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RESEARCH NEWS

12 | 2014 ||

1 Perfect chocolate sheen on confection and sweets

White flecks on sweets with a chocolate glaze are harmless – but esthetically unappealing. More than just improper storage can diminish the glossy sheen. Researchers have discovered other weak points in the production process. Armed with sophisticated analysis, companies can now protect their products effectively from the undesirable coating.

2 Proteins off the roll

Protein-coated Petri dishes are increasingly being used to support cell growth during cell cultivation. Scientists have developed a system for printing protein patterns onto film using a roll-to-roll process, which allows high volumes to be manufactured efficiently and cost-effectively.

3 Smart anti-icing system for rotor blades

In very cold climate zones, the wind can blow with tremendous force. But wind turbines have rarely been built in these regions up to now. The risk of ice formation on the rotor blades is just too high. But now, an energy-efficient heating system frees these turbines from the ice in a matter of seconds. It is only switched on when water freezes.

4 The flying inventory assistant

Standing on top of a ladder several meters high, pad and pen in hand, just to count boxes? Inventories in large warehouses could soon appear quite different and proceed to take flight, in the truest sense of those words: The goal of the InventAIRy Project is to automatically localize and record existing inventories with the aid of flying robots.

5 Mobile radio passive radar makes harbors safer

Many coastal areas and harbors go almost unprotected against acts of terror. Soon a new sensor system relying on signal echoes from cell towers can quickly detect even the smallest of attack boats. This mobile radio passive radar can also help airplanes avoid colliding with wind turbines.

6 Live images from inside materials

X-rays are a tried and tested way to investigate components and materials. Researchers are now developing an X-ray detector capable of delivering particularly high-quality 3D images in real time. This will make it possible to precisely reconstruct even the processes going on inside materials and e.g. provide a reliable way of detecting minoscule faults.

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

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Perfect chocolate sheen on confection and sweets

They are harbingers of the Christmas season: gingerbread, marzipan sweets, spiced cookies, macaroons, truffles and others are all filling the supermarket shelves in the autumn. Enrobed in chocolate coating, these baked Christmas favorites are enticingly mouthwatering for any sweet tooth. But after the consumer unpacks them, the chocolate products seem to be covered with whitish coating. Experts refer to this phenomenon as "fat bloom". Even excellent products with chocolate coating could lose their gloss after a certain amount of storage time has passed, and develop a grey patina. Fat bloom is often mistaken for mold, but it really has nothing to do with this. It has no effect on the taste of the product, and the product is not ruined by it. Nonetheless, the unsightly coating has an adverse visual effect on these treats; they lose some of their quality. "Production of Christmas baked goods already starts in July. This is where the problem lies. Fat bloom does not appear immediately after production, but instead appears days or even weeks later. It can be one of the consequences that come from storage that is too warm, or under temperatures that sharply fluctuate," explains Wolfgang Danzl, food quality expert at the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising. The researcher and his team are helping food makers with their efforts to improve the resistance of their products with chocolate coatings from white flecks.

Small- and medium-sized enterprises suffer the greatest impact, because they produce a majority of the confections and baked goods. Chocolate coatings represent an effective technique for refining these products. In the process, the pastries, cakes, waffles, and bars are run through a fluid, pre-crystallized chocolate stream. They then have to swiftly crystallize within the cooling channel - in other words, solidify - so that a shiny surface results. IVV researchers discovered that this stage is precisely where fat bloom can arise. "It is not uncommon for residual chocolate at the end of the coating stage to flow right back to the start. During this recycling, the shortening used for filling and baking is washed off. We were able to prove that for the first time. To obtain the evidence, we developed commensurate methodology. Until now, there were hardly any investigations on coating systems," Danzl explains. The fat components from the fillings could penetrate to the surface of the confection, and accumulate in the coating. This process is also called "fat migration." Fine fat crystals accumulate at the surface, and thus change the crystallization properties of the chocolate coating. "The filling fats cause the chocolate to crystalize more slowly, making the coating softer. This allows the fat to accumulate even more efficiently. Fat migration is facilitated, which in turn can lead to fat bloom formation," the researcher explains.

Soft coating from nut oil and coconut oil

The type and quantity of the filling fats influences the chocolate's crystallization behavior. Cocoa butter with a minimum proportion of other fats and oils is highly predis-

posed to fat bloom. Most of all nut oil and lauric fats tend to soften the chocolate coating, the IVV researchers determined through their lab testing. This includes coconut oil and palm kernel fat. They contain lauric acid, which does not mix well with the cocoa butter. By unravelling, the crystalline structure is destroyed; as a result, these white flecks emerge.

