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RESEARCH NEWS

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1 Ensuring security for networks of the future

Company networks are inflexible – they are made up of many components that require a good deal of effort to be connected together. That's why networks of the future will be controlled by a central unit. However, this makes them a target for hackers. At CeBIT, Fraunhofer researchers will demonstrate how to protect these future networks.

2 Beer, milk and Co. in bacteria quick test

To guarantee a high quality of their beer, breweries monitor the production process very closely. With a new polymer powder, this monitoring will be able to be faster and simpler in the future. Manufacturers can also test drinks such as milk, juice, cola and red wine with the quick check.

3 Wind-powered freighters

To make ships more eco-efficient, engineers have been working with alternative fuels. A Norwegian engineer is currently pursuing a new approach: With Vindskip™, he has designed a cargo ship that is powered by wind and gas. Software developed by Fraunhofer researchers will ensure an optimum use of the available wind energy at any time.

4 Vehicle body made from cotton, hemp, and wood

Carbon and glass fibers reinforce synthetics so that they can be used for vehicle body construction. But in this regard, there is an abundance of potential found in natural fibers – obtained from hemp, cotton, or wood. If you combined bio-based textile and carbon fibers, you can obtain extremely light yet very sturdy components.

5 Ultrasound technology made to measure

The range of uses for ultrasound is gigantic; the applied technologies are just as diverse. Researchers are now covering a wide range of applications with a new modular system: From sonar systems to medical ultrasound technologies and all the way to the high frequency range – such as for materials testing.

6 Solar chip monitors windows

A new kind of radio chip is intended to warn when windows are left open. This way, you can avoid having the heat go out the window on cold days. The sensor also detects break-in attempts early on. The key: This maintenance-free chip powers up with energy supplied by solar power.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 67 Fraunhofer Institutes and research units at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 23,000, who work with an annual research budget totaling 2 billion euros. About 70 percent of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the Americas and Asia serve to promote international cooperation.

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Ensuring security for networks of the future

Today's company networks comprise hundreds of devices: routers for directing data packets to the right receiver, firewall components for protecting internal networks from the outside world, and network switches. Such networks are extremely inflexible because every component, every router and every switch can carry out only the task it was manufactured for. If the network has to be expanded, the company has to integrate new routers, firewalls or switches and then program them by hand. That's why experts worldwide have been working on flexible networks of the future for the last five years or so, developing what is known as software-defined networking (SDN). It presents one disadvantage, however; it is susceptible to hacker attacks.

Researchers from the Fraunhofer Institute for Applied and Integrated Security AISEC in Garching, near Munich, will be showing how to make SDN secure at the CeBIT trade fair in Hannover, March 16-20. A demonstrator at the Fraunhofer exhibition stand (Hall 9, Booth E40) will show how SDN and all related components can be monitored. One of these components is visualization software, which displays the network's individual components and depicts in real time how the various applications are communicating with the controller. "We can show how software influences the behavior of different components using the controller, or, in the case of an attack, how it disrupts them," says Christian Banse, a security expert at AISEC.

