Fraunhofer

Research News

No. 9 – 2009

Fraunhofer Press
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1 Graffiti-free historic buildings

Many a historic landmark is defaced with graffiti, but the spray paint can only be removed – if at all – using caustic solutions which risk damaging the underlying surface. A new breathable coating provides efficient, all-round protection against attacks by taggers.

2 Dandelion rubber

Most natural rubber comes from rubber trees in Southeast Asia, but this source is now under threat from a fungus. Researchers have optimized the Russian dandelion to make it suitable for large-scale rubber production.

3 Premium info for car drivers

What will the weather be like over the next few hours on the A3 between Nuremberg and Würzburg? Could fog be a problem? A new system will enable automakers to offer their customers additional services – such as weather information or details of vacant parking spaces.

4 Dual simulation improves crash performance

Crash tests often produce startling results. A new simulation process which factors in deformation during production as well as preliminary damage can predict the results of a crash test more accurately than ever.

5 Seal of quality for hygienic equipment

The processing and packaging of food is governed by very strict hygiene rules. Researchers are now testing production equipment for cleanroom suitability and are listing qualified products in an online database.

6 Chip detects microorganisms in ambient air

Microorganisms are active everywhere, even in places where food is produced or processed – but not all are desirable. Researchers can now test the air directly in production halls or warehouses for potentially dangerous microorganisms.

7 The impact of cosmic radiation in space

Satellites and spacecraft have complex microelectronic devices on board. Should they fail, the consequences can be catastrophic. Cosmic radiation in space can damage sensitive electronics. Researchers have been looking into the influence of radiation on electronics.

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A polymer coating designed to protect historic buildings from graffiti: its water-vapor permeability allows the building to breathe despite the protective coating.

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Research News
Topic 1

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Graffiti-free historic buildings

It takes seconds to spray on graffiti, but hours or weeks to remove – especially from porous natural stone or brickwork as found in the majority of historic monuments. The paint penetrates deep into the pores from which it is impossible to remove, even with a pressure hose or multi-component solvents. Often the only answer, other than living with the graffiti, is to etch away a part of the wall. Special anti-graffiti polymer coatings have been on the market for several years. They create a hydrophobic seal that closes the pores, preventing the paint from adhering to the undersurface and allowing it to be wiped off. But as a result the building can no longer breathe, augmenting the risk of mold development or salt efflorescence. Because they cannot be removed easily, such coatings also run counter to the principles of conservation, which require that any changes must be reversible.

"There are conflicting requirements for this kind of polymer coating – it mustn't seal the pores, because it is important that there should be a continuous exchange of air between the building and the external environment, and at the same time it has to prevent the spray paint from penetrating the pores. The coating needs to be sufficiently resistant to withstand both weathering and mechanical cleaning. Moreover, since we're dealing with historic landmarks, it must be possible to completely remove the coating from the walls if required, to restore them to their original condition with little effort and without damaging the structure," says Professor André Laschewsky, who heads the relevant research group at the Fraunhofer Institute for Applied Polymer Research IAP in Potsdam.

As part of an EU-sponsored project, Laschewsky's team and partners from the Center of Polymer and Carbon Materials of the Polish Academy of Sciences in Gliwice and Zabrze have developed a polymer coating that meets these requirements. "Our innovative polymer film seals the pores in the substrate, so that graffiti paint doesn't penetrate. But its micro-porous structure also creates a hydrophobic barrier that allows water vapor to escape from the building while at the same time preventing the infiltration of rainwater," says Laschewsky. The coating can be removed from the surface using a diluted brine solution which modifies its chemical composition and allows it to be washed off. Coordinated by the LABEIN Foundation in Spain and the german Federal Institute for Materials Research and Testing the partners have coated samples of ancient stone and brick and repeatedly covered them with graffiti – which was removed completely each time.

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Dandelion in the greenhouse.

