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RESEARCH NEWS

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1 Paving slabs that clean the air

The concentrations of toxic nitrogen oxide that are present in German cities regularly exceed the maximum permitted levels. That's now about to change, as innovative paving slabs that will help protect the environment are being introduced. Coated in titanium dioxide nanoparticles, they reduce the amount of nitrogen oxide in the air.

2 Making vehicles safer

A car's crash components can spell the difference between life and death. Their job is to absorb energy in a collision in order to protect the driver inside. Researchers have now found a way for the automotive industry to mass-produce a particularly safe class of materials known as thermoplastic fiber composite components.

3 Open software platform helps to save energy

Starting 2011, energy suppliers will be obligated to offer variable power prices. A new energy management software platform will enable customers in future to opt for flexible electricity rates, so that they can purchase power at times when it is available more cheaply.A further advantage is better utilization of the power grid.

4 Timber with antennas

In the future, wood-based radio tags will optimize logistics processes in the forestry. These RFID transponders consist of paper and lignin, an integral part of plants. Thus, they do not disrupt the processing of logs and still make it possible to capture entire truckloads of timber.

5 Digital helpers for the hearing impaired

Every fifth German is hearing impaired. In their private and in their work lives, they are restricted – such as when making a telephone call. Researchers are now ready with a digital solution, one that can partially compensate for the hearing loss. Soon, the system will be integrated into devices such as telephone systems and cell phones.

6 Hydrogen makes metal brittle

Hydrogen is considered the fuel of the future. Yet this lightest of the chemical elements can embrittle the metals used in vehicle engineering. The result: components may malfunction and break. A new special laboratory is aiding researchers' search for hydrogen-compatible metals..

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 59 Fraunhofer Institutes at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 17,000, who work with an annual research budget totaling 1.5 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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Paving slabs that clean the air

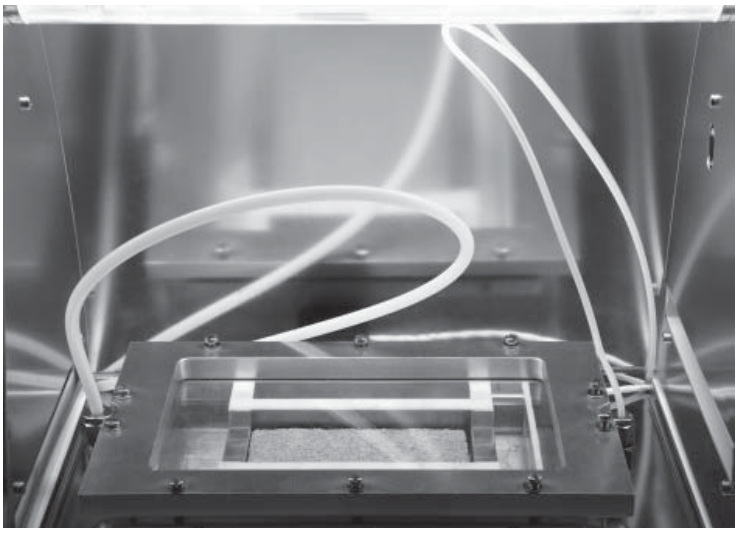
In Germany, ambient air quality is not always as good as it might be – data from the federal environment ministry makes this all too clear. In 2009, the amounts of toxic nitrogen oxide in the atmosphere exceeded the maximum permitted levels at no fewer than 55 percent of air monitoring stations in urban areas. The ministry reports that road traffic is one of the primary sources of these emissions. In light of this fact, the Baroque city of Fulda is currently embarking on new ways to combat air pollution. Special paving slabs that will clean the air are to be laid the length of Petersberger Straße, where recorded pollution levels topped the annual mean limit of 40 micrograms per cubic meter (µg/m^3) last year. These paving slabs are coated with titanium dioxide (TiO_2), which converts harmful substances such as nitrogen oxides into nitrates. Titanium dioxide is a photocatalyst; it uses sunlight to accelerate a naturally-occurring chemical reaction, the speed of which changes with exposure to light. The »Air Clean« nitrogen oxide-reducing paving slabs were developed by F. C. Nüdling Betonelemente. Proof of their effectiveness has subsequently been provided by the Fraunhofer Institute for Molecular Biology and Applied Ecology IME in Schmallenberg, where researchers also determined the risk to the environment posed by the resulting nitrates. Their work was funded by the German Environment Foundation.

