Fraunhofer

RESEARCH NEWS

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1 Nano-dwarves turn tumor assassins

Chemotherapy is often preferred for fighting cancer, but its side effects can be considerable. A new technique may reduce these in future: nanoparticle-encapsulated substances could kill off tumor cells selectively. This will be easier on patients.

2 Need different types of tissue? Just print them!

What sounds like a dream of the future has already been the subject of research for a few years: simply printing out tissue and organs. Now scientists have further refined the technology and are able to produce various tissue types.

3 Taking a close look, whatever the scale

Researchers at the Fraunhofer Development Center X-ray Technology work with the biggest and smallest computed tomography scanners in the world – equipment that is able to scan everything from entire shipping containers to tiny biological samples.

4 Mass producing pocket labs

There is certainly no shortage of lab-on-a-chip (LOC) devices, but in most cases manufacturers have not yet found a cost-effective way to mass produce them. Scientists are now developing a platform for series production of these pocket laboratories.

5 Lasers offer an automated way to test drinking water

To keep drinking water clean, experts are constantly monitoring our supply to check it for contaminants. Now laser technology will give them a helping hand: a new system automatically analyzes water samples at the waterworks itself.

6 Non-toxic flame retardants

Electronics, vehicles, textiles – almost all modern-day products contain some form of plastic. Its high combustibility means it must be protected from naked flames. New techniques simplify the production of environmentally friendly flame retardants.

7 Predicting the life expectancy of solar modules

Solar modules are exposed to many environmental influences that cause material to fatigue over the years. Researchers have developed a procedure to calculate effects of these influences over the long term. This allows reliable lifespan predictions.

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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Nano-dwarves turn tumor assassins

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Hair loss, nausea, vomiting, fatigue, loss of appetite, loss of eye lashes and eye brows, susceptibility to infection – the list of possible side effects from chemotherapy is lengthy. Many cancer patients suffer from the intense effects that accompany the treatment. High dosages of cytostatic agents are injected subcutaneously or administered intravenously to halt the growth of tumors and also to destroy resistant cells. The more frequently that cells divide, the more effective the active agent is. This applies especially to malignant tumors. However, healthy mucosal tissue and hair cells divide very rapidly as well. They are therefore attacked as well. Scientists have searched long and hard for a therapy that selectively kills off the tumor cells without damaging healthy tissue. Using a new methodology, researchers from the Fraunhofer Institute for Applied Polymer Research (IAP) in Potsdam, Germany, hope to break the vicious circle by utilizing nanoparticles as vehicles for the anti-cancer agents. Since the particles resemble cells on account of their structure, they are suited to steering pharmaceutical substances to the tumor selectively, docking there, and efficiently eliminating the malignant cells.

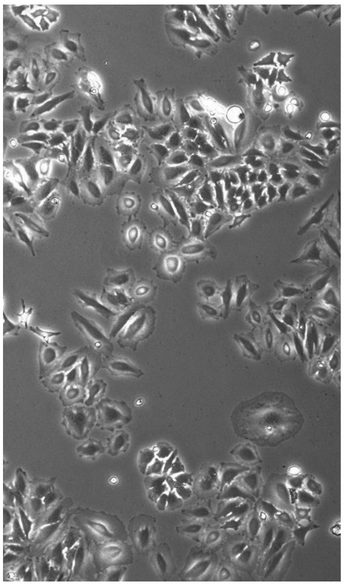
The researchers have decided to use hydrophobic, water-insoluble lipid vesicles as the tiny, 200-250 nanometer pharmaceutical carriers. They are biologically degradable and disintegrate in the body after deployment. Polymers are used to stabilize the nano-envelope, which is furnished with molecules highly specific to and recognized by tumor cells. The envelope of the nanoparticle – experts call it the vesicles – is constructed similarly that of a cell. The scientists load these carriers with doxorubicin, one of the anti-cancer agents frequently used in chemotherapy. Sodium tetradecyl sulfate (STS), a surfactant, helps the active agent to be absorbed better.

