

## RESEARCH NEWS

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### **1 Intelligent training with a Fitness Shirt and an E-bike**

How do we know what the optimum level of training is? A fitness shirt will help us avoid overstraining and under-exertion in the future. The clue: it becomes an intelligent training device when combined with an electric bike and a smartphone.

### **2 More secure App-Store for Android**

Apps often read the data from mobile user devices unnoticed by users. This represents a large security risk, especially for companies. A new App-Store filters out problematic Android applications automatically with the help of detection software.

### **3 Special camera detects tumors**

Cancer patients have the highest probability of recovering if tumors are completely removed. However, tiny clusters of cancer cells are often difficult for surgeons to recognize and remove. A camera makes hidden tumors visible during an operation.

### **4 Solar cells utilize thermal radiation**

Thermal radiation from the sun is largely lost on most silicon solar cells. Up-converters transform the infrared radiation into usable light, however. Researchers have now for the first time successfully adapted this effect for use in generating power

### **5 Speedy analysis of steel fiber reinforced concrete**

Steel fiber reinforced concrete (SFRC) is a practical construction material that is quick and easy to use. But monitoring SFRC quality is difficult, and this has kept industry acceptance low. A new method offers a quick way to examine its composition

### **6 Organic lights and solar cells straight from the printer**

Flickering façades, curved monitors, flashing clothing, fluorescent wallpaper, flexible solar cells – and all printable. This is no make-believe vision of the future; it will soon be possible using a new printing process for organic light-emitting diodes.

### **7 Testing smart plastics in real time**

Nano additives can make plastics scratch and flame proof, or give them antibacterial properties. For this to work, the particle distribution within the plastic compound must be absolutely correct. A new device is now able to test the distribution in real time.

### **8 Newsflash**

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## Intelligent training with a Fitness Shirt and an E-bike

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Fabric manufacturers are experiencing a revolution at present: if clothing previously offered protection against the cold, rain, and snow, the trend now is toward intelligent, proactive, high-tech textiles like self-cleaning jackets, gloves that recognize toxins, and ski anoraks with integrated navigational devices to make life easier for those wearing them. Most clever clothing is only at the prototype stage. It is by no means off-the-rack yet. Soon the FitnessSHIRT from the Fraunhofer Institute for Integrated Circuits IIS in Erlangen, Germany, will be ready for the mass market. It continuously measures physiological signals such as breathing, pulse, and changes in heart rate – metrics of adaptability and stress load. The intelligent sports shirt is expected to be available sometime in the next year, as an investor is already on-board.

### Smart electronics are hidden in the material

Conductive textile electrodes integrated into the shirt's material capture the wearer's cardio activity. In addition, an elastic band around the upper body senses the motion of the chest during breathing. A removable electronic unit attached with snaps digitizes the raw data and calculates additional parameters like pulse rate or breath rate with the help of algorithms. The data are transmitted via radio link to a smartphone or optionally to a PC, where they are evaluated further and can be stored. These parameters form the basis for judging vital functions like stress, performance, exertion, or relaxation.

“The FitnessSHIRT can be employed a number of ways. It offers completely new options for the pursuit of sports, leisure activities, and wellness, as well as options for the medical branch,” says Christian Hofmann, an engineer at IIS. For example, it could act as a training partner to provide seniors or rehabilitation patients with feedback on their vital signs during exercises or bicycling, and protect them from overexertion. Athletes will also benefit: for one thing, the SHIRT is more comfortable to wear than a chest strap. For another, the integrated sensors deliver more detailed information. Besides pulse and respiration, accelerometers sense the movement of the user and carry out an analysis. “If the pulse rate is high, for example, while the breath rate and the exercise activity is low, it could be a sign of possible heart problems,” according to Hofmann.

The developers of the MENTORbike are also persuaded by the high degree of comfort when worn and the possibilities for performance diagnostics. MENTORbike is a new type of training device consisting of a pedelec, a smartphone, and an intelligent user service site on the internet. The project partners, led by BitifEye Digital Test Solutions, want to use the pedelec in combination with the FitnessSHIRT from IIS in future. The SHIRT will have a wireless connection via smartphone to the pedelec and the user service site on the internet, where the data can be viewed, analyzed, and documented.

The smartphone mounted on the bicycle handlebars collects the vital parameters it receives like pulse and breath rate as well as the physical data, for instance the energy expended and the speed, analyzes them, and cuts in the electric motor as needed. "If the pulse rate exceeds a maximum value of 150, for example, the rider is supported by the motor taking some of the load. If the pulse rate falls below a value of 80 beats per minute, the electric motor is throttled back and the pedal loading increased again. The motor output adapts automatically to the fitness of the cyclist," explains Markus Gratzfeld, an engineer with BitifEye. In this way, users are assured of an optimal level of training at all times, with neither over- nor under-exertion. Rehabilitation patients, especially persons with cardiovascular disease, could monitor their performance limits better, exercise more confidently, and increase their range of movement.