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Research News
Topic 2

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Dandelion rubber

Anyone who has picked dandelions as a child will be familiar with the white liquid that seeps out of the stalks as you break them off. Viscous, sticky – and a much sought-after material: natural latex. Around 30,000 everyday products contain natural rubber, everything from car tires, catheter tubes, latex gloves to tops for drinks bottles. Car tires, for instance, would not be elastic enough without the incorporation of natural rubber. The bulk of this material comes from rubber trees in Southeast Asia. Rubber produced in this way can, however, cause allergic reactions, which is clearly an issue with clinical products. A fungus is also creating concern for rubber cultivators. In South America the infection is now so widespread that large-scale cultivation has become virtually impossible. The disease now also appears to have taken root in Southeast Asia's rubber belt. Fungicides still provide at least temporary protection. But if the fungus disease was to reach epidemic proportions, chemical crop protection would be rendered useless – experts fear that the natural latex industry could collapse if that were to happen.

Researchers are therefore turning to other sources – such as the Russian dandelion. Germans, Russians and Americans produced rubber from this plant during the Second World War. Once it is cut, latex seeps out, albeit difficult to use as it polymerizes immediately. Scientists from the Fraunhofer Institute for Molecular Biology and Applied Ecology IME in Aachen have now come a step nearer to large-scale rubber production from dandelions. "We have identified the enzyme responsible for the rapid polymerization and have switched it off," says Prof. Dr. Dirk Prüfer, Head of Department at the IME. "If the plant is cut, the latex flows out instead of being polymerized. We obtain four to five times the amount we would normally. If the plants were to be cultivated on a large scale, every hectare would produce 500 to 1000 kilograms of latex per growing season." The dandelion rubber has not caused any allergies so far, making it ideal for use in hospitals.

In the lab the researchers have genetically modified the dandelion. Their next step will involve cultivating the optimized plants using conventional breeding techniques. In around five years, Prüfer estimates, they may well have achieved their goal. In any case, the dandelion is not just suitable for rubber production: the plant also produces substantial quantities of inulin, a natural sweetener.

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Is there anywhere left to park downtown? Premium services could in future help drivers answer these kinds of questions.

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Research News
Topic 3

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Premium info for car drivers

Clogged access roads, packed car parks – traffic chaos is an everyday occurrence in many inner cities. In future, premium services will help drivers get to their destination quickly, all thanks to exclusive up-to-date information on vacant parking spaces or the weather conditions for the route punched into the navigation system. The information is transmitted via mobile Internet or the digital radio broadcasting system and can be displayed on the roadmap. Warning messages in response to dynamic speed limits would also be another option: if the driver exceeds the current limit – say a limit stipulated by a traffic management system – a warning lamp would come on.

The transmission standard TPEG, short for Transport Protocol Experts Group, provides the basis for the service. Automakers and device manufacturers, information service providers, research institutions and others have joined forces to create a consortium to establish TPEG as a European and international standard. The advantage of TPEG is that it is much faster and more versatile than the conventional "Traffic Message Channel TMC" system. While TMC can distribute some 60 messages per minute, TPEG can handle 3,000.

The new premium services offer a wealth of information that is tailored to specific customer groups: drivers of a specific car brand, owners of a certain portable navigation device or members of an automobile club, all with access to information such as up-to-date parking-space data. Everyone will, however, still have access to information on tailbacks, roadworks and accidents, just as before. Specific customer groups can take advantage of other information, such as vacant parking spaces: researchers at the Fraunhofer Institute for Integrated Circuits IIS in Erlangen have encrypted these premium services. "The security concept adopted by individual suppliers can be totally different," says Birgit Bartel-Kurz, project manager at the IIS. "For instance, a manufacturer offering a low-cost retrofittable navigation system might well be less concerned whether the services can be used without authorization than say a leading automaker. We have encrypted the services offered by individual suppliers using encapsulation. If a key for a certain type of device is cracked, the others are still secure." The Conditional Access System HECA manages with minimal additional information – the encrypted file itself is no larger than the unencrypted file. At the IBC international forum in Amsterdam the researchers will be showcasing the system with their partners from Bayerische Medientechnik GmbH BMT (Hall 8, Stand C81).