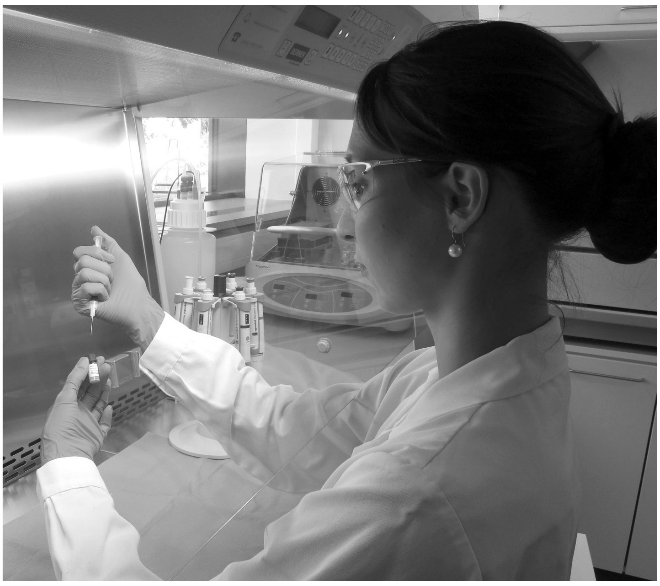
The researchers have already been able to prove the efficacy of their approach in laboratory tests. “We utilized both a cervical cancer strain (HeLa) and cancer of the large intestine (HCT116) for our in-vitro tests. They each react very differently to doxorubicin. HCT116 cells are sensitive to the substance, in contrast to HeLa cells. We ran the experiments with pharmacologically relevant dosages, used by clinicians. The doxorubicin was added to the cell cultures both directly and encapsulated in the nano-carriers,” explains Dr. Joachim Storsberg. He developed the new therapy jointly with Dr. Christian Schmidt and Nurdan Dogangüzel from IAP in close collaboration with colleagues from the pharmaceutical sciences, Prof. Mont Kumpugdee-Vollrath and Dr. J. P. Krause from Beuth University of Applied Sciences in Berlin.

Making chemotherapy more tolerable

The results from the laboratory tests: after three days, 43.3 percent of the HeLa cells survived a dose of unencapsulated, 1 micromolar (µM) doxorubicin. When the active agent was introduced via encapsulated vesicles, only 8.3 percent of the malignant HeLa cells survived. “The pharmaceutical substance in the nano-envelopes was fives times more effective,” says Storsberg. This could also be observed in the tests with the intestinal cancer cells: in this experiment, 46.5 percent of the HCT116 cells survived a dose of 0.1 µM doxorubicin after two days, while only 13.3 percent of the malignant tumor cells failed to be eliminated by administering the active agent in encapsulated form. “With nanoparticles as carriers, a more effective and simultaneously lower dosage is possible. This way, and with a targeted delivery of the active agent, the healthy cells are are likely to be spared and the side effects will be minimized,” says Storsberg. An additional test result: the encapsulation material is only effective when combined with the active agent. The unloaded nano-carrier does not attack the sensitive HCT116 cells. Using their methodology, Storsberg and his team can investigate how effectively an encapsulated pharmaceutical substance acts, as well as how ‘toxic’ the actual nanomaterial is. “That has not been feasible to date,” emphasized the chemist.

The researchers will be presenting their results at Nanotech Dubai, 28-30 October 2013. However, a series of clinical tests with cancer patients will only be set up if these observations are confirmed in in-vivo experiments.





Cervical carcinoma cells can be selectively and effectively killed off with encapsulated anti-cancer agents (left). Doxorubicin being prepared – one of the agents frequently utilized in chemotherapy (right). (© Fraunhofer IAP) | Picture in color and printing quality: www.fraunhofer.de/press

Need different types of tissue? Just print them!

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The recent organ transplant scandals have only made the problem worse. According to the German Organ Transplantation Foundation (DSO), the number of organ donors in the first half of 2013 has declined more than 18 percent in comparison to the same period the previous year. At the same time, one can assume that the demand in the next years will continuously rise, because we continue to age and field of transplantation medicine is continuously advancing. Many critical illnesses can already be successfully treated today by replacing cells, tissue, or organs. Government, industry, and the research establishment have therefore been working hard for some time to improve methods and procedures for artificially producing tissue. This is how the gap in supply is supposed to be closed.

