

RESEARCH NEWS

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1 On the trail of prostate cancer

New biomarkers will improve diagnostics of endemic diseases in future, such as prostate cancer. Their mission: to recognize the tumor earlier and classify it more precisely – thereby helping avoid unnecessary operations.

2 Defending against electromagnetic attacks

Electromagnetic fields can interfere with or damage electronic devices. Electromagnetic radiation is invisible to people. A new measuring instrument can now determine the strength, frequency, and direction of the attack.

3 High-tech athletic shoe for pure running pleasure

Jogging keeps you fit and is healthy. However, athletes that start training can overdo it and easily pull and tear ligaments. A new high-tech running shoe will evaluate running form in real time and thereby counter these injuries in future.

4 Thermoelectric materials nearing production scale

Half-Heusler compounds are especially suited for manufacturing thermoelectric modules. Waste heat can be converted to electricity with them. Researchers have manufactured the alloys for the first time in kilogram quantities.

5 Tougher dies for automotive manufacturing

Forming dies are put under immense strain. Yet by using a laser to alloy their surfaces with filler material you can make them more robust and resistant to wear. This process increases the service life of dies used in automotive manufacturing by 150 percent.

6 Better first response medical care during catastrophes

When large-scale emergencies occur, it often takes far too long before victims receive the care their injuries demand. Now a new electronic system has been designed to support helpers during the initial assessment of victims and to speed up patient care.

7 Free-flowing traffic on the information highway

Our communication networks have to process constantly increasing volumes of data, pushing them to the limits of their capacity. An analyzer makes it possible to test new, efficient transmission formats quickly and with the minimum of fuss.

8 Newsflash

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 66 institutes and independent research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of more than 22,000, who work with an annual research budget totaling 1.9 billion euros. Roughly two thirds of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the USA and Asia serve to promote international cooperation.

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On the trail of prostate cancer

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Does the patient have cancer of the prostate gland, commonly called prostate cancer? A question like this is difficult for physicians to answer. Up to now, they have been dependent on clues provided by the prostate-specific antigen PSA. If the prostate gland is attacked by cancer, it releases more of this protein into the bloodstream. However, this test has a weakness: it is very imprecise. If it yields an elevated value, patients have to undergo a biopsy. This involves the practitioner taking several tissue samples using a biopsy needle and having them examined by a pathologist. This entails certain risks, just like any intervention. It can lead to infections in rare cases.

If the physicians detect malignant tumor tissue in the biopsy, they usually have to remove the prostate. However, besides the aggressive form of prostate cancer, there is also a type that only grows very slowly and may not need to be operated on. It has been difficult to differentiate it from the aggressively growing tumors until now, though. The result: physicians operate on the majority of the 70,000 people in Germany who are diagnosed with prostate cancer every year. "Some of these interventions could potentially be avoided if we were to have a biomarker that revealed what kind of cancer is involved," says Prof. Friedemann Horn, Professor of Molecular Immunology at the University of Leipzig and department head of the Fraunhofer Institute for Cell Therapy and Immunology IZI in Leipzig. The term 'biomarker' denotes a measurement value that shows whether a person or an organ is healthy or diseased – these could be metabolic products, specific proteins, or nucleic acids, for instance.