Researchers from IIS will demonstrate how the MENTORbike will work in conjunction with the FitnessSHIRT live at the Medica 2013 Trade Fair in Düsseldorf in the Fraunhofer Joint Booth (Halle 10, Booth F05), 20-23 November. Scientists want to make differential analysis of cardiac function possible with their FitnessSHIRT in the future and also monitor the heart for arrhythmia. Experts are presently developing the suitable algorithms. A medical-quality ECG might then be captured by the clever clothing for purposes of cardiac analysis. Physicians would be able to use the SHIRT for long-term ECGs.



**The FitnessSHIRT reads out physiological signals like pulse and breath continuously when worn. The interpreted data can be viewed on a smartphone or tablet PC, for example. (© Fraunhofer IIS) | Picture in color and printing quality: [www.fraunhofer.de/press](http://www.fraunhofer.de/press)**

## More secure App-Store for Android

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Apps. Everyone has them and everyone uses them. These small computer programs installed on our smartphones and tablet computers make work and play easier. With just the tip of a finger on the square icons, we know where and when the next rain clouds are expected, we can book train tickets while travelling, start gaming while mobile, or listen to our favorite music. For most of us, these little mobile helpers have become indispensable. A total of almost two million of them are already available today on the platforms of the two largest providers, Apple and Google. And the trend is rising.

### Privacy risks and commercial harms

However, the miniprograms are not always benevolent. "The business model for free Apps often goes like this: you need pay nothing for my services, but in exchange I'm grabbing your data," reflects Dr. Julian Schütte of the Fraunhofer-Research Centre for Applied and Integrated Security AISEC in Garching near Munich. The Apps pick up the data usually without the knowledge of the user. The theft runs from address data, to emails and locations, right through to identification numbers of the user devices. The App developers pass the data to third parties for geographical and personal advertising. "A fact that perhaps is viewed less critically or even as being useful, if the Apps are used privately. For companies, by contrast, they conceal big risks. If email with commercially sensitive content, geographical information on employees, or confidential contact information is passed without knowledge, it is not just problematic for technical reasons of data privacy protection. It can also do commercial harm," warns Schütte.

To protect against this danger, corporate IT departments are increasing their monitoring of Apps used by employees. "With an established mobile operating system like 'iOS', Mobile Device Managers – IT Department employees who administrate the pool of corporate cellphones – already have quite good control over the software stored upon the devices. However, for latecomer and now market-leader 'Android', there is currently no tool with which corporate IT can prevent downloading of 'wild' Apps, to our knowledge," as Schütte describes the challenge for corporations.

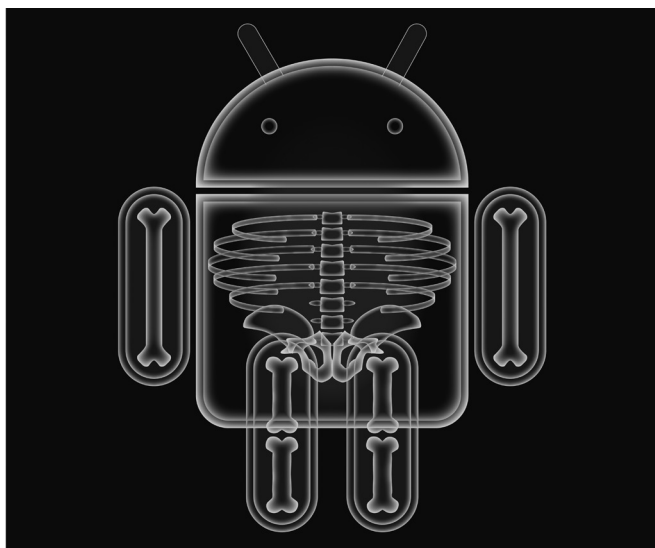
Scientists at AISEC have now closed this loophole. Their new App-Store filters out problematic Android Apps automatically and offers employees only mobile applications that conform to a corporation's own guidelines on IT security. "Administrators and Mobile Device Managers are able to determine themselves which Apps are permitted to be installed and which ones are not," as describes Schütte the added value.

Additional significant advantages of the AISEC solution: the analysis of the Apps is flexible and can be adapted to a wide range of company directives. In addition, the IT Department can also stipulate that Apps are only permitted to communicate through

encryption. "That is no small feature during these times of NSA spying scandals," according to Schütte. And finally, the software does not just work for Apps offered today. "With the aid of our App-Store, companies are able to build markets with their own Apps that are clean from a security point of view," Schütte adds.