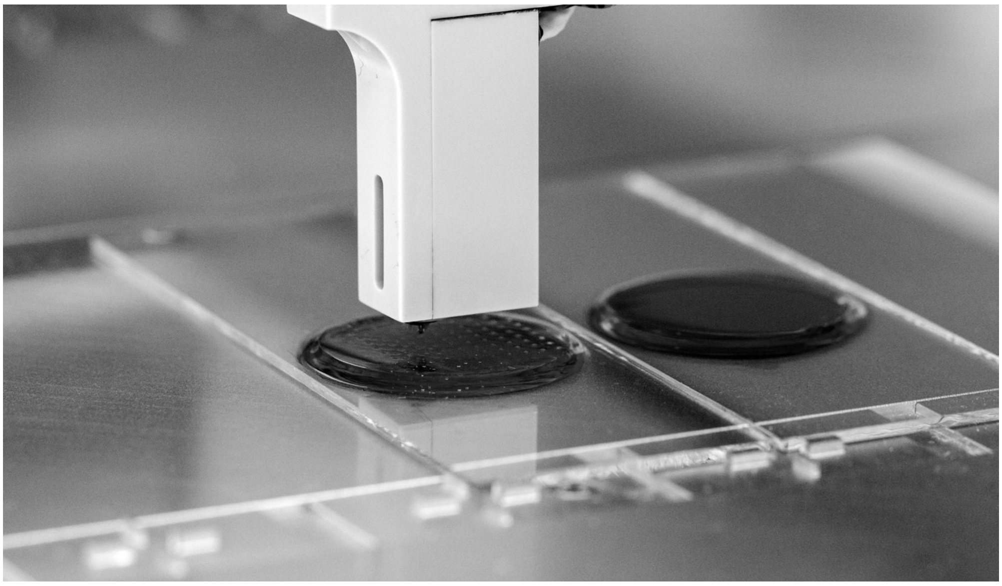
Bio-ink made from living cells

One technology might assume a decisive role in this effort, one that we are all familiar with from the office, and that most of us would certainly not immediately connect with the production of artificial tissue: the inkjet printer. Scientists of the Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB) in Stuttgart have succeeded in developing suitable bio-inks for this printing technology. The transparent liquids consist of components from the natural tissue matrix and living cells. The substance is based on a well known biological material: gelatin. Gelatin is derived from collagen, the main constituent of native tissue. The researchers have chemically modified the gelling behavior of the gelatin to adapt the biological molecules for printing. Instead of gelling like unmodified gelatin, the bio-inks remain fluid during printing. Only after they are irradiated with UV light, they crosslink and cure to form hydrogels. These are polymers containing a huge amount of water (just like native tissue), but which are stable in aqueous environments and when being warmed up to physiological 37°C. The researchers can control the chemical modification of the biological molecules so that the resulting gels have differing strengths and swelling characteristics. The properties of natural tissue can therefore be imitated – from solid cartilage to soft adipose tissue.

In Stuttgart synthetic raw materials are printed as well that can serve as substitutes for the extracellular matrix. For example a system that cures to a hydrogel devoid of by-products, and can be immediately populated with genuine cells. “We are concentrating at the moment on the ‘natural’ variant. That way we remain very close to the original material. Even if the potential for synthetic hydrogels is big, we still need to learn a fair amount about the interactions between the artificial substances and cells or natural tissue. Our biomolecule-based variants provide the cells with a natural environment instead, and therefore can promote the self-organizing behavior of the printed cells to form a functional tissue model,” explains Dr. Kirsten Borchers in describing the approach at IGB.

The printers at the labs in Stuttgart have a lot in common with conventional office printers: the ink reservoirs and jets are all the same. The differences are discovered only under close inspection. For example, the heater on the ink container with which the right temperature of the bio-inks is set. The number of jets and tanks is smaller than in the office counterpart as well. "We would like to increase the number of these in co-operation with industry and other Fraunhofer Institutes in order to simultaneously print using various inks with different cells and matrices. This way we can come closer to replicating complex structures and different types of tissue," says Borchers.

The big challenge at the moment is to produce vascularized tissue. This means tissue that has its own system of blood vessels through which the tissue can be provided with nutrients. IGB is working on this jointly with other partners under Project ArtiVasc 3D, supported by the European Union. The core of this project is a technology platform to generate fine blood vessels from synthetic materials and thereby create for the first time artificial skin with its subcutaneous adipose tissue. "This step is very important for printing tissue or entire organs in the future. Only once we are successful in producing tissue that can be nourished through a system of blood vessels can printing larger tissue structures become feasible," says Borchers in closing. She will be exhibiting the IGB bioinks at Biotechnica in Hanover, 8-10 October 2013 (Hall 9, Booth E09).



In the lab instead of at the office: researchers using inkjet printers to print cell suspensions onto shimmering pink hydrogel pads, which prevent desiccation. (© Fraunhofer IGB) | Picture in color and printing quality: www.fraunhofer.de/press

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Taking a close look, whatever the scale

RESEARCH NEWS
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Following the 50 km/h crash test, all that was left of the car was a heap of metal – one that contains valuable information on how vehicle safety could be improved. But the only way engineers can get at this information is if they can see inside the vehicle to analyze how its individual components reacted to the force of the impact. The typical two-dimensional X-ray images used in conventional materials testing are often not accurate enough, as what they show is no more than a kind of shadow-picture taken from a single angle. Computed tomography (CT) offers researchers many more possibilities for examining components: By recording parts in all three dimensions, it allows them to be measured and inspected in a contact-free and non-destructive way. But how do you fit an entire car into a CT scanner?