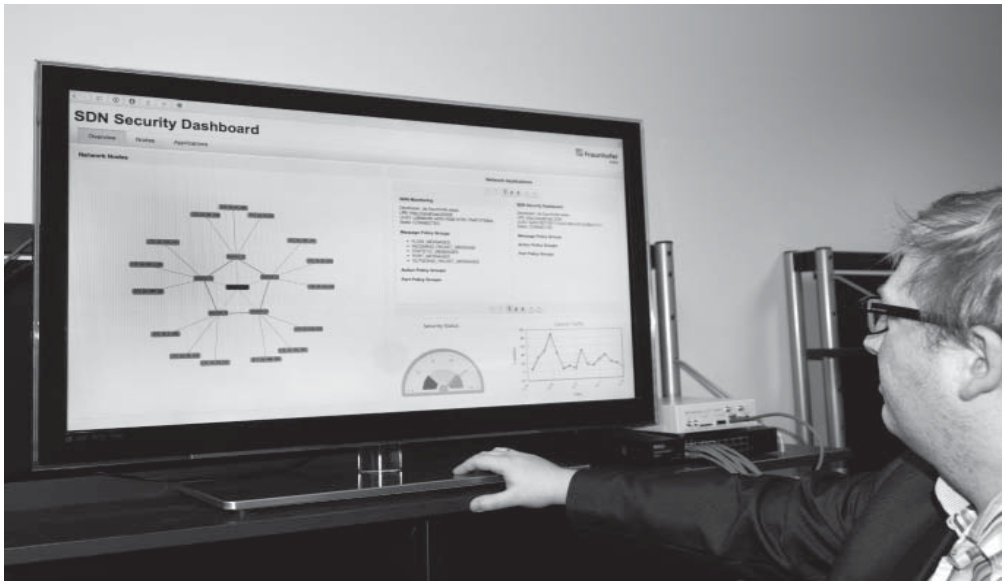
But how exactly does SDN work, and why is it so vulnerable to attack? "In the future, the plan is for a central control unit to tell the many network components what to do. To put it simply, routers, firewalls and switches lose their individual intelligence – they only follow orders from the controller," says Banse. This makes a network much more flexible, because the controller can allocate completely new tasks to a router or switch that were not intended when the component was manufactured. Plus, the tedious task of manually configuring components during installation is eliminated because components no longer need to be assigned to a specific place in the network – the controller simply uses them as needed at the moment.

The controller is a popular target for hackers

Manufacturers have begun offering the first routers and switches that are SDN-compatible and have the necessary flexibility. "With all the hype surrounding the new adaptability made possible by a central control unit, SDN security has been neglected," warns Banse. "That's why we're developing solutions to make SDN more secure from the outset, before such systems become firmly established." In the future, networks will be controlled solely by a central controller – Banse sees this as a problem, because it might provide the perfect loophole for attackers to access the entire network. "On top of that, a whole set of new applications are being developed for SDN – for instance for firewall components or routing," says Banse. "We have make sure that

these applications are reliable." It would be disastrous if, for example, outsiders were able to gain access to the company network using software installed accessing the controller.

That's why Banse and his colleagues started off by analyzing the interaction of all SDN components to identify vulnerabilities. "You have to precisely define how deep into the network a new application is allowed to go, for example. Otherwise the stability and security of the network is not guaranteed." So far, there are no sufficient security standards for communication among individual SDN components, but AISEC researchers are lobbying hard for an international standard. In addition to their visualization solution, at CeBIT Banse and his team will also present technical means for preventing unauthorized applications or malware from gaining access to SDN systems. They are developing ways to monitor if an app really carries out only the task for which it was intended. If it performs unplanned or undesirable activities, i.e. malware, it is rejected and blocked by the system.



With their visualization software, AISEC researchers can monitor every component in software-defined networking (SDN). (© Fraunhofer AISEC) | Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Applied and Integrated Security AISEC | Parkring 4 | 85748 Garching | www.aisec.fraunhofer.de
Press: Viktor Deleski | Phone +49 89 3229986-169 | viktor.deleski@aisec.fraunhofer.de

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Beer, milk and Co. in bacteria quick test

It tastes full-bodied and spicy, is tasty and is a welcome refreshment, especially in the hot summer months – Beer is very popular throughout the world. For brewers, a consistently high quality of the drink is essential. To ensure this, the companies try to keep the product free from harmful microorganisms. This is because pathogens that enter into the beer during the brewing process can spoil the pleasure of the drink. They not only provide strong variations in taste and smell; the beer can also become cloudy, sour and unwholesome.