Biomarkers provide insight

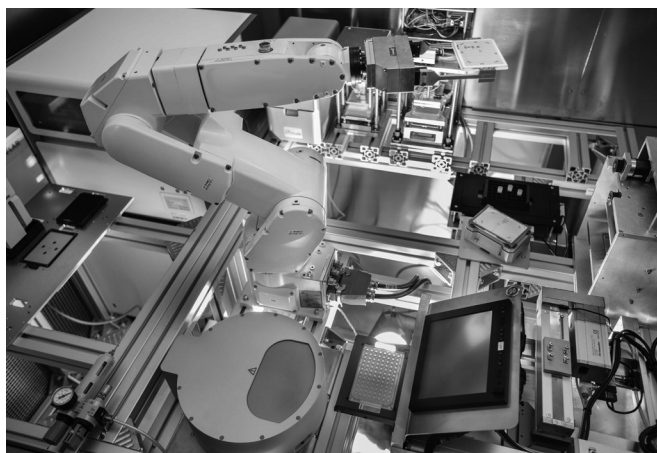
Researchers are hoping now to locate biomarkers like this through the RIBOLUTION Project, which is short for "Integrated Platform for Identification and Validation of Innovative RNA-based Biomarkers for Personalized Medicine" (www.ribolution.de). The project is being supported by the Fraunhofer Future Foundation. The Fraunhofer Institutes for Applied Information Technology FIT, Interfacial Engineering and Biotechnology IGB, Manufacturing Engineering and Automation IPA, Toxicology and Experimental Medicine ITEM, and Cell Therapy and Immunology IZI are participating in addition to several universities. The project involves not nearly just prostate cancer – researchers also hope to improve the diagnoses of other endemic diseases like rheumatism and chronic obstructive lung disease, which is characterized by coughing, production of sputum and difficulty in breathing. The research will concentrate on the search for ribonucleic acids, RNAs for short, that can indicate the biological state of cells and tissues very accurately.

However, how do the scientists know which biomarkers are early indicators of prostate cancer, or which RNA differentiates slow-growing tumors from aggressive ones? To find these kinds of biomarkers, the scientists compare healthy and tumorous tissue. Physi-

cians at the University Hospital Dresden led by Prof. Manfred Wirth have been storing specimens of these in liquid nitrogen for fifteen years and documenting the course of the disease in patients even after they are released. Before the researchers could investigate these samples in detail, however, they had to prepare them: they cleaved every single tissue sample into 150 ultra-thin sections – each only a few thousandths of a millimeter thick – and classified them anew. “In the meantime, we now have more than 100,000 tissue sections that are unambiguously classified. There has never been a biological database of this quality before now,” according to Horn.

Researchers have sequenced the complete genome for 64 of these specimens – that is, analyzed and quantified any RNA present in the samples. They have obtained a very large quantity of data for their efforts: 300,000 RNAs have been decoded, with the information adding up to 50 terabytes – that represents about 100,000 CDs. The scientists have compared the data and have already found 4,000 RNAs out of the 300,000 that could turn out to be biomarkers. They will check these again against a larger group of patients and trim the selection down further. “We are excited about the initial results of this validation process,” reports Horn. He sees a good chance that several of the biomarkers discovered can improve the diagnoses of prostate cancer.

“Interest from the medical technology industry is gigantic,” says Horn. If the results of RIBOLUTION are confirmed, then a corresponding biomarker assay, i.e. a biomarker test kit, could be on the market in few years – and physicians as well as patients could simply and quickly obtain information about the state of prostate cancer. The market is big: over 100,000 assays would be needed just in Germany annually.



IPA has developed the means to simultaneously measure RNA molecules specifically and precisely from tiny samples of many specimens at once. Fully-automated facility for validation of biomarkers. (© Fraunhofer IZI) | Picture in color and printing quality: www.fraunhofer.de/press

Defending against electromagnetic attacks

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We are all familiar with the power of electromagnetic attacks from the movies: in *Ocean's Eleven*, George Clooney's gang disables Las Vegas' power grid, and Keanu Reeves' henchmen hold off the enemy robot fighters from their spaceship in the *Matrix* Trilogy. The heroes in the films succeed by sending out a very strong electromagnetic pulse. This changes the voltage in the vicinity so that regulators, switches, and circuit boards in electronic equipment go crazy. You cannot smell, taste, or feel this radiation. Those affected by it do not know why computers or machines breakdown or from which direction the attack comes.

"What works on the silver screen is also conceivable in reality," confirms Michael Jöster from the Fraunhofer Institute for Technological Trend Analysis INT in Euskirchen, just south of Cologne, Germany. The researchers there are concentrating on the question of how these attacks can be detected. They have developed a measurement instrument for this purpose that is capable of determining the strength, frequency, and direction of electromagnetic attacks. The engineering requirements are steep: the detector must measure very high field strengths from very short pulses, yet not be destroyed or damaged itself.