The security filter for Android Apps consists of an App installed on the user device that is directly connected to the IT architecture of the corporation through the analysis system called "App Ray" running in the backend. Searching for and downloading Apps takes place exclusively through this App. "Employees are automatically presented only with safe applications," explains Schütte. That is guaranteed by the centerpiece of the store – the Backend Analysis Tool. It puts Apps through their paces automatically and then authorizes them for release or not. "With the help of App-Ray, we know where data flow to and from within an App, can investigate the files and source text they contain, chase down the technical details of all the data flows, run the App within a test environment and observe its behavior there. This creates a total security picture of every single mobile application available," as Schütte describes the MO. The AISEC solution works as a framework that integrates existing security features. Such as an analysis tool that investigates the Apps using forty different virus scanners simultaneously.

The researchers have already programmed a prototype of the secure App-Store. A demo video of App-Ray can be viewed at the following web address: <http://www.app-ray.de/>



**"App-Ray" puts Android Apps through a digital X-ray machine. Employees can only install safe applications.**  
(© Fraunhofer AISEC) | Picture in color and printing quality: [www.fraunhofer.de/press](http://www.fraunhofer.de/press)

## Special camera detects tumors

Tumor removal surgeries pose a great challenge even to skillful and experienced surgeons. For one thing, tumor margins are blending into healthy tissue and are difficult to differentiate. For another, distributed domains of cancer and pre-malignancies are difficult to recognize. Up to now, doctors depend exclusively upon their trained eyes when excising pieces of tumors. In future, a new special camera system can help visualize during operation even the smallest, easy-to-overlook malignant pieces of tumor and thereby support the surgeons during complicated interventions.

The trick: the camera can display fluorescent molecules that “paint” the cancer tissue. These are injected into the patients blood circulation prior to the operation and selectively attach onto the tumor during their trip through the body. If the corresponding area is then illuminated with a specific wavelength, fluorescence is emitted and the malignant tissue glows green, blue, red, or any other color, depending on the injected dye, while the healthy tissue appears the same. In this way, the surgeon can see clusters of tumors cells that cannot be recognized by the naked eye.

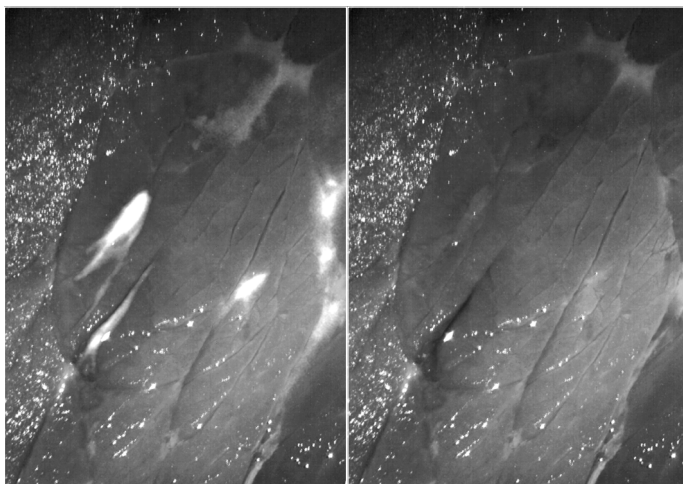
### **New system reveals several dyes simultaneously**

Researchers at the Fraunhofer Project Group for Automation in Medicine and Biotechnology (PAMB), which belongs to the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA), have developed a new surgical aid, a multispectral fluorescence camera system. In the future, this special camera will integrate into various medical imaging systems such as, surgical microscopes and endoscopes, etc. The scientists from Mannheim, Germany, will make the debut of a prototype of this high-tech system at the Medica Trade Fair in Düsseldorf in the joint Fraunhofer booth (Halle 10, Booth F05) between 20-23 November. The novel aspect about this camera: it can display several fluorescent dyes and the reflectance image simultaneously in real time – systems available until now have not been able to achieve this. The advantage: arteries and delicate nerves that must not be injured during an intervention can likewise be colored with dye. They too can then be detected with the new camera, since they are set apart from their surroundings.

“The visibility of the dye to the camera depends in large part on the selection of the correct set of fluorescence filters. The filter separates the incident excitation wavelengths from the fluorescing wavelengths so that the diseased tissue is also set apart from its surroundings, even at very low light intensities,” says Nikolas Dimitriadis, a scientist at PAMB. The researchers and their colleague require only one camera and one set of filters for their photographs, which can present up to four dyes at the same time. Software developed in-house analyses and processes the images in seconds and presents it continuously on a monitor during surgery. The information from the fluorescent image is superposed on the normal color image. “The operator receives signifi-

cantly more accurate information. Millimeter-sized tumor remnants or metastases that a surgeon would otherwise possibly overlook are recognizable in detail on the monitor. Patients operated under fluorescent light have improved chances of survival," says Dr. Nikolas Dimitriadis, head of the Biomedical Optics Group at PAMB.