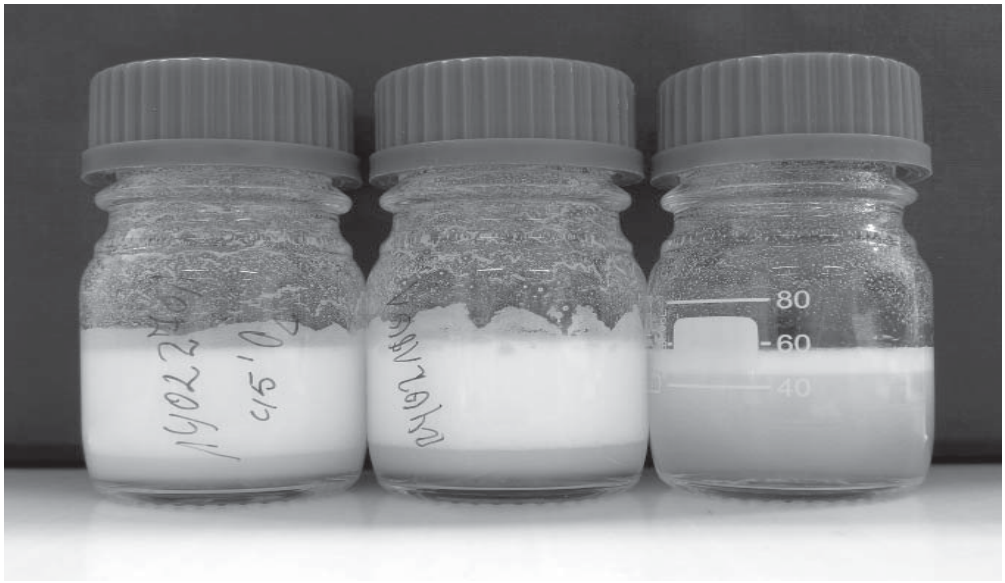
Therefore, ongoing quality controls accompany the production process. However, conventional microbiological methods require five to seven days to detect beverage-spoiling organisms, such as bacteria and yeasts. It is often too late at that point to take corrective action. In collaboration with the company GEN-IAL from Troisdorf, researchers at the Fraunhofer Institute for Applied Polymer Research IAP in Potsdam have developed a polymer powder that significantly simplifies these tests and shortens the time that they require. The company supplies breweries with analysis tools for quality control.

From the test to the reliable result takes two to three days. The reason: Until recently, beer has been filtered in special equipment. In this process, the bacteria remain on a membrane and are then elaborately cultivated in a special culture medium before they can be examined microscopically. The new polymer powder from the IAP replaces this process: The powder is added to the liquid sample. The powder's functionalized surface binds the bacteria efficiently. The pathogens adhere to the 100 to 200 micron powder particles. These can be easily removed along with the microbes in a specially developed system and analyzed directly using various microbiological methods. The time-consuming enrichment in a nutrient medium is no longer necessary.

Quality control of large quantities of beverages possible

With the new method, food experts can investigate beer and other beverages for infection by pathogens, which was hardly or not at all possible with the traditional membrane filtration method. "Membrane filtration is not suitable for the quality control of beverages such as fruit juices, milk, cola and red wine. They contain so much solid or suspended matter that the filter clogs quickly," explains Dr. Andreas Holländer, scientist at the IAP. Breweries have also only been able to examine small sample volumes of up to one liter via membrane filtration. With the polymer powder, tests with 30 liters or more are possible. "Wherever a small amount of microbes has to be extracted from a large amount of liquid, the new technique can be useful," adds Holländer. "Through the use of the powder, food safety is increased, since it is more likely to find trace contaminants in large volumes of the beverages," says Dr. Jutta Schönling, managing director of Gen-IAL.

Also the equipment with which the surface of the powder particles is functionalized has been developed by Dr. Holländer and his team from the IAP. This equipment will now be used by the company GEN-IAL for the pilot production. The launch is planned for 2015, and interested users will already be able to buy the powder in the spring of this year.



The functionalized polymer powder disperses in water. (© Fraunhofer IAP) | Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Applied Polymer Research IAP | Geiselbergstr. 69 | 14476 Potsdam-Golm | www.iap.fraunhofer.de
Press: Kathrin Begemann | Phone +49 331 568-1161 | kathrin.begemann@iap.fraunhofer.de

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Wind-powered freighters

International shipping is transporting 90 percent of all goods on earth. Running on heavy fuel oil freighters contribute to pollution. The International Maritime Organization (IMO) wants to reduce the environmental impact of ocean liners. One of the measures: Starting from 2020, ships will only be allowed to use fuel containing maximum 0.1 percent sulfur in their fuel in certain areas. However, the higher-quality fuel with less sulfur is more expensive than the heavy fuel oil which is currently used. Shipping companies are thus facing a major challenge in reducing their fuel costs while complying with the emission guidelines.