Identifying the type, location, and duration of the attacks

Four specialized antennas make up the INT demonstration instrument that sample the environment around the subject device to be protected. Each of these covers a quadrant of 90 degrees and detects all types of electromagnetic sources. A high-frequency module preconditions the signals for measurement and determines when the electromagnetic pulse started and stopped. A computer in a monitoring station connected via an optical conductor then calculates the values for the signal and presents them on a screen. "We identify the type and location of the source of the invisible attack as well as its duration as though we had a sixth sense. Those affected by the attack can use this information to mount a rapid and appropriate protective response," explains Jöster. The threat scenarios are real: criminals disrupt computer networks of banks, exchanges, and companies. They cause confusion in order to bypass monitoring points or overcome alarm systems, enabling them to penetrate into secure areas. Individual cases of these kinds of attacks have already been documented: thieves used electromagnetic waves to crack the security systems of limousines in Berlin. Their weapons are no larger than a suitcase. High-power microwave sources are suitable for those kinds of attacks, for example. Depending on the field strength, the attacker using these high-power microwaves can be located several meters from the target of the attack. "Located in the right position, it is enough to press a button to trigger the pulse. Just like in *Ocean's Eleven* or *Matrix*, the electronic systems nearby can fail or be damaged," as Jöster describes the danger.

Electronic devices can withstand a certain amount of radiation. This is measured in volts per meter (V/m) – called the electromagnetic compatibility (EMC). Otherwise, they would not operate reliably. Every device could interfere with others in its immediate vicinity. Depending on the category of usage, they therefore have to fulfill specific EMC requirements. These are significantly higher for industrial applications than for common things like Smartphones, televisions, or stereo equipment. One example where safety is important is automotive engineering. “The importance of electronic components will continue to increase in the future. Completely shielding individual devices from electromagnetic radiation would certainly be theoretically possible, but much too expensive though. Systems are needed that can detect these kinds of attacks. If you know what is attacking, you can also react correctly to it,” according to Jöster.



Tools for defending against electromagnetic attack (right to left): an antenna set (on tripod) for sensing the environment, a RF measuring device for conditioning the signals and a computer that calculates the relevant data. (© Fraunhofer INT) | Picture in color and printing quality: www.fraunhofer.de/press

High-tech athletic shoe for pure running pleasure

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Hardly any sport is as popular as jogging. About ten million people in Germany are training regularly. No wonder, because running is the ideal way to reduce stress, lose excess fat, and improve endurance. Running stabilizes the immune system, prevents cardiovascular disease, and builds muscle. However, despite its numerous positive effects, jogging is a desirable sport with undesirable side effects – and the number of running injuries and joint complaints is increasing. Runners run risks of twisting or injuring an ankle joint, especially on uneven ground or when fatigued. Pulled ligaments or even a broken ankle can result. If muscles are not warmed up or a person overestimates their condition, training is often interrupted due to knee pain and pulled or torn muscles.

To prevent these kinds of injuries and symptoms of muscle overload during training, researchers from the Fraunhofer Institute for Photonic Microsystems IPMS in collaboration with five partners are developing a specialized running shoe in the EU Project RUNSAFER (www.runsafer.eu). Sensors and microelectronics integrated into the sole of the shoe will measure the biomechanical data of the athlete and evaluate the runner's form with the help of measurements in real time. "Pulse-rate watches and chest straps record only vital signs like breathing and heart rate. In contrast, our running shoe medically evaluates and monitors training while jogging. It informs the runner for example of incorrect foot position, asymmetric loading, or warns of exhaustion or overload. There has never been a comparable device before," says Dr. Andreas Heinig, a scientist at IPMS.