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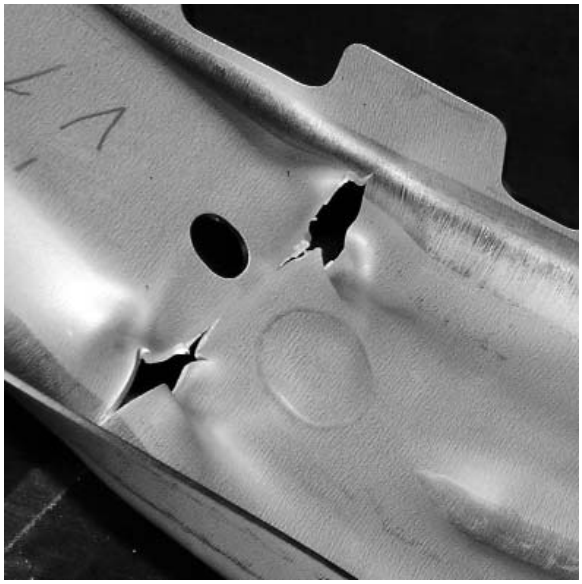

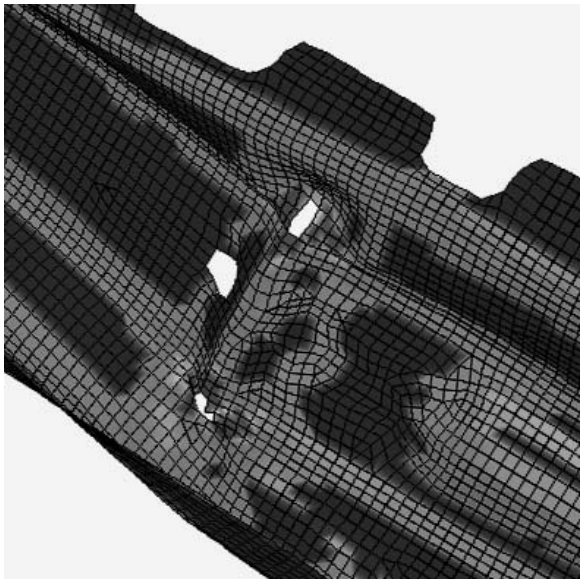

Left: Damage to a component made out of high-strength steel after a crash test. Right: Computed damage in a crash simulation.

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Research News
Topic 4

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Dual simulation improves crash performance

There are components that save lives: if a car rolls over during an accident, the 'B-pillar' plays a key role. It forms one of the connections between the floor and roof of the vehicle and is designed to prevent the passenger cell from deforming too much. The materials from which the B-pillar is manufactured therefore need to meet very exacting requirements: to save fuel they need to be ultra-lightweight, yet at the same time need to be tremendously strong and must not break. Yet what does the optimum component actually look like? With the aid of countless experiments, simulations and crash tests, the auto industry has been getting nearer to answering this question. Now Fraunhofer researchers are providing further impetus to development.

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Engineers will usually carry out a range of virtual tests. Known materials properties provide the basic knowledge in such a scenario. "We are well aware of the physical and mechanical characteristics of the materials in their original state," says Dr. Dong-Zhi Sun, Group leader at the Fraunhofer Institute for Mechanics of Materials IWM. Yet during the course of the manufacturing process, the components change: with a B-pillar, for instance, the material goes through a complicated manufacturing chain. As it is deformed and stretched, minor damage such as pore formation may occur. "If you're going to fit these kinds of parts into vehicles, you need to take into account their deformation history during manufacture," explains Sun. That's why the researchers have developed a special method: "With our failure model, we can simulate manufacturing processes more effectively," explains Sun. "To ensure we understand the manufacturing processes inside out, we work together closely with automakers and materials producers." Thanks to the simulation, the researchers can precisely model and analyze the deformation of the component during manufacture. So they know to what extent the process affects the properties of the end product, and whether the manufacturing process gives rise to potential preliminary damage such as pore formation and microcracks. The engineers combine the results of the process simulation with a crash simulation, which is conducted using a newly developed material model.

The new method enables components with optimum properties and improved crash performance to be developed. "Unlike conventional crash simulations, we can predict far more accurately how extensively the component will deform during the crash before it fails," says Sun.

Various mold cultures on a nutrient solution.