A new way of reducing fuel consumption, emissions and bunker expenses is being pursued by the Norwegian engineer Terje Lade, managing director of the company Lade AS: With Vindskip™ he has designed a type of ship that does not use heavy fuel oil but utilizes wind for propulsion. The highlight: The hull of the freighter serves as a wing sail. On the high seas, Vindskip™ will benefit from free-blowing wind making it very energy efficient. For low-wind passages, in order to maneuver the ship on the open sea while also maintaining a constant speed, it is equipped with an environmentally friendly and cost-effective propulsion machinery running on liquefied natural gas (LNG). With the combination of wind and liquefied natural gas as an alternative fuel to heavy fuel oil, the fuel consumption is estimated to be only 60 percent of a reference ship on average. Carbone dioxide emissions are reduced by 80 percent, according to calculations by the Norwegian company.

Weather routing module determines the optimal course

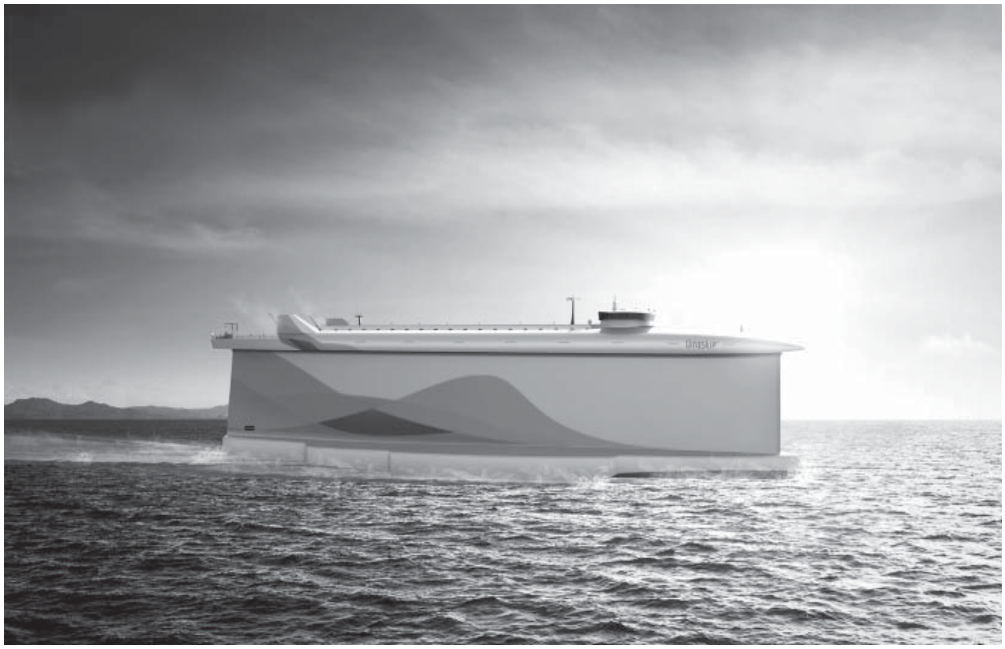
For efficient operation, it is critical that the available wind energy is used in the best possible way. In order to calculate the optimal sailing route, researchers from Fraunhofer Center for Maritime Logistics and Services CML, a division of Fraunhofer Institute for Material Flow and Logistics IML, have developed a customized weather routing module for Vindskip™. Considering meteorological data the software for the new ship type uses a navigation algorithm to calculate a route with the optimum angle to the wind for maximum effect of the design. “With our weather routing module the best route can be calculated in order to consume as little fuel as possible. As a result costs are reduced. After all, bunker expenses account for the largest part of the total costs in the shipping industry,” says Laura Walther, researcher at CML in Hamburg. For the complex calculations, the researcher and her team apply numerous parameters, such as aero- and hydrodynamic data as well as weather forecasts from the meteorological services, such as wind speed and wave height.