Smartphone app gives feedback on training performance

The measurement system can be easily installed and removed from the soles of the shoes. To charge it, the pair of shoes is placed on a charger that is included. Besides the microcontroller, the RF module, and batteries, the system comprises accelerometers and GPS sensors that capture the biomechanical signals from the body as well as the runner's speed and transmit it via Bluetooth to the runner's Smartphone. A Smartphone app evaluates the data in a split second with the help of specialized algorithms and gives the athlete feedback on training performance. If necessary, the app makes suggestions about running form or the training routine.

"The app could recommend running more slowly, for example, or rolling off the foot differently, suggest seeking a different running surface or stopping if necessary," as Heinig describes the different guidance. In addition, the measured values are transferred during the run from the Smartphone to a website for further processing, evaluation, and display. A customized training program can be set up based on this data with personalized performance goals that are constantly updated.

A prototype of the running shoe is already done, as is the cell phone app. The researchers are presently working on a still smaller version of the microelectronics and sensors – a big challenge, particularly since the system must be waterproof, light, and durable. The high-tech shoe should be available for sale by the beginning of 2015. RUNSAFER-Project partner New Millenium Sports SL, the Spanish manufacturer of athletic shoes and sportswear and owner of the Kelme brand, will be bringing it onto the market.



Joggers will be able to prevent future injuries like pulled ligaments or torn muscles thanks to the specialized running shoe.

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Thermoelectric materials nearing production scale

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More than two-thirds of the energy from primary sources like oil and gas utilized worldwide today is lost through waste heat. Thermoelectric modules in power plants, industrial or heating systems, as well as in automobiles can make use of part of this. Thermoelectric devices harvest electrical power from temperature differences. For example, if integrated in the exhaust system of an auto, such a module could use the waste heat for electrical power generation and take some of the load off the alternator. "In view of the continually stricter environmental regulations of the EU, this can also be of interest to the automobile manufacturers," according to Dr. Kilian Bartholomé from the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg, Germany.

Even though the fundamental principles have been known for almost 200 years, most of the technology is still at an elementary stage. Efficient manufacturing processes and suitable materials are still needed. IPM has succeeded in making a big jump in development. The researchers have shown that half-Heusler compounds – which are highly suitable materials for thermoelectric processes – can be produced significantly more efficiently and cost-effectively than has been previously possible. They are collaborating with Robert Bosch GmbH, the Institut für Anorganische Chemie und Analytische Chemie (Institute for Inorganic and Analytical Chemistry) at Johannes-Gutenberg-Universität Mainz, Vacuumschmelze GmbH (vacuum smelter works) in Hanau and Isabellenhütte Heusler GmbH (smelting and foundry works) in Dillenburg on the "thermoHEUSLER" Project, supported by the German Federal Ministry of Economics and Technology (BMWi).

"Half-Heusler compounds are highly suitable for thermoelectric applications. They fulfill – almost – all of the necessary criteria," explains Project Director Dr. Benjamin Balke, an expert in materials development at University Mainz. "The alloys consist of a wide range of materials, nickel being one, and are much more environmentally friendly than previous materials, possess good thermoelectric properties, and withstand high temperatures."

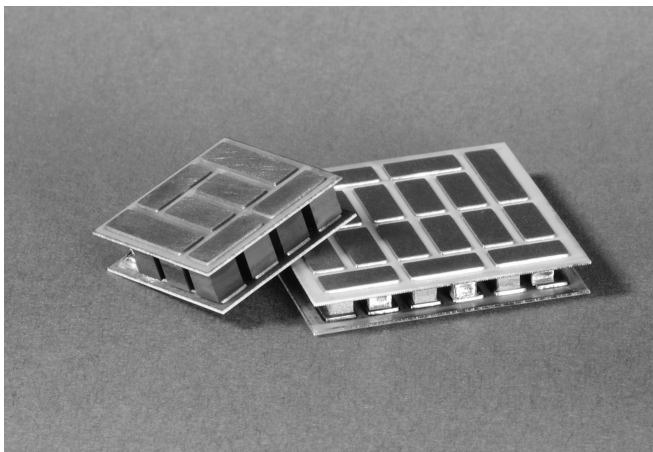
Efficient material produced in kilogram quantities