In order to be able to employ the multispectral fluorescence camera system as adaptably as possible, it can be converted to other combinations of dyes. "One preparation that is already available to make tumors visible is 5-amino levulinic acid (5-ALA). Physicians employ this especially for glioblastomas – one of the most frequent malignant brain tumors in adults," explains Dimitriadis. 5-ALA leads to an accumulation of a red dye in the tumor and can likewise be detected with the camera. The multispectral fluorescence imaging system should have passed testing for use with humans as soon as next year. The first clinical tests with patients suffering from glioblastomas are planned for 2014.



**Left: the new camera displays colored structures by means of fluorescent dyes (light areas shown here). (© Fraunhofer IPA) | Picture in color and printing quality: [www.fraunhofer.de/press](http://www.fraunhofer.de/press)**



## Solar cells utilize thermal radiation

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There is more to solar radiation than meets the eye: sunburn develops from unseen UV radiation, while we sense infrared radiation as heat on our skin, though invisible to us. Solar cells also 'see' only a portion of solar radiation: approximately 20 percent of the energy contained in the solar spectrum is unavailable to cells made of silicon – they are unable to utilize a part of the infrared radiation, the short-wavelength IR radiation, for generating power.

Researchers of the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, together with their colleagues at the University of Bern, Switzerland, and the Heriot-Watt University in Edinburgh, Scotland, have now for the first time made a portion of this radiation usable with the assistance of a practical up-converter. The technology that transforms infrared into usable light has been known about since the 1960s. However, it has only been investigated in connection with solar cells since 1996. "We have been able to adapt both the solar cells and the up-converter so as to obtain the biggest improvement in efficiency so far," reports Stefan Fischer happily, a scientist at ISE. The potential is big: silicon solar cells theoretically convert about thirty percent of sunlight falling upon them into electrical power. Up-converters could increase this portion to a level of forty percent.

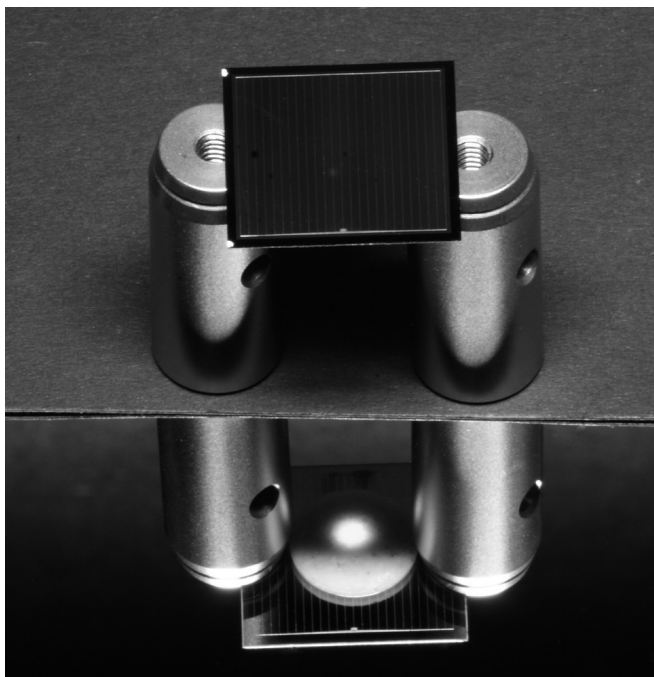
### A ladder for light particles

However, how does the up-converter manage to utilize the infrared radiation for the solar cells? As solar radiation falls on the solar cells, they absorb the visible and near-infrared light. The infrared portion is not absorbed, however, it goes right through them. On the backside, the radiation runs into the up-converter – essentially a micro-crystalline powder made of sodium yttrium fluoride embedded in a polymer. Part of the yttrium has been replaced by the scientists with the element erbium, which is active in the optical range and responsible in the end for the up-conversion.

As the light falls on this up-converter, it excites the erbium ions. That means they are raised to a higher energy state. You can imagine this reaction like climbing up a ladder: an electron in the ion uses the energy of the light particle to climb up the first step of the ladder. A second light particle enables the electron to climb to the second step, and so on. An ion that has been excited in this manner can "jump down" from the highest step or state. In doing so, it emits light with an energy equal to all of the light particles that have helped the electron to climb on up. The up-converter collects, so to speak, the energy of several of these particles and transfers it to a single one. This has so much energy then that the solar cells "see" it and can utilize it.

Researchers had to adapt the solar cells in order to be able to employ an up-converter such as this. Normally, metal is vapour-deposited on the backside, enabling current to

flow out of the solar cells – so no light can shine through normally. “We equipped the solar cells with metal lattices on the front and rear sides so that IR light can pass through the solar cells. In addition, the light can be used by both faces of the cell – we call this a bi-facial solar cell,” explains Fischer. Scientists have applied specialized anti-reflection coatings to the front and rear sides of the solar cell. These cancel reflections at the surfaces and assure that the cells absorb as much light as possible. “This is the first time we have adapted the anti-reflection coating to the backside of the solar cell as well. That could increase the efficiency of the modules and raise their energy yields. The first companies are already trying to accomplish this by implementing bi-facial solar cells,” says Fischer, emphasizing the potential of the approach.