So how is it possible that the Vindskip™ is being pulled forward? “At angles close to headwind the wind generates a force in the ship’s direction. The ship is pulled forward. Since the hull is shaped like a symmetrical air foil, the oblique wind on the opposite

side – leeward – has to travel a longer distance. This causes a vacuum at the windward side that pulls the ship forward," explains Vindskip™ patent-holder Lade. This makes the freighter move at speeds of up to 18 to 19 knots, hence just as fast as conventionally powered ships. Due to its very low fuel consumption, Vindskip™ can utilize liquefied natural gas (LNG) as fuel and still be capable – in the worst case – of 70 days of steaming between bunkering. Thus, it can meet all of today's and tomorrow's challenges with regards to fuel economy and emission control.

Wind-tunnel tests completed successfully

The researchers from CML are continually developing the weather routing tool further; the first version has been available since mid-December 2014. By the end of January 2015, the software will be handed over to the company Lade AS. Ship types that are particularly relevant to the Vindskip™-design, for which the weather routing module is developed, are ships like car and truck carriers, big ferries, container ships and LNG carriers. Terje Lade forecasts that the freighter will set sail as soon as 2019. First, the ship model has to pass numerous tests in a marine research model tank – also called a towing tank by experts. Tests in wind tunnels have already been completed successfully.



The hull of the cargo ship Vindskip™ acts as a large wing sail. (© LADE AS) | Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Material Flow and Logistics IML, Fraunhofer Center for Maritime Logistics und Services CML | Schwarzenbergstr. 95D | 21073 Hamburg | www.cml.fraunhofer.de
Press: Claudia Bosse | Phone +49 40 42878 4476 | claudia.bosse@cml.fraunhofer.de

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Vehicle body made from cotton, hemp, and wood

"Lightweight" is an important buzzword in automotive engineering, and just as important in the aerospace sector, too. Carmakers are increasingly counting on fiber reinforced synthetics. These fibers, which are embedded into the synthetic matrix, give the material its additional durability. Exactly which material you choose to use depends on its eventual application. Thus, primarily carbon fiber is used in Formula 1 racing. However, one drawback is its high price; even its processing can be tough. These are the reasons why carbon fiber-reinforced plastics (CFRPs) have still not yet found their path into wide-scale serial production so far to date. Glass fibers, on the other hand, are certainly reasonably priced, but heavy by comparison. But this may soon change, thanks to some new research approaches by researchers at the Application Center for Wood Fiber Research HOFZET of the Fraunhofer Institute for Wood Research, the Wilhelm-Klauditz-Institut WKI in Braunschweig.

Combining advantages, eliminating disadvantages

The scientists are relying on natural fibers of botanical origin. Variants derived from hemp, flax, cotton and wood are about as affordable as glass fibers, and moreover have a lower density than the pendants made of glass or carbon. Another advantage: If you incinerate them at the end of their life cycle, they produce additional energy – without leaving residues. Nevertheless, their durability and stability don´t reach that of carbon fibers. "Depending on the application, we are therefore combining carbon with various bio-based textile fibers," explains Prof. Dr.-Ing. Hans-Josef Endres, head of the Application Center for Wood Fiber Research. The fibers typically exist as fabrics that are placed on each other accordingly and are embedded by the plastic matrix. "We use carbon fibers in those areas where the part undergoes intense mechanical stress; in other areas, it's natural fibers. This way, we can leverage the strengths of the respective fibers and get rid of the disadvantages to a great extent. "The outcome: the parts are cost-effective, have a very high degree of durability, possess excellent acoustic properties and are substantially more ecological than pure carbon components.