Dr. Monika Herrchen, a scientist at the IME, says: »Experiments in Italian cities had already shown that photocatalytic paving slabs can improve the air quality. We wanted to see if they would also be effective here in Germany, where we have lower levels of light intensity and fewer hours of sunshine. Of course, the more intense the sunshine, the quicker the degradation of harmful substances, so our aim was to identify the formula with the highest photocatalytic efficiency rating.«

To begin with, concrete manufacturer F.C. Nüdling produced a range of sample slabs incorporating different surfaces, colors, types of cement and TiO_2 contents. Since the nitrogen oxide degradation rates achieved using standard commercial photocatalytic cement (i.e. cement that reacts to solar radiation) proved unsatisfactory, the company ultimately had to develop its own, more effective formula. »We were able to verify the effectiveness of the optimized slabs in a variety of tests,« confirms Herrchen. During an extended time field test, the scientist and her team recorded nitrogen oxide degradation rates of 20 to 30 percent in specially-created street canyons. The measurements were taken at a height of three meters above the photocatalytic slabs, in variable wind and light conditions. When the wind was still, the experts recorded degradation rates as high as 70 percent for both nitrogen monoxide (NO)

and nitrogen dioxide (NO_2). Measurements likewise taken at a height of three meters above the Gothaer Platz in Erfurt, which is already paved with Air Clean paving slabs, revealed an average degradation rate of 20 percent for NO_2 and 38 percent for NO.

Herrchen points out an additional benefit of these paving slabs: »They also remain stable over the long term. Measurements recorded from 14 to 23 months after they were laid revealed no change from the initial degradation capability.« Furthermore, the nitrate that is generated during the conversion process poses absolutely no risk to the environment. It runs off into the drainage system, then into a wastewater treatment plant, before finally ending up on a farmer's field or in the groundwater. The maximum possible nitrate concentration traceable back to photocatalytic reactions is around five milligrams per liter (mg/l), while the maximum permitted concentration of nitrate in groundwater is 50 mg/l. Herrchen sums up: »All in all, it's possible to say that Air Clean significantly improves the air quality within a short space of time, and thus helps protect the environment.«



Initial tests in the measuring chamber confirm that paving slabs coated with titanium dioxide can reduce ambient nitrogen oxide levels. (© Fraunhofer IME)

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Making vehicles safer

Vehicles used to be predominantly made of steel. However, this raw material has long faced stiff competition from other materials, and modern cars are now built from a mixture of steels, aluminum and fiber-reinforced plastics. Highly stressed load-bearing structures and crash components that are designed to buckle on impact help to reinforce the body in order to protect the vehicle's occupants in the event of a collision. Automakers have previously constructed these parts from composites using a thermoset (i.e. infusible) matrix. But this approach has a number of disadvantages: as well as being difficult to implement efficiently in a mass production environment, it can also be potentially hazardous since this material tends to »delaminate« into sharp-edged splinters in a collision. A further problem is the fact that thermosets cannot be recycled. Researchers from the Fraunhofer Institute for Chemical Technology ICT in Pfinztal have now found a solution to this problem by developing a new class of materials designed for large-scale use in vehicle construction: thermoplastic fiber composite materials. Once they have reached the end of their useful life, they can be shredded, melted down and reused to produce high-quality parts. And they also perform significantly better in crash tests: thermoplastic components reinforced with textile structures absorb the enormous forces generated in a collision through viscoelastic deformation of the matrix material – without splintering.

Researchers had previously failed to come up with a suitable manufacturing technique for thermoplastic composite structures made from high performance fibers, but the ICT engineers have now developed a process suitable for mass production which makes it possible to manufacture up to 100,000 parts a year. »Our method offers comparatively short production times,« states Dieter Gittel, a project manager at ICT. »The cycle time to produce thermoplastic components is only around five minutes. Comparable thermoset components frequently require more than 20 minutes.«

The Fraunhofer researchers have named their technique thermoplastic RTM (T-RTM). It is derived from the conventional RTM (Resin Transfer Molding) technique for thermoset fiber composites. The composite is formed in a single step. »We insert the pre-heated textile structure into a temperature-controlled molding tool so that the fiber structures are placed in alignment with the anticipated stress. That enables us to produce very lightweight components,« Gittel explains. The preferred types of reinforcement comprise carbon or glass fibers, and the researchers have also developed highly specialized structures. The next step involves injecting the activated monomer melt into the molding chamber. This contains a catalyst and activator

system – chemical substances that are required for polymerization. The ingenious part is that the researchers can select the system and the processing temperature in a way that enables them to set the minimum required processing time.