**A two-sided silicon solar cell – positioned here on aluminum cylinders – is illuminated from above by an infrared laser. (© Fraunhofer ISE) | Picture in color and printing quality: [www.fraunhofer.de/press](http://www.fraunhofer.de/press)**

## Speedy analysis of steel fiber reinforced concrete

RESEARCH NEWS

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Concrete is the world's most popular building material: we use it to bridge rivers and valleys, build walls and line tunnels. The most common form of concrete is steel reinforced – a principle that will be familiar to anyone who has ever taken a closer look at a building site. Long steel rods, also called rebars, are bent into a dense framework, known as the reinforcement, which is then filled with concrete. But building with steel reinforced concrete is time consuming. It can take days or even weeks before the reinforcement for large buildings is fully assembled, the rebars bound together, and everything ready for the concrete pour.

Steel fiber reinforced concrete is a much quicker alternative, as steel fibers about the length of pine needles are simply mixed in to the liquid concrete. Once the concrete sets, this network of fibers does exactly the same job as traditional rebar reinforcement, increasing the concrete's tensile strength and counteracting cracks. Despite this, SFRC is not very widely used in the construction industry. The reason is that it was always very difficult to determine the quality of the material in the past, as there was no method for simply and reliably analyzing the distribution of fibers in the concrete. And yet it is this distribution that determines the material's load bearing capacity. If there are zones within the concrete where fibers are clumped together, or if certain sections of a slab contain no steel fibers whatsoever, the material is much less able to withstand stresses. This represents an element of risk that many construction companies are not willing to take, causing them to shy away from using SFRC.

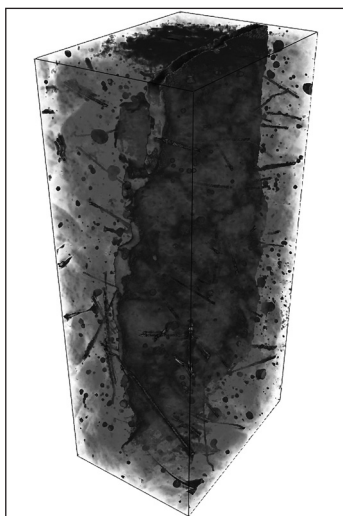
### Software for evaluating the fiber matrix

Help has now arrived in the form of a new analysis method developed by mathematicians at the Fraunhofer Institute for Industrial Mathematics ITWM in Kaiserslautern. It uses probability calculations to work out the distribution of all the fibers within concrete samples in a matter of seconds. Project leader Dr. Ronald Rösch and his team of experts use X-ray computed tomography in a way he describes as not dissimilar to how CT scans are used in medicine. "The only difference is that we use it to examine samples taken from finished concrete components, not people," Dr. Rösch explains. Scientists take a core sample about ten centimeters in length from the concrete to be tested. The sample is then X-rayed using an industrial CT scanner at a resolution around a thousand times finer than that achieved by medical scanners. This system reveals even the finest micrometer-sized structures within the material, and generates a high-resolution 3D data set for the concrete sample that contains some eight billion pixels – a huge file. Rösch and his team then use their new software to analyze this image data. By assessing differences in contrast, the software is able to assign each pixel to a particular structure within the material, be it concrete, a small stone, a trapped air bubble or a steel fiber. As the software works its way through the data set, all the fibers gradually become visible in the image.

„In and of itself this picture isn't much use, however, as the tangled network of fibers is so dense that it's almost impossible to make out individual ones with the naked eye," explains Rösch. This led the experts in Kaiserslautern to develop software that brings order to the chaos by analyzing the system as a whole rather than evaluating each individual fiber. The program simply decides whether a particular pixel represents part of a steel fiber, and calculates the orientation of that fiber.

For each pixel, the program calculates the composition of the material adjacent to it. Is it a fiber, or not? Instances where numerous fibers touch or cross over each other are the most interesting, as to begin with it is unclear which of all the adjacent pixels actually belongs to which fiber. Does that pixel belong to the fiber coming in from the top left, or to the one crossing the others directly from above? This is where the probability calculation comes in. It weighs up the location of each pixel, and attributes it to a particular fiber based on what makes logical sense. The results tell the experts everything they need to know, revealing not only the proportion of steel fibers in the sample, but also their orientation. "This is especially important when the concrete component has to absorb forces coming from a particular direction," says Rösch. An example of this is bridges carrying cars and trains at high speed.

It goes without saying that Rösch is aware of the system's current limitations; a CT scanner the size of a small wall closet is simply too big for practical use on a building site. „But this is an obstacle we can overcome," he says. "Our colleagues at the Fraunhofer Development Center for X-ray Technology EZRT in Erlangen have already developed a machine the size of a beer crate." A prototype for practical application could be available in five years, Rösch estimates.



