Fraunhofer, which is present with more than a dozen Fraunhofer Institutes and Fraunhofer Academy – representing leading partners from industry, research and academia.

Prof. Jens Gutzmer from Helmholtz-Zentrum Dresden-Rossendorf, the key coordinating partner said: "The EIT will enable our partnership to make a real societal change and to turn the challenge of raw materials dependence into a strategic strength for Europe. Our goal is to boost the competitiveness, growth and attractiveness of the European raw materials sector via radical innovation and entrepreneurship. We want to focus on sustainable growth and job creation by boosting start-ups, SMEs and education; and we are the strongest consortium ever created in the raw materials field. By 2022, we are aiming to create, among others, 64 start-ups and 5 new primary and secondary sources of critical raw materials (CRM)."

"With the support of the EIT and funds from Horizon 2020, these partnerships have a great opportunity to attract the best researchers, students and entrepreneurs. This will be crucial to ensure that they contribute to our efforts to improve Europe's innovation capacity and competitiveness," said European Commissioner Tibor Navracsics.

Partnerships that have a chance to attract the best

The "EIT RawMaterials" KIC is expected to turn investment into tangible economic and social impact, including new businesses and business opportunities, risk taking and entrepreneurs contributing to sustainable economic growth. This, in turn, will boost the competitiveness of the European raw materials sector and generate new, high quality jobs. KIC will have its headquarters in Berlin jointly hosted by Fraunhofer and Helmholz institutes. In addition there are six transnational co-location centres in Wroclaw, Poland; Espoo, Finnland; Leuven, Belgium; Lulea, Sweden; Metz, France; and Rome, Italy. The winning consortium has a broad coverage across the materials chain and is considered the strongest partnership that has ever been assembled in the raw materials sector. It aims at strengthening innovation in the sector by introducing new solutions, products and services for sustainable exploration, extraction, processing, recycling and substitution. KIC wants to make the sector more attractive to young people by developing Master and PhD programes in close collaboration with world-class partners from education, research and industry.

The Knowledge and Innovation Community "EIT RawMaterials" is a pan-European partnership. © *dpa*

It takes more than two years to establish such a large consortium. Helmholtz and Fraunhofer have finally coordinated the application process of the proposal to EIT, which a core-team of more than 40 specialists from industry, education and research worked hard for. "In the beginning it was a challenge to understand each other, as we are from very different disciplines, not linked to each other, and it was a big task to convince industrial key partners and end-users, as the return of invest cannot be calculated directly – it is a mix of education, knowledge, innovation and networking", says Dr. Michael Popall from the Fraunhofer Institute for Silicate Research ISC, who had been one of the initiators and co-coordinator of KIC and is in the team since the early days. With its partners Fraunhofer also joined and established the transnational French-German co-location centre in Metz, France. Here the research will focus on substitution of critical and toxic materials in products and on optimized performance. The region is home to various materials suppliers and end-users in the area of mobility and machinery. The German hub, one of the local contact bureaus of the co-location centre, will be at the Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS in Alzenau/Hanau, Germany. ■

The Campus will be located in the Imbabura region 100 kilometers north-west of Quito. © *UMSICHT*

From Oberhausen to Ecuador

During the past years, Ecuador has shown that the stabilization of its international competitiveness is one crucial aspect of the government's strategy. The national economic plan will not only invest in the infrastructure but also in education, academics and research. The establishment of a structured economic area and research landscape is being furthered actively and aligns itself with positive examples worldwide – examples like Fraunhofer.

One of the main issues is the city YACHAY – City of Knowledge with a size of approximately 4500 hectares at completion, located about 100 kilometers in the north-west of the capital Quito in the Imbabura region. The word YACHAY is derived from the indigenous Quechua language and means "knowledge, education, learning" This shows directly what the major project is about. Ecuador takes action on the education. And Fraunhofer will be part of it. Just recently a Memorandum of Understanding (MoU) was signed by YACHAY and the Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT in Oberhausen.

Mixed energy for Saudi Arabia

Saudi Arabia has a rapidly growing demand for electricity and water desalination. The consumption of Energy will triple in the next 20 years. In order to produce enough Power the Kindom has foundes King Abdullah City for Atomic and Renewable Energy, K.A.CARE, based in Riyadh. It will prepare the transition to a balanced energy mix, strengthening Saudi Arabia's ability to meet future international demand for oil. In order to use more renewable energy by taking advantage of the Kingdom's abundant natural resources – such as high solar intensity and promising wind and geothermal resources – K.A.CARE will cooperate with the Fraunhofer Institute for Solar Energy Systems ISE. Both institutions signed a »Collaboration Framework Agreement« that will serve as a basis for various projects between the two organizations over the next years. Cooperation areas include renewable energy research and development as well as testing and training.

Prepares the transition to the future: The King Abdullah City for Atomic and Renewable Energy, K.A.CARE. © K.A.CARE

Strengthening ties to Israel

Israel is one of the world leaders in technology. The country is therfore an extremly attractive partner for Fraunhofer. Now Europe's largest organization for applied research is cooperating with the Israeli industrialist Stef Wertheimer. The goal of the partnership is to bring Fraunhofer institutes together with companies, research institutions, and the public sector in Israel.

To further this goal, Fraunhofer and Lavon industrial park have signed a letter of intent to establish a joint communications platform. Wertheimer owns the Lavon complex, which is located to the north of Haifa. The partnership will give Fraunhofer access to networks of excellence in Israel and the opportunity to work with its companies, universities and research institutions. For their part, the Israelis will gain the opportunity to network with Fraunhofer Institutes and scientists. Further goals include launching joint research projects, organizing scientist exchanges, and intensifying educational transfer. Initially, activities will focus on manufacturing-centered industry in northern Israel.

"Bringing relations to a new level"

The further strategic development of the partnership will be the responsibility of an expert group led by Wertheimer and Raoul Klingner, Director International Business Development at the Fraunhofer-Gesellschaft. Other supporters include Emanuel Liban, Chairman of the Israeli Society of Mechanical Engineers, and Prof. Rafael Wertheim, scientist at the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz and a close confidant of Wertheimer's. Prof. Wertheim has been appointed as Fraunhofer Senior Advisor in Israel in January 2015.

"Israel is one of the most innovative countries in the world," says Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft. "As a location for technology-oriented companies, Israel is particularly well-known for its many successful start ups. Fraunhofer has had ties with the country for many years: together with the Hebrew University of Jerusalem, for example, we are optimizing the effectiveness of various medications, while a previous collaboration successfully improved the efficiency of production processes at an industrial company located in Lavon Industrial Park . Our partnership with an industrialist of Stef Wertheimer's caliber, who is so highly regarded in Israel and Germany, will bring this exchange to a new level. The partnership follows the clearly defined principles of our internationalization strategy: scientific added value for Fraunhofer and positive effects for Germany and the partner country. This year we are celebrating 50 years of German-Israeli relations. I'm delighted that our cooperation will further strengthen the good relationship between the two countries."

"Fraunhofer is one of the leading research institutions in the world," stresses Stef Wertheimer. "The principal focus of our cooperation will be on promoting applied research in Israel. Each side will benefit from the knowledge and expertise of the other. However, for me it was important that the cooperation should achieve more than just the exchange of research know-how. It will also create jobs and have an educational component. And because good education and good jobs are major contributors to stability in our region, partnerships like this will hopefully give a boost to the peace process between Palestinians and Israelis."

The Lavon Industrial Park

Editorial notes

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