Engineers characterize thermoelectric suitability by the "ZT value". Industry requires ZT values greater than one. The partners in the thermoHEUSLER Project have now achieved a value of 1.2. "That corresponds to the best published values for half-Heusler compounds thus far," says Bartholomé. It is crucial for industrial applications to attain the efficiency values during mass production that were obtained in the lab. During the thermoHEUSLER Project, Vacuumschmelze and Isabellenhütte have successfully manufactured this very efficient half-Heusler material in kilogram quantities for the first time. The alloys synthesized by them result from a long tradition: the German mining engi-

neer, chemist, and namesake of the compound, Friedrich Heusler, was head of Isabelhütte Heusler GmbH at one time.

Thermoelectric modules are assembled from blocks a few millimeters each in size. These consist of two different types of thermoelectric materials, N-type and P-type. A critical aspect for the efficiency of the modules is the design of their electrical contacts. These need to withstand large temperature differences, yet at the same time keep the electrical resistance as small as possible. This is exactly what the scientists have accomplished in the thermoHEUSLER Project by using a specially developed soldering system.

Various international consortia have shown that thermoelectric modules can contribute to energy efficiency in automobiles. Prototypes have already created up to 600 watts of electrical power from the waste heat in the exhaust system of an auto. "There were almost 60 million motor vehicles registered in Germany at the beginning of the year. If all of these were equipped with small thermoelectric power plants in the exhaust systems, energy on the order of the amount produced annually by a nuclear power plant could theoretically be saved today," according to Bartholomé. "That corresponds to a savings of several million tons of CO₂."



The individual components of thermoelectric modules are only a few millimeters in size. They are cut from specific alloys – such as half-Heusler compounds.

(© Fraunhofer IPM) | Picture in color and printing quality: www.fraunhofer.de/press

Tougher dies for automotive manufacturing

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Slowly the metal punch approaches the piece of sheet metal and pushes it into the press with a force of several tons, producing automotive components in a matter of seconds. Known as deep drawing, this special forming process is used by the automotive industry to form vehicle body parts into the requisite shape. As smooth and delicate as the process looks in the production hall, it actually puts enormous strain on dies. This is because of the high pressure generated during the pressing operation – above all at the die shoulders. These are the areas of forming dies where the material is drawn into the requisite shape, and it is precisely these surfaces that tend to wear very quickly. To function properly, the dies have to be maintained regularly and even replaced in extreme cases. This can see expensive manufacturing machines standing idle for up to an hour. Moreover, pressing dies are costly, one-of-a-kind items made from special raw materials. Even dies just a few centimeters in size cost up to 600 euros.

What manufacturers need are processes that increase the lifetime of dies and reduce set-up times. One such method is laser metal deposition. A laser beam carefully melts the surface of the die and the filler material to produce a local layer that guards against wear on the die surface. This process increases the robustness and resilience of the stainless steel die at critical points. The laser beam treatment is completed in fractions of a second. What has been lacking until now, however, is a universal, reproducible process for practical industrial use. This deficiency has now been remedied by researchers from the Fraunhofer Institute for Production Technology IPT in Aachen together with the tool maker Mühlhoff Umformtechnik GmbH and further partners in the course of a project within the Green Carbody Technologies Innovation Alliance (InnoCaT®).

Lifetime increased by 150 percent

Researchers rebuilt a conventional five-axis milling machine so that it could be used to alloy forming dies automatically via laser. The machine can be embedded into the current manufacturing process and increases the lifetime of dies by over 150 percent. The new process also improves the quality of components and makes it possible to plan set-up times with greater precision, as practical tests carried out on Mühlhoff's premises have shown. Mühlhoff, which is based in the Uedem municipality of North Rhine-Westphalia in western Germany and which has over 340 employees, manufactures sheet metal components for the automotive industry. The company's own toolshop supplies its various production locations with forming dies.