**The CT scan creates a detailed image of the concrete cylinder. The crack runs through the darker surface.**  
(© Fraunhofer ITWM) | Picture in color and printing quality: [www.fraunhofer.de/press](http://www.fraunhofer.de/press)

## Organic lights and solar cells straight from the printer

RESEARCH NEWS

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Time is slowly running out for bulky television sets, boxy neon signs and the square-edged backlit displays we all know from shops and airports. It won't be long before families gathering together to watch television at home will be calling out: "Unroll the screen, dear, the film's about to start!" And members of the public may soon encounter screens everywhere they go, as almost any surface can be made into a display. "These may just be ideas at the moment, but they have every chance of becoming reality," says Dr. Armin Wedel, head of division at the Fraunhofer Institute for Applied Polymer Research IAP in Potsdam-Golm. The first curved screens were on display at this year's consumer electronics trade show (IFA) in Berlin. The technology behind it all? OLEDs: flexible, organic, light-emitting diodes.

### Molecule solutions as ink

But the potential offered by this technology extends beyond screens and displays for consumer electronics, according to Wedel. He believes OLEDs are also ideally suited to all kinds of lighting and to digital signage applications – that is to say, advertising and information systems such as electronic posters, advertisements, large image projections, road signs and traffic management systems. The scientists worked together with mechanical engineering company MBRAUN to develop a production facility able to create OLEDs as well as organic solar cells on an industrial scale. The innovative part is that it is now possible to print OLEDs and solar cells from solutions containing luminescent organic molecules and absorptive molecules respectively, which makes printing them onto a carrier film very straightforward. Usually, printing them involves vaporizing small molecules in a high vacuum, making it a very expensive process.

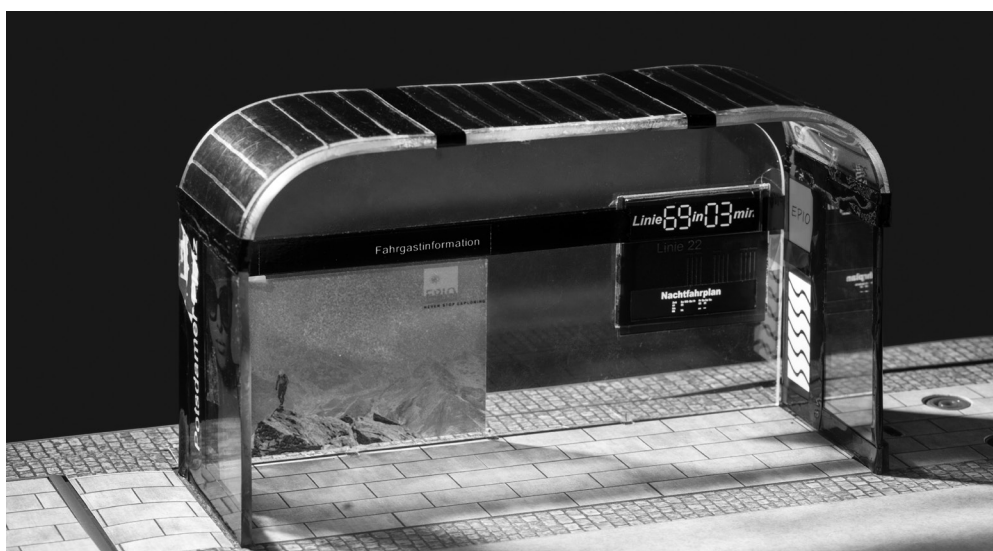
Scientists had previously only ever used various printing technologies to design components on a laboratory scale. They can now produce larger sample series – and this is particularly advantageous for the applications that the IAP has in mind, as large illuminated surfaces and information systems require tailored solutions produced in relatively small numbers. "We're now able to produce organic components under close-to-real-life manufacturing conditions with relative ease. Now for the first time it will be possible to translate new ideas into commercial products," Wedel says.

At the heart of the pilot plant is a robot that controls different printers that basically act like an inkjet printing system. OLEDs are applied to the carrier material one layer at a time using a variety of starting materials. This produces a very homogenous surface that creates a perfect lighting layer. "We're able to service upscale niche markets by offering tailored solutions, as we can apply the organic electronic system to customers' specifications, just like in digital printing," explains Wedel.

Industry experts estimate that printed OLEDs hold out the promise of becoming a billion-dollar market. "The focus in Germany and Europe is on OLED lighting because this is the home market for large companies such as Osram and Philips," explains Wedel. "The manufacturing facility will help secure competitive advantages in this particular segment of the market. It strengthens the German research community, and also demonstrates the capabilities of German plant engineering," says Dr. Martin Reinelt, CEO of MBRAUN in Garching.