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Research News
Topic 5

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Seal of quality for hygienic equipment

Before entering the cleanroom, the researcher dons special protective clothing to avoid carrying germs or other impurities into the highly sensitive environment. But it's not only people who have to conform to the strict hygiene requirements. Every item of equipment in the room, from lithography units to swivel chairs, must also comply with international guidelines.

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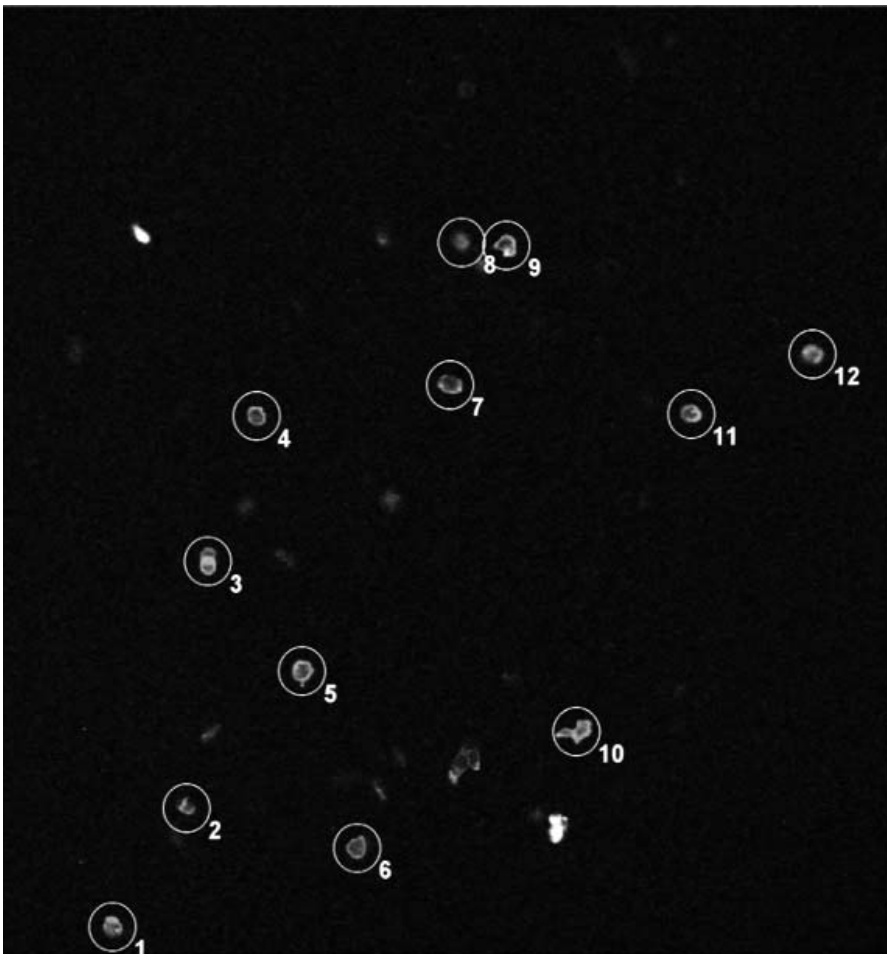
Equipment manufacturers can have their products inspected and certified at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart. "This service was initially aimed at the semiconductor industry, but it is now attracting many customers from other sectors such as pharmacy or the food-processing industry, where hygiene standards are very high," says Markus Keller. In the cleanroom manufacturing and microfabrication department he tests equipment for its cleanroom suitability – from wall and floor coverings to tools right through to complete interiors. "To find out, for example, whether a surface can be easily disinfected we examine its surface finish under the microscope – the smoother, the better. The material must also be resistant to attack by certain chemicals," explains Keller. He also examines the design and assembly of furniture extremely closely – are there any inaccessible corners where dirt could settle? Are there any screws which are not tightened correctly? Badly designed pipe connections – including screw connections – could result in fat or protein residues being pressed into tiny hollow spaces, which at first sight are not visible at all – the best conditions for germs. The scientists must also measure whether materials emit particles or release gases at high temperatures. "Our testing devices are so precise that we can detect particle emissions in the sub-micrometer region," says Keller.