In addition to the laser metal deposition machine, another key part of the system is the integrated CAx software (CA = computer-aided). This software allows all the requisite laser surface treatment processes to be controlled in a clear, reproducible manner. All necessary process parameters are transmitted to the machine without the need for any

interface. Processes can be simulated in detail and optimized in advance of actual processing operations.

In 2010, over 60 partners from industry and research joined together in InnoCaT® with the aim of carrying out joint research into innovations and synergies along the automotive process chain. For the first time, they analyzed the complex production flows in their entirety and from a resource efficiency perspective, taking in each stage from tool-making to pressing, car body construction, and painting car body shells. Five collaborative projects and 30 sub-projects yielded technical solutions and general approaches for increasing energy and resource efficiency before the initiative came to an end this summer.

Researchers will demonstrate this achievement at this year's Euromold trade show in Frankfurt from December 3 to 6, at Fraunhofer's joint exhibition booth (Hall 11, Booth C68).



Thanks to laser metal deposition, the optimized forming die from Mühlhoff Umformtechnik GmbH is more robust than the previous. The photo shows the machine system used.

(© Fraunhofer IPT) | Print-quality color photo: www.fraunhofer.de/presse

Better first response medical care during catastrophes

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When a major catastrophic event occurs, every second counts. During instances such as natural disasters, terrorist attacks, accidents in chemical plants, or train crashes, many human lives depend on how well the rescue services are coordinated. The better relief forces communicate with each other, the more victims they can rescue. The swifter the initial assessment of those affected by the disaster (during which they are tagged according to the severity of their injuries), the faster they can be evacuated and taken to suitable nearby hospitals. At present, this initial assessment – or “triage” as the professionals call it – is carried out using colored paper tags which first responders attach to victims. The color coding (green, yellow, red, and black) indicates the severity of the injury and the treatment priority. Pulse and respiratory rate are noted on the tags by hand. This collected data summarizes the condition of the victim at the time of triage, but the manual process means frequent updates are seldom possible. Another drawback is that the paper tags are easily damaged during poor weather conditions.

Better first response medical care, optimized emergency management, and the more effective operation of rescue forces in response to large-scale accidents are the goals that the EU’s BRIDGE project is trying to promote (www.bridgeproject.eu). The EU is funding the project to the tune of 13 million euros, and the Fraunhofer Institute for Applied Information Technology FIT in the German city of Sankt Augustin is responsible for its overall technical coordination. With eTriage, FIT researchers are developing a system to replace the paper tags. The system will locate casualties and transmit their vital signs such as pulse, respiratory rate, and blood oxygen to emergency response control centers in real time.

Emergency management with GPS and RFID

eTriage consists of several elements. Instead of using paper tags, first responders put color-coded armbands made of light, bendy plastic on casualties. These triage armbands are the cornerstone of the system and comprise a GPS sensor, an RFID chip, and a network component for communication with the data network. Unharmed people receive only an armband with GPS sensor, whereas unstable and severely injured victims have sensors attached to their bodies that transmit vital signs to the emergency response control center. The armband functions as an interface and network node. The data can be transmitted via a ZigBee – a slow but far-ranging and economical radio network – but also via WLAN or the cellular network.

“This is a big advantage, because communication is often the first thing that breaks down during a catastrophe. We use the other networks when they’re available, but when they’re not, we simply build our independent, fully functioning ZigBee network. The required infrastructure is already there in the armbands. It works automatically – there’s no extra work involved,” explains Erion Elmasllari, a scientist at FIT. Triage relays

attached to first responders' belts additionally function as caches, data backup and data transmitters should the ZigBee network ever collapse.

Data transmitted by triage armbands is displayed on a tablet PC or smartphone. A map view and an augmented reality view give first responders and response coordinators a quick overview of the situation on the ground. By clicking on icons whose colors match those of the armbands, they receive all the information available about the location of victims, their state of health, degree of injury, and physical signs. Rescuers see at a glance where the majority of severely injured casualties are located. They can decide immediately which hospitals victims should be taken to, whether on-site care is sufficient or whether helicopters should be requested. "With our eTriage system, a severely injured person categorized as red is reported within no more than 30 seconds and can be evacuated immediately. With the conventional paper tag method, it often takes up to 30 minutes before the victim is evacuated," says Elmasllari.