OLEDs have several advantages over conventional display technologies. Unlike liquid crystal displays they do not require backlighting, which means they consume less energy. As it is the diodes themselves that emit colored light, contrast and color reproduction are better. The electroluminescent displays also offer a large viewing angle of almost 180 degrees. And because they require no backlighting, they can be very thin, making it possible to create entirely new shapes.

There are still several challenges to be met before OLEDs become firmly established on the market. "The main hurdle, as far as I'm concerned, is the high level of investment required to set up manufacturing," says Wedel. This is why, at least where lighting is concerned, he expects OLEDs to complement rather than replace conventional lighting devices. His view of where OLED production technology could head is less modest: "My vision is that the day will come when all we need do is switch ink cartridges in our printers in order to print out our own lighting devices."



**Organic light-emitting diodes (OLEDs) – here at the bus stop of the future – will soon come out of printing machines. (© Fraunhofer IAP / Till Budde) | Picture in color and printing quality: [www.fraunhofer.de/press](http://www.fraunhofer.de/press)**

## Testing smart plastics in real time

RESEARCH NEWS

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We encounter functional plastics parts whenever we open the refrigerator door. Besides being easy to clean and ergonomically shaped, the material built into a refrigerator also have antibacterial properties, thanks to nano-sized additives mixed in with the pellets of plastic during the manufacturing process. Parts like these can be modified to have all sorts of different properties, which vary according to the type and shape of the particles of additive and their distribution within the polymer compound. Even though these particles are less than 100 nanometers across, it takes just a tiny quantity to make the plastic antibacterial, scratch proof and flame retardant, electrically or thermally conductive, or to give it greater mechanical rigidity. For these properties to function as intended, the ratio of pellets to additives and the overall particle distribution has to be exactly right. Until now, checking this has always been a very complicated and time-consuming process that had to be carried out after the material is made. Manufacturers are often only able to achieve the desired plastic formula after mixing several trial batches, which slows down the production process and wastes material.

The Fraunhofer Institute for Chemical Technology ICT in Pfinztal near Karlsruhe has been working with other partners to develop a tool for characterizing polymer nanocomposites during the ongoing production process itself. "This is not only more cost-effective in terms of material and time, it also helps us to improve the quality of the properties that the added nanoparticles bring to the polymer," says Irma Mikonsaari of the ICT.

### On-the-spot analysis directly at source

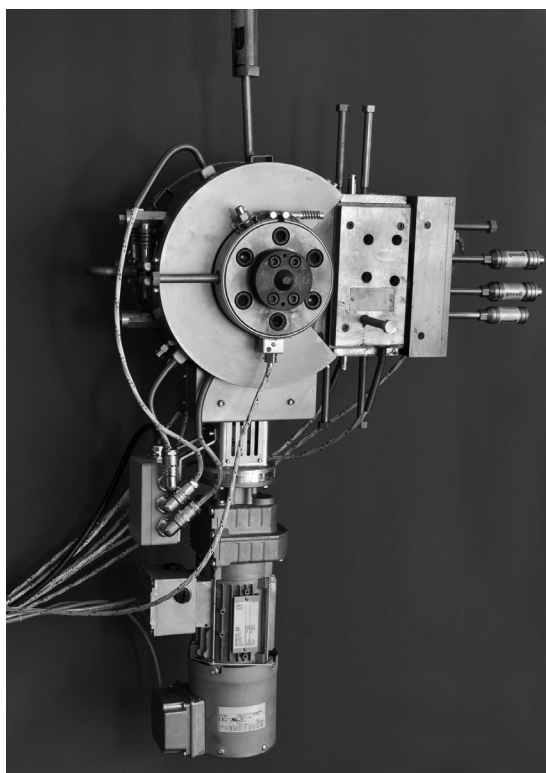
<sup>on</sup>BOX is simply mounted to the exit nozzle of the conveyor, where its sensors analyze and characterize the polymer compound while it is still in the mixing plant. The sensors use a combination of technologies including spectroscopy, ultrasound and microwaves to test the composition of the polymer-nanoparticle compound. They measure its viscosity, pressure and particle distribution, including any possible fluctuations in concentration, while simultaneously measuring the compound's temperature and its thermal and electrical conductivity. A computer then compares this data to the system's command variables and processes it inside an artificial neural network. The computer determines the precise mixing ratios needed to achieve the intended effect as well as the manufacturing process this requires, and feeds this information directly to the machine's control system. "The result is that the network of nanoparticles develops just as we want it to," says Mikonsaari, "with optimal distribution of the individual particles." She adds: "We are able to characterize the state of the polymer melt as it is being discharged through the nozzle."