XXL CT scanner developed for shipping containers

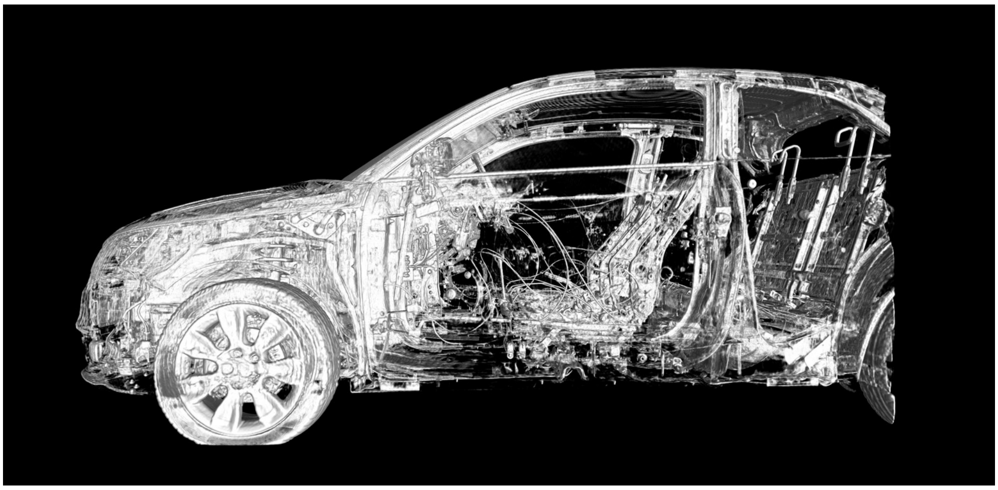
Scientists at the Fraunhofer Institute for Integrated Circuits IIS have the answer. They have developed a huge CT scanner that will in future scan cars, airplane wings and even entire shipping containers. It works as follows: First, the object to be examined is hoisted onto a giant turntable. As it turns, an X-ray source on one side of the object moves up and down, and these movements are mirrored by a four-meter-long X-ray detector on the other. The readings are sent to a computer, which then generates a three-dimensional image. “We have never been able to carry out non-destructive materials testing on this scale before,” says Professor Randolf Hanke, director of the Fraunhofer Development Center X-ray Technology EZRT. At the resolution the system currently achieves – which at 0.8 mm is already extremely high – scientists can make out even the tiniest of details with pin-sharp precision on objects that are several meters in size. Researchers hope soon to improve the resolution even further to 0.4 mm. Some of the potential uses for this technology include bringing prototypes of new cars into alignment with design data, or spotting material failures such as minuscule cracks in automotive or aircraft components. Security forces could use the giant scanner to detect explosives or other prohibited objects in shipping containers without having to open them.

CT machine heading for nanoscale scans

This giant piece of equipment has a counterpart that Prof. Hanke can comfortably carry around with him wherever he goes. No bigger than a microwave oven, and with a resolution of 0.02 mm, it can scan anything from the smallest plastic parts to biological samples. Now that they have developed what is currently the smallest portabel CT scanner in the world, Prof. Hanke and his team are already working on the next innovation: a device that will be able to push the limits of geometric magnification down to even higher resolutions. The aim is to be able to scan at nanoscale level, that is to say, at a magnitude of under 100 nanometers. This vision has been driving Prof.

Hanke's research for the last 15 years. He and his team of students and postgraduates at the Chair of X-ray Microscopy at the University of Würzburg recently enjoyed a significant breakthrough. "We've now succeeded in customizing an electron microscope in such a way that it is able to produce a nano X-ray source," he explained. The clever part is that the electric charge carriers that generate the X-rays are conducted onto the side of a thin needle. The resulting X-rays emitted from the tip of this needle deliver a precise focal point 50 nm in diameter for scanning nanoscale objects in clearly defined detail. One thing this technology would allow biologists to do is to analyze the way water is transported within wood fibers.

In July of this year, the new EZRT building was officially opened in Fürth-Atzenhof, and Prof. Hanke is very pleased: "This new building, which will be home to our industrial computed tomography activities, allows us to pool our expertise to address problems at any scale in a wide range of fields. Our equipment and understanding of the process means we can scan everything from ancient works of art to entire wind turbines."



Through the eye of the XXL CT scanner: A car reveals its innermost secrets at the Fraunhofer Development Center for X-ray Technology EZRT in Fürth. (© Fraunhofer IIS) | Picture in color and printing quality: www.fraunhofer.de/press

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Mass producing pocket labs

RESEARCH NEWS
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Ask anyone to imagine what a chemical analysis laboratory looks like, and most will picture the following scene: a large room filled with electrical equipment, extractor hoods and chemical substances, in which white-robed researchers are busy unlocking the secrets behind all sorts of scientific processes. But there are also laboratories of a very different kind, for instance labs-on-a-chip (LOCs). These "pocket labs" are able to automatically perform a complete analysis of even the tiniest liquid samples, integrating all the required functions onto a chip that's just a few centimeters long. Experts all over the world have developed many powerful LOC devices in recent years, but very few pocket labs have made it onto the market.