A demonstration part has confirmed the benefits of this new class of material: the trunk liner for the Porsche »Carrera 4« weighs up to 50 percent less than the original aluminum part. To improve the crash behavior of the vehicle's overall structure, the ICT engineers also calculated the optimum fiber placement. Another advantage of the T-RTM process is that the cost of the thermoplastic matrix material and the cost of its processing are up to 50 percent lower than the equivalent costs for thermoset structures. Over the next few years it is anticipated that these kinds of components will start to be used in vehicle and machine construction as well as in the leisure industry. Experts in the field will be exhibiting the trunk liner for the Porsche »Carrera 4« at the Composites Europe fair in Essen from September 14 to 16 (Hall 12, Booth C33).

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Open software platform helps to save energy

Faced with rising electricity and heating costs, more and more consumers are opting to save energy, and now the government is beginning to help them. As from 2011, energy suppliers will be required to offer electricity at variable rates under the German Energy Act (EnWG § 40,3). The idea behind the new law is simple: variable rates should encourage people to make a conscious effort to control their consumption. This is where the new open software platform will come into its own in future, helping electricity consumers to handle the new flexible rates and make their energy consumption more intelligent. The OGEMA (Open Gateway Energy Management Alliance) Framework was developed by the Fraunhofer Institute for Wind Energy and Energy System Technologies IWES in Kassel. It is a freely available Java-based, open-source platform for energy management that links both consumers and producers of energy to the control centers of the grid operators and power suppliers. Via a display, customers will be able to monitor a variable electricity price and wait for times when rates are lower in order to start their dishwashers for instance. »Variable rates allow demand for electricity to be steered. When grid utilization levels are low, electricity can be offered at lower rates. This makes it lucrative, for example, for consumers to run their washing machines at night. Flexible pricing is an incentive to gradually shift power consumption to times when there is an oversupply of wind energy. After all, with the growing trend towards to renewable energy sources it is becoming ever more important to adapt one's consumption to suit the supply.« That is how Dr. Philipp Strauß, engineer and division director at IWES, explains the concept behind the software.

But nobody really wants to spend time checking up on electricity prices several times a day, which is why the researchers responsible for the OGEMA Framework developed a software program called BEMI (Bidirectional Energy Management Interface) that relieves consumers of this very task. The software automatically controls appliances such as refrigerators, washing machines, heat pumps and air-conditioning. But OGEMA programming is not just the domain of the researchers: True to the principle of other open-source projects such as Linux, all developers are free to design software for the platform, thus implementing their ideas for the automated and more efficient use of energy. »Currently, there is no open system for the home automation field that enables different manufacturers to develop dedicated apps,« says Dr. David Nestle, IWES group manager, underlining the special feature of the OGEMA Framework.

In order to continue developing the concept and making it better known, the IWES

launched the OGEMA Alliance this summer, which a number of companies, such as Mannheim-based energy supplier MVV and solar energy wholesaler Entrason, have already joined. »Our hope is that, within a short space of time, numerous applications will arise to meet the needs of private households and small businesses,« says Nestle. One conceivable innovation is an app that adapts the operation of electrical appliances to the power generation pattern of a household's own photovoltaic system or that coordinates individual room heating to suit the consumer's daily routine.

At the moment, researchers are working on the first version of the OGEMA-software, which will be available later this year as a gratis download: An field test will be carried out as part of the E-energy projects »Modellstadt Mannheim« and the EU-sponsored SmartHouse/SmartGrid. Initially, the use of the system will be tested in 100 households, with a further field test involving 1500 customers planned for next year.