Mikonsaari will be presenting <sup>on</sup>BOX on November 19, 2013 at the NanoOnSpect workshop being held at the ICT in Pfinztal, where it will be attached to a pilot plant



able to process 30 kilograms of polymer compound. ICT researchers will also be reporting on the current status of the EU-funded NanoOnSpect project. Those invited to attend include raw material suppliers, plastics manufacturers and companies that process and reuse smart plastics.

NanoOnSpect was launched in 2011 and will run for a total of four years. The consortium draws on the scientific community, associations and industrial partners and was set up with the aim of optimizing manufacturing processes for smart plastics that feature nanoparticle additives. Project partners are seeking to achieve this in two ways: on the one hand, they are developing technologies that help to improve characterization of the size, structure and distribution of the nanoparticle additives as well as the properties of the polymer compounds. On the other, they are designing a new mixing procedure that combines the advantages of existing processes. “<sup>on</sup>BOX is a very tangible product of our research from which industry stands to benefit immediately,” says Mikonsaari, pointing out the relevance of the new tool and its scope for practical application.



**<sup>on</sup>BOX uses a sensor system to test the composition of plastics enriched with nanoparticles. The unit is mounted directly onto the mixing plant, and is able to monitor particle distribution. (© Fraunhofer ICT) | Picture in color and printing quality: [www.fraunhofer.de/press](http://www.fraunhofer.de/press)**



## Changes in woodland use

Leaves rustling in the wind, sunbeams slanting through the undergrowth, birds hopping from branch to branch – when most people think of woodland, they associate it with long walks, leisure time and relaxation. But forest ecosystems also have an economic role to play, providing us with wood for use as fuel and as the raw material for building materials and paper. The Fraunhofer Center for Central and Eastern Europe MOEZ in Leipzig worked with colleagues from the University of Freiburg to investigate changing forest land-use policies and practices in Europe over the last 60 years. Their study forms part of INTEGRAL, an EU project on the management of European forest ecosystems.

This survey of European forest use is the first of its kind. It produced several surprising results that the scientists intend to turn into firm recommendations for political action. Researchers discovered, for instance, that the number of forest owners had gone up in many European countries, although with owners often laying claim to smaller areas of woodland than before. Commercial woodland use has also changed, with emerging economic powers such as China making a big impact. China's wood-processing industry has undergone rapid growth and brought major change to global trade structures. Another trend uncovered by the survey is that wood is in greater demand than ever before for fuel. However, it remains to be seen whether this trend will continue, given the competition to put wood to other uses and the rising price of biomass.

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## Cost-effective recycling of black plastics with terahertz waves

Cut into lots of tiny pieces, the car dashboard is unrecognizable as it crawls along the conveyor belt at the recycling plant. The plastic parts are heading for new lives as insulation material, pieces of clothing or garden furniture. But reusing this material relies on the machine being able to separate out each of the different kinds of plastic with absolute accuracy. This is precisely where it gets tricky, as conventional sensor systems such as near-infrared spectrometer imaging technologies often struggle to achieve the necessary accuracy, particularly where black plastics are concerned. The problem is that carbon black, which is added to color the material, absorbs most of the electromagnetic radiation in both the visible and infrared wavelength ranges needed to distinguish between different types of plastic.

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Three Fraunhofer Institutes – for Optronics, System Technologies and Image Exploitation IOSB in Karlsruhe, for High Frequency Physics and Radar Techniques FHR in Wachtberg, and for Intelligent Analysis and Information Systems IAIS in Sankt Augustin – are working together to try and close this loophole in the recycling system in a project entitled blackVALUE. They have now shown that it is possible to build a plant that uses terahertz (THz) spectroscopy and highly efficient identification algorithms to recycle black plastics on an industrial scale. This kind of sorting machine centers around a camera that uses lower THz frequencies to characterize materials cost-effectively and at high throughput.

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**Data detectives in double-glazed windows**

Double-glazed windows have to withstand everything from baking sunlight to icy winds and biting cold. And it's not just the temperature fluctuations themselves they have to cope with, but also the resulting changes in pressure between the two panes of glass. The glass panels bow outwards or inwards as temperatures rise and fall, and this exerts forces that can lead to tiny cracks forming at the edge of the panes. Such cracks are barely visible to the naked eye, but are large enough for the insulating gas to escape, which results in the windows losing their insulating properties.

Now window manufacturers will be able to use special measuring instruments called data loggers to measure the temperatures and pressures within the windows, thereby helping them to optimize their production processes and product designs. Developed by researchers from the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg, these sensors are only a few millimeters wide, meaning they fit in the narrow space between the panes of glass. Staff at Technische Universität Darmstadt's testing facility fitted the data loggers inside 40 different double-glazed windows and placed these in a climate chamber. Over a period of 12 weeks, the windows are subjected to temperatures ranging from -18 and +53 degrees Celsius. The sensors take pressure and temperature readings throughout this period of time, transmitting the data to an outside receiver as well as storing it in their own integrated memory. In this way the sensors are helping to make double-glazed windows that are even more airtight.

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