Researchers were able to test the system's reliability in a live situation during a five-hour major disaster exercise – a simulated terrorist attack on a ferry terminal – that took place this October in Stavanger in Norway. Throughout the large-scale operation with 350 victims, 50 first responders, 30 ambulances, several helicopters, and a mobile response control center, the interplay of triage components worked perfectly. The next milestone is a two-month test within a relief organization, with researchers looking to demonstrate how eTriage can speed up patient care, improve logistical processes, and optimize rescue procedures.



The armband color coding indicates the severity of injury. First responders can decide immediately whether the victim should be taken to a hospital or can be treated on site.
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Free-flowing traffic on the information highway

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Our information highways are becoming increasingly busy places: according to the German Federal Network Agency, in 2012 Germans sent 4.3 billion gigabytes of data through the virtual transport network via broadband. In addition, around 140 million gigabytes were transmitted over cellular networks. At the same time, the requirements for transmission quality and speed have been growing. Primarily as a result of data-intensive applications such as multimedia content, today's communication networks are sometimes pushed to the limits of their capacity – and there is a real danger of traffic jams on the information highway. In future, only an improved infrastructure will suffice to quickly and reliably transport the growing masses of bits and bytes. However, as with conventional transportation, simply building new “roads” is not a realistic option with these virtual networks. “The available radio frequency spectrum is already largely exhausted in many places. This means that we have to use the existing frequencies more efficiently,” explains Dr. Klaus-Dieter Langer from the Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, HHI in Berlin. The same goes for the landline network: exploiting existing capacities with state-of-the-art technology is often cheaper than laying new cables.

Consequently, Langer and his team are working on transmitting more information in less bandwidth. To achieve this goal, they are testing out new modulation formats for fiber optic transmission technology. These are methods for accommodating as many bits as possible in a frequency unit. The simplest modulation format consists of a sequence of the values 0 and 1, which is achieved by switching the transmission signal on and off. The researchers' concepts may involve adding several intermediate values, for instance, in order to obtain a higher bit rate. “Although complex modulation formats often seem very promising in theory, they can turn out to have unexpected effects when we test them,” says Langer. In order to test the practicability of new transmission techniques, researchers usually use signal generators as found in circuit design. More sophisticated versions – arbitrary waveform generators or AWGs for short – are capable of creating random sequences of signals. Such a tool can make life much easier for researchers and developers. “Otherwise, we would have to construct specific circuits for the required signals. And that would be far too time-consuming, particularly with complicated signal forms,” explains Langer.

World's fastest analyzer for testing transmission techniques

Fraunhofer HHI in Berlin has developed what is currently the fastest AWG in the world. At sample rates of 70 GSa/s – that is, 70 billion sample values a second – it is possible to quickly and easily simulate any kind of scenario with very high data rates and signal frequencies. The AWG is based on two digital-to-analog converters with 35 GSa/s each and the highest bandwidth available on the market. The predecessor to today's analyzer was originally developed by HHI researchers for their own use, but it aroused such

interest that the technology is now also available to the institute's customers. As well as testing new modulation formats, the high-end AWG can also be used to optimize existing transmission methods: "For example, we can deliberately impair the signal to find out how tolerant the transmission is to signal fluctuations and to identify any points of weakness," says Langer.

The findings help to improve transmission techniques for existing broadband and radio networks, making us better able to cope with the constantly growing flood of data. "In addition to speed, energy efficiency is also an important factor here – just think of big data centers such as the ones Google operates," points out Langer. However, demand for highly efficient transmission methods is also increasing among companies looking to further develop high-tech devices – such methods are the key to faster computers and smaller, more powerful devices.