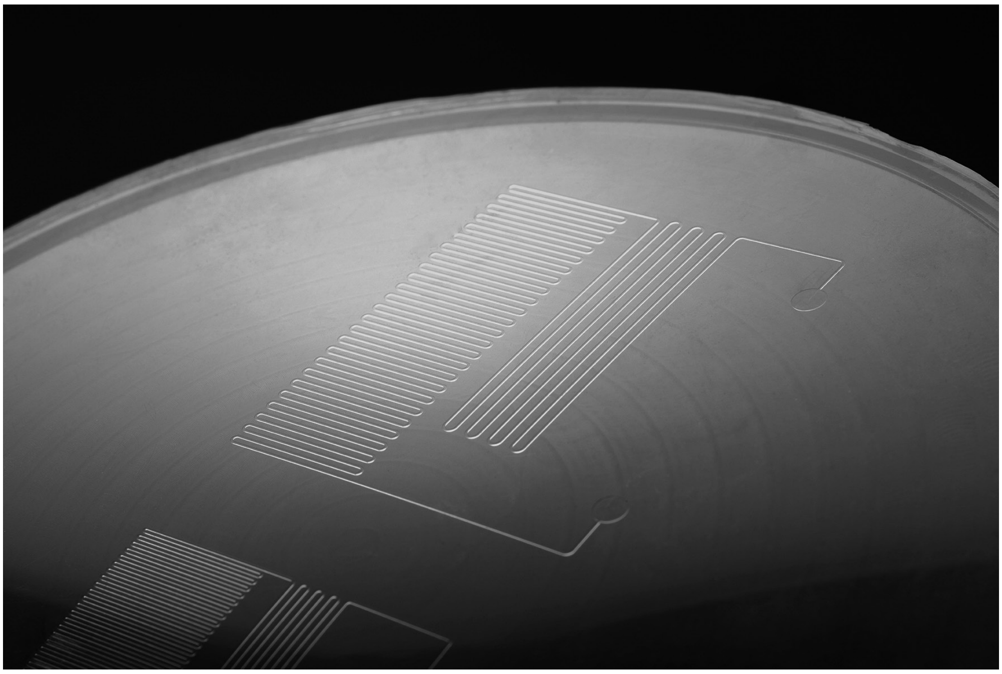
Scientists at the Fraunhofer Institute for Production Technology IPT in Aachen want to find out why so many LOCs are not a commercial success. They are working with colleagues from polyscale GmbH & Co. KG, an IPT spin-off, and ten other industrial partners from Germany, Finland, Spain, the United Kingdom, France and Italy on ways to make LOCs marketable. Their ML² project is funded by the EU's Seventh Framework Programme (FP7), which is providing a total of 7.69 million euros in funding through fall 2016. "One of the main reasons LOCs don't make it to market is that the technologies used to fabricate them are often not transferrable to industrial-scale production," says Christoph Baum, group manager at the IPT. What's more, it is far from easy to integrate electrical functions into pocket labs, and of the approaches taken to date, none has yet proved suitable for mass production.

Platform for series production

The ML² project aims to completely revise the way pocket labs are made so they are more suited to series production. "Our objective is to create a design and production platform that will enable us to manufacture all the components we need," says Baum. This includes producing the tiny channel structures within which liquids flow and react with each other, and coating the surfaces so that bioactive substances can bond with them. Then there are optical components, and electrical circuits for heating the channels, for example. The experts apply each of these components to individual films that are then assembled to form the complete "laboratory". The films are connected to one another via vertical channels machined through the individual layers using a laser.

The first step the researchers have taken is to adapt and modify the manufacturing process for each layer to suit mass-production requirements. When it comes to creating the channel structures, the team has moved away from the usual injection molding or wet chemical processing techniques in favor of roll-to-roll processing. This involves transferring the negative imprint of the channels onto a roller to create an embossing cylinder that then imprints a pattern of depressions on a continuous roll of film. The electrical circuits are printed onto film with an inkjet printer using special ink that contains copper or silver nanoparticles.

Each manufacturing stage is fine-tuned by the researchers in the process of producing a number of demonstrator LOCs – for instance a pregnancy test with a digital display. These tests are currently produced in low-wage countries, but with increased automation set to slash manufacturing costs by up to 50 percent in future, production would once again be commercially viable in a high-wage country such as Germany. The team aims to have all the demonstrators built and the individual manufacturing processes optimized by 2014. Then it will be a case of fitting the various steps in the manufacturing process together, making sure they match up, and implementing the entire sequence on an industrial scale.



Microfluidic negative for structuring films. (© Fraunhofer IPT) | Picture in color and printing quality: www.fraunhofer.de/press

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Lasers offer an automated way to test drinking water

In today's world, we simply cannot do without lasers. We use them to print out documents, play CDs or DVDs, weld, cut, or bend car components, survey roads, monitor our bloodstream, and even remove tumors from our bodies. Now researchers from the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg have developed the technology for a further application. Their quantum cascade laser – a particular type of infrared laser – forms the core of an analysis apparatus that allows drinking water to be sampled automatically at the waterworks itself. As a result, water companies can determine within a few minutes whether their water contains any impurities – and what those impurities are. The system has been designed in order to enable immediate identification of dangerous substances. "The equipment samples the water for dangerous substances at the waterworks itself in the course of routine operations, and allows for a rapid response," says Dr. Frank Fuchs, summarizing the advantages of the system. Dr. Fuchs is Fraunhofer IAF coordinator for the IRLSENS project, which is funded by Germany's Federal Ministry of Education and Research (BMBF).

To examine the components of water, experts use molecular spectroscopy: that is to say, they examine the optical spectra of the molecules in the water. Each chemical compound has a unique spectrum, since individual molecules vibrate and absorb light at characteristic frequencies. Water itself is a very strong absorber of infrared light; since the light sources employed to date have delivered little power, until now examinations of this sort have been possible only in a laboratory setting. "The main sticking point is the intensity of the light. In order to be in a position to employ molecular spectroscopy at the waterworks itself, we needed to find a more powerful light source," explains Fuchs.