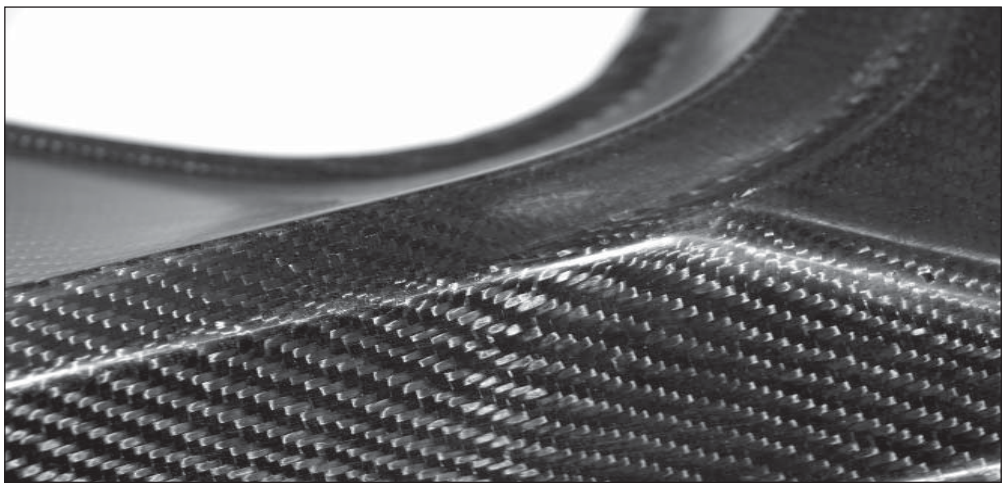
Typically, you treat the surface of the natural fibers so that they can be run easily through the textile equipment, and can be processed as well as possible into fabrics – this is also referred to as "sizing the surface of the fiber". While this is important for textile production, it is usually counterproductive, however, if composite materials have to be processed. "This is why, from a materials engineering perspective, we optimize the surfaces of the fibers," says Endres. Specialized surface treatments or coatings are intended to ensure that the fibers can be combined and interact in the best possible way with the matrix or the plastic mass. The potential is vast: "By ensuring that the fibers bond to the matrix optimally, we can increase the durability of the materials by up to 50 percent," Endres explains in concrete terms. While such surface treatments

are customary with glass and carbon fibers, when it comes to use textile fibers for reinforcement, the researchers are treading on virgin territory.

The entire production chain in sight – all the way to waste disposal

The researchers are doing more than creating the new hybrid materials. They are also studying how the processing processes for these new materials can be implemented on an industrial scale. By the same token, they also have an eye on the proper disposal of hybrid materials. Because when it comes to recycling, fiber composite materials are a proverbial "tough nut to crack." For instance, how can expensive carbon fibers be extracted from the matrix and recovered? With the hybrid materials they've engineered, the scientists are already considering in advance how these can be reprocessed or how, at least, individual materials components can be recovered for a new use or application. In doing so, they are pursuing various physical, thermal, and chemical approaches, depending on the material composition.

At the nature.tec professional trade show at the Grüne Woche from January 16 to 25 in Berlin, WKI will unveil and present various textile bio-based hybrid materials (Hall 5.2A). The researchers will also present fiber form-pressed components for the automotive industry there. Fibers inside these parts are embedded into a thermoplastic matrix - plastic, that is – which can be shaped at ultra-high temperatures, or into a duroplastic synthetic matrix that, once it has fully hardened, can no longer be formed.



Carbon and hemp-fiber reinforced component. (© Fraunhofer WKI) | Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut WKI, Application Center for Wood Fiber Research HOFZET | Bienroder Weg 54E | 38108 Braunschweig | www.wki.fraunhofer.de
Press: Simone Peist | Phone +49 531 2155-208 | simone.peist@wki.fraunhofer.de

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Ultrasound technology made to measure

Ultrasound technologies make visible what remains hidden from our naked eyes: Physicians study tissue changes in our bodies with the aid of sonography; submarines equipped use sonar systems to get their bearings in the darkness of the deep sea; and for materials and components testing, ultrasound provides a non-destructive alternative to costly technologies that are not real-time capable. Depending on the application, a variety of technologies can be used. "Complete systems are typically developed, based on unique customer specifications. Within this context, that only allows them to be used for a very limited area, however, the development expenditure is really quite high," explains Steffen Tretbar of the Fraunhofer Institute for Biomedical Engineering IBMT in St. Ingbert.