At a rate of 70 billion sample values a second, Fraunhofer HHI's arbitrary waveform generator tests new transmission formats quickly and with the minimum of fuss. (© Fraunhofer HHI) | Print-quality color photo: www.fraunhofer.de/presse

Freely adjustable shock absorbers

Shock absorbers have their work cut out on bumpy roads. But whereas some drivers have a sportier driving style and are happy to accept harder damping for better cornering, others prefer greater comfort. Magnetorheological shock absorbers make damping infinitely adjustable. With this technology, a current-carrying coil in the shock absorber's piston generates a magnetic field that causes a fluid to harden. The stronger the magnetic field, the more viscous the fluid becomes and the harder the damping. The system consumes around 20 watts for average damping. When power is cut, the damping reverts to its softest state.

Researchers at the Fraunhofer Institute for Silicate Research ISC in the German city of Würzburg have developed a shock absorber that offers a better safeguard against outages. A permanent magnet supplies a constant magnetic field for average damping – without using any electrical energy. Only when damping is to be increased or reduced is the coil activated to strengthen or weaken the magnetic field. Another new technology is based on a switchable magnet, where a short current pulse in the coil is sufficient to adjust the magnetization to requirements. This saves energy when damping has to be changed only rarely, such as when the vehicle's load is altered.

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Laser welding as driver of innovation

Can a laser weld with precision amid pounding machinery? The prototype of a new laser welding machine, developed within the EU's Orbital project, has passed the acid test: it has demonstrated that it can operate reliably under tough everyday working conditions at the companies INTEGASA and ENSA, who manufacture heat exchangers for heavy industry in Spain. It is designed to replace the welding guns traditionally used in manufacturing to weld perforated tube sheets with thousands of tubes. This is a time-intensive process, and European manufacturers are finding it very difficult to cope with the competition from low-wage countries.

In future, lasers will do this job: baseplate and tube are welded together quickly and with pinpoint accuracy; a few seconds later, the robot arm, which transports the processing head, moves on to the next hole. "The prototype can even fuse materials that are considered difficult to weld," says Patrick Herwig from the Fraunhofer Institute for Material and Beam Technology IWS in Dresden, which designed and tested the

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welding head within the EU project. Manufacturing heat exchangers, for example, calls for exotic material combinations. Heat exchangers are used in the chemical industry to draw heat away from hot, caustic solutions. Consequently, the tubes must be corrosion-resistant on the inside. On the other side, in the tank, there is a chemically neutral liquid that absorbs heat. Here it is possible to use low-cost materials. Where the tank and tubes meet, the different materials have to be joined. This pushes classical welding technology to its limits, whereas lasers manage the task with ease.

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Fuel cell generates power from methane

You can see the digesters at the Dresden sewage treatment plant from miles around. In them is thick brown sludge heated at around 38 degrees Celsius and used to obtain methane gas. This sewage gas powers a combined heat and power station. In this way, the sewage plant covers 60 percent of its own electricity needs. The power it produces would be sufficient to supply up to 16,000 households with electricity. However, it is possible to get even more from the gas. "Compared to a combined heat and power station, fuel cells are considerably more effective," explains Matthias Jahn from the Dresden-based Fraunhofer Institute for Ceramic Technologies and Systems IKTS. Whereas conventional technology is able to achieve 40 percent efficiency at most, with the remainder lost as heat, fuel cells can reach an efficiency of 50 percent. "While cogeneration technology is largely exhausted, there is still scope for development with fuel cells," says department head Jahn.

Jahn and his team are currently testing a solid oxide fuel cell (SOFC) under real conditions at the Dresden sewage works. The SOFC does not use hydrogen, which is energy-intensive to obtain, but rather sewage gas from municipal sewerage. "Our system remains stable in operation even when the methane content fluctuates between 30 and 70 percent," explains Jahn. The carbon dioxide present in the biogas does not have to be separated out; it is used in the process. This allows greater flexibility in the composition of the fuel gas: food and market waste, leftovers from food production, and the contents of households' organic waste bins can all go into the mix.

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