Taking water samples in the course of routine operations

Fraunhofer IAF's quantum cascade laser produces light that is up to 1000 times more concentrated than the silicon carbide thermal emitters used in the laboratory to date. Infrared radiation – which is at longer wavelengths that the human eye does not register – can be used to analyze impurities in the water. For molecular spectroscopy, analysts are interested in wavelengths between 7.3 and 11 micrometers. No longer must the water samples be prepared in the laboratory, costing time and money. Instead, they can be taken in situ in the course of routine operations. The measurement system is only a little larger than a shoebox, works automatically, and requires hardly any maintenance.

A demonstrator has already successfully undergone initial practical testing. At the Kleine Kinzig waterworks in the Black Forest, tests were conducted on various concentrations of sweetener as a simulant substance. Measurements were taken every three minutes over a period of six weeks, with the fully automated system collecting a total of 21,000 samples. The results were excellent: every sample was recorded in perfect detail, and there was not a single error. Even the concerns regarding the susceptibility of the laser spectrometer to vibrations were proved unfounded, since the machines and pumps in operation in the machine hall had no adverse impact on the test results. Providing there is sufficient demand, project partner Bruker Optik, the company that built the demonstrator, would like to develop the measurement system into a finished product.

The German drinking water system maintains extremely high quality standards. All German waterworks have their water samples checked regularly in laboratories such as the project partner Water Technology Center (TZW) in Karlsruhe. What's more, each individual waterworks keeps a close eye on misting, pH value, and electric conductivity so that they can intervene immediately in the case of any anomaly. "If we see any such anomalies, this novel laser technology can quickly identify the dangerous substance on site and support water experts as they assess the situation," finishes Fuchs.

Little larger than a shoebox, the demonstrator was developed as part of the IRLSENS project. It is a quick and automated way to analyze water samples at the waterworks itself. (© Martin Wagenhan/ Fraunhofer IAF) | Picture in color and printing quality: www.fraunhofer.de/press

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Non-toxic flame retardants

RESEARCH NEWS
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Alarmingly, some 600 people die in household fires in Germany ever year. Often started by nothing more than a small tea light, such fires can soon take hold. Once a few objects are alight, room temperatures shoot up as high as 800 degrees Celsius, and flames quickly spread to other rooms, leaving inhabitants with precious little time to escape after a fire has broken out – usually no more than around two minutes.

Modern-day apartments and offices contain considerably more combustible materials than they did a few decades ago. Items such as furniture, electronics and electrical equipment are predominantly made up of highly flammable materials that ignite easily, meaning such products would be ablaze in no time at all if it were not for addition of flame retardants. For instance, it only takes eight minutes for a television that has not been fire- proofed to go up in flames, whereas a TV set that has been treated with retardants remains undamaged. Prof. Dr. Manfred Döring and his team at the Fraunhofer Institute for Structural Durability and System Reliability LBF develop flame retardants for polymer materials. These are used inthe transport and construction industries, in electronics and electrical appliances, and many other applications. "Flame retardants prevent fires and slow the spread of the blaze. People are given more time to escape, sometimes up to 20 minutes, which significantly increases the chance of surviving a fire unharmed," says Döring.

Flame retardants must meet high standards

Flame retardants have to satisfy a number of challenging criteria. They must be environmentally friendly, non-hazardous to humans, animals and plants, and must not release any additional toxic fumes when they burn. These additives should not escape the finished product into the atmosphere, or when it comes into contact with water. And researchers must make sure the flame retardant does not react with the plastic or other components in unwelcome ways that might alter the material, influence its functionality or affect its appearance. "Flame resistant work clothing, for instance, has to be machine washable, but cannot lose its protective properties every time it is washed. To prevent the chance of a short circuit developing into a fire, printed circuit boards in electronic devices must remain fully functional and flame retardant over many years, at temperatures that can range from -40 to +60 degrees Celsius," says Döring. He and his team of scientists only work with halogen-free, non-toxic flame retardant additives, and tailor each substance to the particular plastic in question. Depending on the intended application for the material, they use inorganic compounds and compounds containing nitrogen and phosphorous.

One such product will be on display at the K 2013 trade fair from 16 to 23 October in Düsseldorf. Fraunhofer LBF scientists are presenting a halogen-free, polymeric flame retardant for fibers that is suitable for use in flame retardant seat covers, for instance.

What is unique about their product is that the scientists introduce the polymeric flame retardant as part of the extrusion process, a technique that is commonly used in the plastics industry. A polymer that is suitable for fiber spinning is mixed with a flame retardant polymer in the extruder. This is the machine that feeds raw plastic material along a jacketed screw that heats, melts and compacts the plastic before passing it through another tool under pressure to form a continuous profile. The flame retardant is evenly mixed into the base polymer by simple mechanical action. This method gives plastics manufacturers the advantage of being able to personally control the amount of flame retardant polymer that gets added, meaning that they are able to produce flame resistant polymers according to their own formulae for the very first time.