Tretbar and his team therefore are taking a new path: The scientists have developed a multichannel ultrasound platform that uses a modular configuration so that it can be adapted to a set of applications that are entirely different from each other, such as real-time treatment monitoring. "This way, we can both quickly respond to customer requests for the widest array of applications, and also offer money-saving solutions," says Tretbar. The system uses basic components, like main board, power supply, and control software that always stays the same. "Then we put application specific components – the front-end boards – into this main board, like with a building-block system," explains Tretbar.

In order to adapt an application, the frequency range of the ultrasound waves is a key regulating screw. Sonar systems typically move within the low-frequency range (from the kilohertz range to about two MHz). This way, you admittedly do not get a high spatial resolution of the images; however, you can "see" up to several hundred meters deep. Unlike with its use in medicine: Here the physician needs records with the highest possible resolution. For this purpose, the sound waves do not have to traverse any long stretches, but instead just penetrate a couple of centimeters into the body. For this reason, medical ultrasound typically hovers within a frequency range of between 2 to 20 MHz. Very high frequencies, up to the 100 MHz range, enable resolutions in the µm-range, e.g., for materials testing or the imaging of small animals that is needed with the development of new technologies. The researchers developed coresponding front-end boards for all three areas.

Swift interfaces to the computer

In order to fine-tune the system, you merely need to configure the software accordingly. "We have realized very fast interfaces to the PC. This way, we can control the systems in real time, enable very swift signal processing with repeat rates in the kHz/ range, and simply implement new software algorithms that have been adapted for various applications," explains Tretbar. Another advantage of the ultrasound platform:

Scientists can refer back to not only classic image data, but also to the unprocessed raw signals of each element in the ultrasound array. This allows them to develop completely new technologies.

The various modules are ready for deployment – primarily corporation from the medical field have signaled their interest in such developments. In order to turn the technology into concrete products, the experts from IBMT offer two approaches: Either they apply software interfaces to the ultrasound systems that are integrated directly into the customer's system. Or the second option is to integrate the customer's application into the software of the ultrasound system and then realize a software product for the entire application. As part of the research platform, IBMT's development expertise covers all technology components – from ultrasound transducers and new ultrasound technologies to complete systems and their certification or approval as a medical product.

Modular ultrasound platform for medical applications. (© Fraunhofer IBMT) | Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Biomedical Engineering IBMT | Ensheimer Straße 48 | 66386 St. Ingbert | www.ibmt.fraunhofer.de
Press: Dipl.-Phys. Annette Maurer | Phone +49 6894 980-102 | annette.maurer@ibmt.fraunhofer.de

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Solar chip monitors windows

It happens all too often in the cold times of the year: You open the window in the morning for fresh air and forget to shut it again. A thermostat reports cold temperatures, and the heating is turned up full blast – right out the window. But open windows are a problem with more than just the heating or storms. A window tilted open, for example, is a direct invitation to intruders. It would be desirable to have an automated system that notices open windows and sends an alarm signal to the tenant. There are certainly home and building systems today that register the window status. As a rule, however, the sensors have to be attached by cable to the alarm center inside the home or building itself. In other cases, battery-operated radio sensors are used. But changing batteries in structures that have several windows can lead to a considerable maintenance expense. Researchers from the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg therefore developed a pragmatic alternative: a radio sensor chip about the size of a fingernail that is mounted directly in the window. The tiny sensor is coated with a solar cell and it supplies itself with power.