A certificate is issued for products that meet all the relevant criteria. The "Fraunhofer IPA TESTED DEVICE" is recognized as a reliable seal of quality in industrial circles. The Stuttgart-based institute publishes a list of certified products in an openly accessible online database. It is up to the customers themselves to decide whether and to what extent the test results for their products are disclosed. Keller sees benefits for both sides: "Potential buyers can easily search for suitable products, and for manufacturers the listing in the database is a good reference that they can use in their advertising." The database www.tested-device.com already contains over 600 products.



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The fluorescent marking of the antibody causes the bound test particles – which fit like a key in a lock – to emit a red glow.

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Research News
Topic 6

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Chip detects microorganisms in ambient air

Microorganisms are everywhere, but many can be destructive – for example, in the production and processing of food. They can cause food to perish or alter its taste, e.g. by disrupting the fermentation process when making cheese. Until now, testing ambient air for these microorganisms has been expensive and time-consuming, and traditional microbiological processes have reached their limits.

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Researchers from six Fraunhofer Institutes have now developed a test system capable of carrying out such tests on the spot and in less than half an hour. "We take a plastic chip and apply a gel to it. We embed special fluorescent-marked antibodies in this gel. These detect very specific microorganisms which can then be viewed under a fluorescence microscope," explains Gerd Sulz, project manager at the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg. The test system monitors the ambient air by accumulating different microorganisms and particles – including dust – on the gel, and segregating only particles between one and ten micrometers in size. The antibodies in the gel bind to specific microorganisms, which fit into them like a key in a lock. They do not bind to specks of dust or other germs. The task of the Freiburg scientists is to detect the identified microorganisms using an optical technique. The first step is a wash cycle that removes all the antibodies not bound to microorganisms. This is done by applying an electrical voltage – the unbound antibodies are so small that they can be moved through the gel by the electric field, whilst the antibodies that have latched onto a microorganism remain trapped. A glance at the chip reveals whether any antibodies, and how many, have bound to microorganisms – the trapped antibodies glow red due to the fluorescent marking. The result provides information about the type and number of potentially dangerous microorganisms in the air.

A prototype of the test system has already been built. The researchers have used it successfully to carry out measurement cycles with relevant test particles and are now working on software to fully automate the process. The researchers will be presenting the test system at the Anuga food trade fair in Cologne from October 10 to 14 (Hall 5, Stand B020).

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Research News
Topic 7

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The impact of cosmic radiation in space

What influence does cosmic radiation have on electronics that are packed into satellites and spacecraft? Researchers at the Fraunhofer Institute for Technological Trend Analysis INT in Euskirchen, the European Space Agency ESA and the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt are looking into just that. Scientists are using the particle accelerator at the GSI to bombard microelectronic components with relativistic ions, under the direction of the INT scientists. The GSI accelerator is the only facility in Europe that can be used to produce ion radiation similar to the cosmic radiation encountered in space. The research project aims to test the suitability of various microchips for use in space. Furthermore, fundamental research is being conducted which will help develop radiation-resistant, lighter and more compact electronics to save room and weight. In future, space systems will be able to dispense with the hitherto necessary shielding and backup electronics that are built-in for certain devices.

"We want to investigate systematically for the first time how the energy from ion beams affects microelectronics," says Stefan Metzger, project manager at the Fraunhofer Institute. Staff from the INT are supporting the project with a customized measurement infrastructure, which can be used to detect these kinds of faults in electronic devices. In an initial experiment, the scientists bombarded a microchip provided by ESA with gold ions. The analysis confirmed their hypothesis that the chip's susceptibility to failure largely depends on the energy in the ions. More systematic bombardment tests involving various devices and a range of ions and energy levels are planned over the next few years as part of a detailed study.

"Ion beams are the main constituent of cosmic radiation and have the greatest impact on microelectronics. We need to understand this influence precisely if we want to optimize electronics specifically for space applications in future," says Marco Durante, director of the Biophysics department at the GSI. Even a single ion can cause damage to microelectronic devices. The ion's high electric charge and energy can generate free carriers in the semiconductor materials in the microchip. These in turn generate small electric currents, which can cause the chip to malfunction or fail.

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