The research team at Fraunhofer LBF is in the process of setting up a fire safety laboratory that will offer a broad range of services towards the end of 2014. Chemists and engineers will then conduct efficiency tests on flame retardants found in polymers, and develop formulae for synthetic polymers such as thermoplastics, thermosets and composites. They will examine and test the efficiency of multi-component systems, or what experts refer to as "synergetic mixtures" – compounds that multiply the inherent properties of their individual components. The scientists can also synthesize halogen-free fire retardants and scale up the synthesis as required. The range of possible applications is vast, given the growing share of components made of plastic, all of which have to be treated with flame retardants.

Many multi-plug connectors pose a fire risk, as they can overheat if the current flow is high. Flame retardants in the connector can prevent fires or slow the spread of the blaze. (© Fraunhofer LBF) | Picture in color and printing quality: www.fraunhofer.de/press

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Predicting the life expectancy of solar modules

RESEARCH NEWS
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People who invest in their own solar panels for the roof would like as a rule to profit from them over the long term – but how long will this technology actually last for? While most manufacturers guarantee a lifetime of up to 25 years to their customers, the manufacturers themselves cannot make reliable predictions about the expected operating life. The modules must fulfill certain standards, of course, to be approved for operation. This involves exposing them in various trials to high temperatures and high mechanical loading. "However, the results only predict something about the robustness of a brand-new sample with respect to extreme, short-term loading. In contrast, age-related effects that only appear over the course of time, such as material fatigue, are pertinent for the actual operating life," explains Alexander Fromm from the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg.

The scientist is part of a project called Reliability of Photovoltaic Modules II, funded by Germany's Federal Environment Ministry (BMU), and is working on a new procedure for predicting the operating life of solar cell modules. "Using a dual approach, we combine actual measurements with a numeric simulation," according to Fromm. To this end, Fromm is initially investigating how mechanical loading affects units in field tests. This is because snow loads, temperature fluctuations, and wind gusts create mechanical stresses and associated strain and elongation in the modules. This leads to material fatigue in the long term. Both the plastic embedding material and the cell connectors in particular – thin strips of copper that connect the solar cells to one another – are susceptible. "It is like continually bending a paper clip back and forth. At some point, it breaks," explains Fromm.

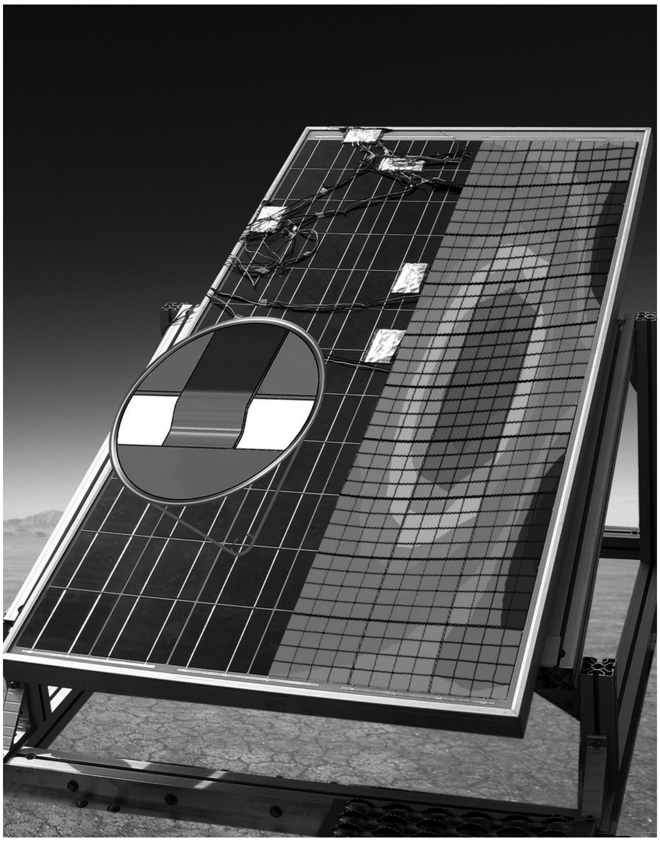
Even light winds cause module oscillations

To be able to grasp the effect of these influences on the material, the researchers equipped a complete solar module with sensors that use changes in resistance to measure strains and elongations of the construction components. In turn, this allows the mechanical stresses in the material to be calculated. Fromm and his team determined from the data evaluation that even light wind suffices to cause oscillations in the module. The higher the ambient temperature, the more pronounced these oscillations become. Moreover, the resonant frequency increases over time as the plastic material gets stiffer and more brittle, due to UV radiation. "The pivotal question now is how these influences affect the operating life of the components over the long term. Our simulations come into play at this point," according to Fromm.