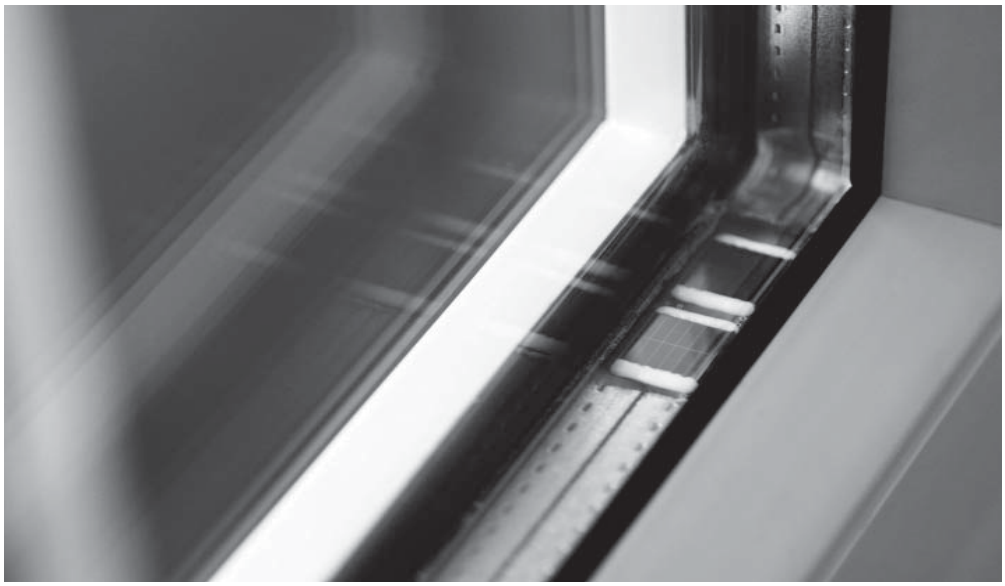
Sensors differentiate between ball and crowbar

At ten millimeters, the chip is as narrow as a pane of insulating glass is thick. It is installed on the aluminum profile between the glass that maintains the distance between the panes. Thanks to this window space, the solar cell obtains adequate light, even in the darkness of winter. Integrated in the chip are magnet and acceleration sensors that register if the window is open just a crack or all the way. The chip can send a signal via radio to the base station in the building if a window has remained open for too long. The applications of the radio chip are diverse. It can remind homeowners to ventilate regularly or warn if a window is still open when they leave the home. In addition, it offers reliable protection from intruders even for closed windows. Because the sensors can differentiate very precisely between various fluctuations - for example, a ball that slams against the pane, or an intruder's crowbar that ratchets open the window frame. Within a tenth of a second, the system detects the disturbance and sounds the alarm if there is any doubt.

The IMS researchers around electrical engineer Dr. Gerd vom Bögel and physicist Dr. Andreas Goehlich have mastered just these two challenges: First of all, they succeeded in depositing the solar cell directly onto the uneven surface of the chip. Secondly, the chip consumes power so meagerly that energy from the miniscule solar cell spans the dark hours. The microchips are coated with numerous conductor paths, its surface is thereby made very uneven. "This is why we had to find a means of filling in and evening the surface, like a street profile, prior to coating it with the solar cell," vom Bögel says.

Currently IMS sensor prototypes can store enough power for up to 30 hours of darkness. This is expected to lead to the emergence of a product over the next two years that can even bridge up to two weeks of darkness. By keeping both processor and chip extremely small, the latter is extremely frugal. In addition, the researchers constructed switches that consume little energy, and engineered very short radio protocols. "We have extracted every possible micro-ampere," says vom Bögel. Adding to the overall conservation of power is the fact that the sensor always switches to sleep mode. Depending on the user's preferences, the sensor can be set so that it wakes up every few minutes, or even seconds, and takes a measurement. The Israeli firm SOLCHIP, which was asking for solar cells on chips at IMS around two years ago, provided the impetus to developing the solar radio chip. Andreas Goehlich's group of developers succeeded in integrating the solar cells on the surface of the chips. Using these solar cells, SOLCHIP seeks to monitor the street traffic for example, or the climate conditions in vineyards.

"As you can see, there are a lot of application areas," vom Bögel says. The production costs are so minimal because the application of the solar coating is directly connected to the production process of the chips. "Only a handful of additional production steps are needed so that manufacturing can also be accomplished in high quantities." From January 19 to 24 the radio sensor chip will be shown at the BAU trade fair in Munich (Hall C2, Stand 119).



The chip affixed to the window frame supplies itself with energy. (© Fraunhofer IMS) | Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Microelectronic Circuits und Systems IMS | Finkenstraße 61 | 47057 Duisburg | www.ims.fraunhofer.de
Press: Michael Bollerott | Phone +49 203 3783-227 | michael.bollerott@ims.fraunhofer.de