Using a mobile display, researchers program the system to start a washing machine at a certain time. (© Fraunhofer IWES)

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Timber with antennas

Forest hikers are most familiar with the colorful markings on tree trunks waiting along trails to be hauled away. Only insiders know how to interpret them though. »In principle, each forester or forest owner has his or her own marking system,« observes Mike Wäsche from the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg. Together with colleagues from the Fraunhofer Institute for Reliability and Microintegration IZM, the Thuringian State Forestry, Hunting and Fishing Agency and other forestry partners the business information specialist intends to replace these markings with standardized transponders, i.e. radio tags. At the same time, they intend to establish a logistics standard based on RFIOD for the exchange of data between forest owners, logging and hauling operations and commercial end users.

While the ELDAT standard for ELectronic DATa exchange of sales information has been employed in forestry since, it incorporates logistics processes ionly rudimentarily. In addition, there are gaps in the IT infrastructure: »So far only the major players have implemented information technologies,« regrets Wäsche. However, everyone involved could profit from integrated electronic data exchange in conjunction with RFID – even small and medium-sized operations that are primarily responsible for logging and transport: Data such as the origin, quality, quantity and destination of logs would only have to be recorded once. Moreover timber can be allocated rapidly and reliably, which expedites invoicing and facilitates transportation control.

High-grade logs for furniture or parquetry is already frequently marked with numbered tags or radio tags. However, the partners in the project »Intelligent Wood - RFID in Timber Logistics« desire a more practicable solution that is suited for marking all types of wood – even the over 13 million cubic meters of industrial timber produced in Germany each year. Industrial wood is defibered and processed into pulp, paper or composite wood panels. »Since the profit margins in this sector are slight, the RFID transponders used may not cost much nor disrupt further processing of the wood,« the project manager Wäsche points out. Hence, the team at IZM has developed a new wood-based transponder: With the exception of its antenna, the tag consists of paper and lignin. Large quantities of the resin-like polymer are yielded when cellulose is extracted from wood. »The transponder's fraction of metal ist far below the typical levels of impurities in and around wood,« explains Christine Kallmayer, group manager at IZM. To keep costs down, only a numeric code is stored on the radio tag. All other information is stored in the individual actors' management and accounting systems. Tags are read when a vehicle drives by: When making a delivery to a mill, the

truck and its cargo pass through a reader gate. All delivered logs are captured in bulk while still on the vehicle. Theoretically, one to two RFID transponders per truckload suffice to uniquely identify everything. If a load of timber originates from multiple suppliers, at least every twentieth or thirtieth log must be marked – depending on the size of the individual loads – to alloate it reliably. Although the project will run until early 2011, the IFF is already giving thought to inquiries from the chemical industry. The same principle could be applied to capture and track metal drums filled with hazardous liquids.

A truck passes through a special gate: Its entire truckload of timber is captured as it drives through the reader gate. (© Mike Wäsche/Fraunhofer IFF)

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Digital helpers for the hearing impaired

»Pardon me? Would you mind speaking louder, please? I can't understand you.«" About 13 million Germans cannot hear well. And it is not necessarily an issue of age. According to data from the German Association for the Deaf, roughly 19 percent of those over 14 years are hearing impaired. In the over-65 bracket, the numbers increase to every second person. Hearing abilities diminish primarily between the ages of 40 and 50. Many of those affected indicate that the impairment limits their performance at the workplace. Most difficulties involve communication. Of particular difficulty are telephone communications - such as via the Internet (Voice over IP). Here, the telephone conversation is conducted via computer networks using the Internet Protocol. Ambient noise and acoustic echoes often impede the conversation. For the hearing impaired, it is especially problematic. They can only use this Internet option on a very limited basis. They have to increase the volume just to be able to follow the conversation at all. But by doing so, the background noises are also intensified. In any case, signal frequencies that are already loud rapidly become virtually intolerable when intensified further.

In response to this, developers at the Fraunhofer Institute for Digital Media Technology IDMT in Oldenburg have come up with a digital solution. In the »Speech-Improved Telephony« project sponsored by the federal ministry for the economy and technology BMWi, they work on algorithms typically used for hearing aids that can at least partially compensate for the hearing loss. The trick: Each hearing impaired person has quite specific frequencies that are difficult for him or her. »Adjusted to the individual user, soft signals are intensified while loud signals remain unchanged since they would otherwise be perceived as unpleasantly loud,« explains engineer Stefan Goetze of the Hearing, Speech and Audio Technology project group at IDMT. The system also detects background noises and reduces these to a minimum. This provides advantages not only to people who have difficulty hearing. If a call originates from a loud environment, such as an open-plan office, even persons with normal hearing can benefit from the signal processing. The system can be set for each call in such a manner that it delivers a consistently intelligible sound pattern.