For this purpose, a detailed 3D simulation of the solar module has been worked out. Based on the measurements from the field tests, numerical calculations can be used to derive long term effects of the environmental influences on the module components and what kind of mechanical stresses develop. "Using the simulation, we have learned for example that the brittleness caused by UV radiation plays a much greater role in material fatigue than has been assumed thus far," says Fromm. To be able to predict the operating life of a module, the researchers combine the measurement values from the field test with known specific tensile strengths of the corresponding materials. These numbers predict the load at which the material is expected to break or separate.

No ready-made, large scale industrial test

The procedure can be implemented immediately. However, to produce optimal and reliable prognoses, the developers require highly detailed specific material data and information about the geometry of the module that is to be tested. "Our procedure does not offer a ready-made, large scale industrial test, but instead is individually tuned for each customer," explains Fromm. Using their calculations, the researchers are then able not only to make predictions about the expected operating life but also to depict potential improvements with regard to geometry and material as well as to predict the effects of various materials on the mechanical stresses in the module.



Sensors measure the elongations that arise in solar modules. Their operating life can be calculated from this data. (© Fraunhofer IWM) | Picture in color and printing quality: www.fraunhofer.de/press

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Micro-technology saves jet fuel

Occasionally jetting down to southerly climes for a long weekend is no longer a rarity. To put it succinctly, air travel is booming. Aircraft should therefore get to their destinations with as much fuel-economy as possible. One thing that can help is the use of special fludic systems that are called AFC actuators. They sit along the trailing edges of the aircraft's wings within the flaps and are deployed during take-offs and landings, blowing air through tiny holes in the surface of the flap. The actuators delay the onset of boundary layer separation and increase the aircraft's lift. Researchers at the Fraunhofer Institute for Electronic Nano Systems ENAS in Chemnitz, Germany, have now been able to increase the performance level of these actuators as part of the "Clean Sky" major industrial project involving over eighty partners from research and industry. They have optimized synthetic jet actuators (SJA) to such an extent that the air flows out the holes one-and-a-half times faster. In addition, the SJAs are smaller than usual. Instead of the four to five centimeters (about one-and-a-half to two inches) previously, they are now only about one centimeter wide (.4 inches). As a result, many more of the actuators can fit within the aircraft's flaps.

The researchers have also optimized the pulsed jet actuators. In this case, pressurized air flows from a valve in the base, filling a chamber, and then escapes through the hole onto the upper wing surface. With the help of micro-machining techniques, the scientists were able to design the valve to be so small that it can be placed directly beside the hole. This has also led to improvements in performance. While a synthetic jet actuator prototype has already been tested, the pulsed jet actuator is still in development.

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Sensors protect the Rotterdam quayside

The saline seawater ceaselessly eats into the concrete of the quayside, day after day, year after year. These are the most difficult conditions that steel-reinforced concrete has to withstand. The salt, in form of salt ions, penetrates the alkaline concrete and neutralizes it, i.e. alters it chemically. The situation becomes especially dire if the ions reach the steel reinforcement. The steel rods corrode, crevices form, and slabs of concrete can fracture and separate. In a word, the quayside loses its stability. However, it is difficult to establish when the harmful ions have penetrated far enough through the concrete to attack the steel as well.

Things are different with the new quayside in Rotterdam. The construction company has integrated passive RFID sensors along the reinforcing rods during quay construction. Once the salt ions reach a sensor, they eat away its special wire. The more of them that are corroded by the ions, the more advanced the corrosion has become. A transponder in the sensor transmits the data to an RFID reader. The extent of the hazard is displayed to the harbor official responsible for the quayside. As a result, maintenance work on the structure can be initiated before the reinforcement is damaged. This makes it possible to save millions in concrete construction costs. The sensor was developed by staff at BS2 Sicherheitssystems GmbH in Boppard, Germany. Researchers of the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg integrated the passive, wireless transponder system. The scientists will be presenting the system at the EURO ID 2013 trade fair in Frankfurt, Germany, from November 5-7 (Hall 4, Booth D08).

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95 percent less lubricant

The less lubricant used in manufacturing, the better it is for the environment, for production costs, and not least for occupational safety as well. The trend is therefore towards micro-lubrication. The limiting factor has long been primarily the reliability of the metering system. At delivery rates below 25 micrograms per second (μg/s), even the smallest irregularities can lead to the machine’s bearings running dry.

Researchers of the Fraunhofer Research Institution for Modular Solid State Technologies EMFT jointly with the GMN Paul Müller Industrie Co. have now developed a micro-lubrication system that can reduce oil consumption by up to 95 percent. However, in order to guarantee a continuous film of lubricant on the bearing surfaces, a new kind of metering monitor was employed by the scientists in Munich. At the completion of each lubricating interval, a gas bubble is injected into the metering channel. Several sensors in this channel are able to measure its precise size and speed, and determine from this the precise amount of oil delivered. The measurements are processed by a microchip that can re-adjust the lubrication pump’s frequency for the desired delivery quantity. The reduced amount of oil provides further advantages: it reduces wear and increases the efficiency of the equipment. Presently, the project team is improving the metering algorithm in order to achieve even lower metering rates of as little as 5 μg/s.

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