»One particular challenge is to figure out how users can moderate the algorithms themselves in a user-friendly manner. For seniors in particular, simple methods for making adjustments needed to be found. We were able to solve this on a test telephone through a special display. Two audio signals with different sound were visualized through flowers. By pressing on the flowers, the seniors can regulate the desired

sound. This automatically adjusts the algorithm parameters to the hearing ability of the individual user,« explains Goetze.

The algorithms can be integrated into all audio devices. Scientists have already installed them on an iPod Touch, a telephone system, a video conferencing system and a television. The devices are currently available as demo models. »The first products will probably become available in two years,« says Goetze. »If our technology is incorporated into consumer devices, then those affected will no longer have to constantly rely on their hearing aids.« The researchers will display a video conferencing system in which their algorithms are installed at this year's IFA in Berlin, the leading trade show for consumer electronics and home appliances, September 3-8 (Hall 8.1, Booth 4).

Researchers at Fraunhofer IDMT have equipped an iPod Touch with their algorithms. These can partially compensate for hearing loss among the hearing impaired. (© Fraunhofer IDMT)

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Hydrogen makes metal brittle

Most likely, there is hardly a soul that cannot recall K.I.T.T. – the legendary talking supercar from the US television series »Knight Rider«. A hydrogen turbo motor fuels the fantasy vehicle and propels it on the chase for the bad guys at over 300 miles an hour. In the future, cars may be equipped with hydrogen propulsion not just in the movies, but in real life as well. In the transportation and energy sectors, hydrogen is viewed as an eventual alternative to the raw materials of fossil-fuel power, such as coal, petroleum and natural gas. However, for metals like steel, aluminum and magnesium - which are commonly used in automotive and energy technology – hydrogen is not quite ideal. It can make these metals brittle; the ductility of the metal becomes reduced. Its durability deteriorates. This can lead to sudden failure of parts and components. But ordinary components like ball bearings which are used in almost all industrial machinery, could also be affected.

This lightest of the chemical elements permeates the raw materials of which the vehicle is made not only when filling the tank, but also through various manufacturing processes. Hydrogen can infiltrate the metal lattice through corrosion, or during chromium-plating of car parts. Infiltration may likewise occur during welding, milling or pressing. The result is always the same: the material may tear or break without warning. Costly repairs are the consequence. To prevent cracks and breakage in the future, the researchers at the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg are studying hydrogen-induced embrittlement. Their objective: to find materials and manufacturing processes that are compatible with hydrogen. »With our new special laboratory, we are investigating how and at which speed hydrogen migrates through a metal. We are able to detect the points at which the element accumulates in the material, and where it doesn't,« says Nicholas Winzer, researcher at IWM.

Since the risk potential mostly emanates from the diffusible, and therefore mobile, portion of the hydrogen, it is necessary to separate this from the entire hydrogen content. Researchers can release and simultaneously measure the movable part of the hydrogen by heat treatment, where samples are continuously heated up. In addition, the experts can measure the rate that hydrogen is transported through the metal while simultaneously applying stress to the material samples mechanically. They can determine how the hydrogen in the metal behaves when tension is increased. For this purpose, the scientists use special tensile test equipment that permit simultaneous mechanical loading and infiltration with hydrogen. Next, they determine how resistant the material is. »In industry, components have to withstand the combined forces

of temperature, mechanical stress and hydrogen. With the new special laboratory, we can provide the necessary analytical procedures,« as Winzer explains the special feature of the simultaneous tests.

The researchers use the results from the laboratory tests for computer simulation, with which they calculate the hydrogen embrittlement in the metals. In doing so, they enlist atomic and FEM simulation to investigate the interaction between hydrogen and metal both on an atomic and a macroscopic scale. »Through the combination of special laboratory and simulation tools, we have found out which materials are suitable for hydrogen, and how manufacturing processes can be improved. With this knowledge, we can support companies from the industry,« says Dr. Wulf Pfeiffer, head of the process and materials analysis business unit at IWM.

A researcher installs an environmental chamber in the special laboratory in which metals' susceptibility to stress corrosion can be tested. (© Fraunhofer IWM)

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