Producers can arrange to have the food experts at IVV investigate their chocolates at the laboratory. For this purpose, they have to remove the fluid mass from the tank during production. The researchers are capable of evaluating the quality of the chocolates, identify the proportion of filling fat, and analyze precisely how great the risk is for fat bloom to occur. They advise the companies about how to optimize the production processes by implementing which measures. Depending on the application, you can counteract the phenomenon by adjusting the temperature gauge, the refrigeration channel or the backflow. Evaluating the baking and filling fats could furthermore help improve recipes.

On the conveyor belt, chocolate-coated wafers are moved through the cooling channel. (© Fraunhofer IVV) | Picture in color and printing quality: www.fraunhofer.de/press

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Proteins off the roll

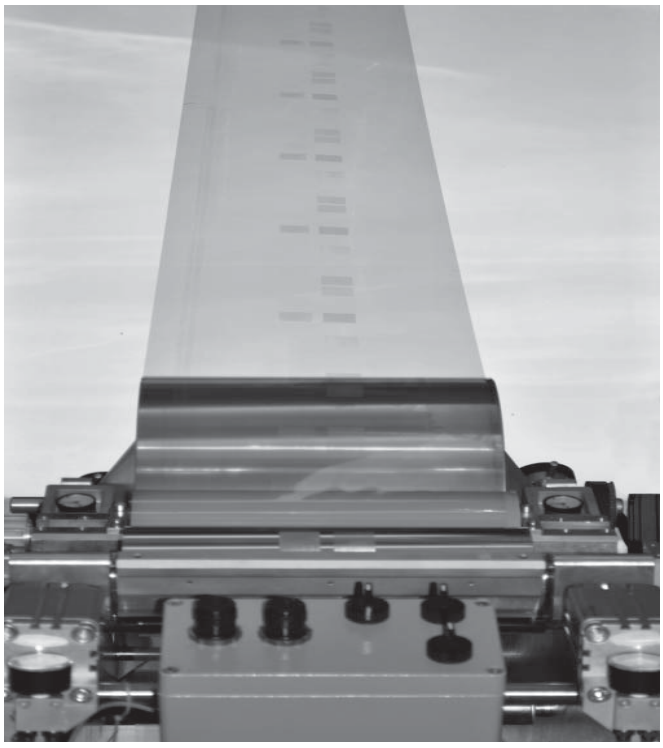
Cells are the smallest living components of an organism, making them a highly sought-after material for biomedical researchers. They are incorporated into biosensors for use in several areas, such as diagnostics, drug development or environmental analysis. Cell cultivation helps scientists make strides in all these areas, which also benefits the consumer. However, artificially cultivating cells in the lab that occur naturally in human, animal or plant organisms is not all that easy. Even cells are able to perceive their surroundings, and a "foreign" environment can change them; for instance, their shape or behavior. When this happens, the cell cultures become less useful for experimental purposes. "It's like setting out to analyze the typical behavior of someone who lives in a big city by sticking them in a desert," says Dr. Thomas Velten from the Fraunhofer Institute for Biomedical Engineering IBMT in St. Ingbert, Germany.

One way to counteract this effect is to coat a substrate such as the bottom of a Petri dish with proteins to help the cells "feel more at home." However, all existing methods for doing so have drawbacks. Spin-coating, for instance, involves placing a drop of liquid protein in the center of the substrate and distributing it over the surface with a kind of spinning process. "This process wastes a considerable proportion of the liquid, as some of it doesn't even end up on the substrate," says Velten. Microcontact printing is different. In this technique, fine protein structures in the micrometer range are printed directly onto the substrate itself. This not only uses resources more efficiently, but also allows scientists to create very fine protein structures for the cells to organize themselves around. Researchers can then selectively control the arrangement of the cells. However, for large-area, low-cost applications such as those required in biotechnology, microcontact printing is too labor-intensive and expensive.

Protein ink without solvents

Scientists at Fraunhofer IBMT therefore decided to take a new approach. Together with the company SAUERESSIG, they are working to develop a roll-to-roll printing plant for applying microstructured protein patterns to large-area film substrates. The roll-to-roll method is commonly used for processing large surface areas quickly and cost-effectively, and works in a way similar to newspaper printing. First, the substrate is wound onto a roll, with an empty roll positioned opposite. The printing processes take place between the two, with the substrate always being wound onto the empty roll at the other end. However, this process can't simply be transferred one-to-one to biotechnology applications. For one thing, standard ink is not suitable as a print medium. "Solvents are often added to the ink to make sure it dries quickly, but these destroy the proteins," explains Velten. To solve this problem, the IBMT experts developed a new, specialized protein ink. They also had to ensure that the other materials used in the process, such as the film substrate, are biocompatible.

Project partners have already managed to successfully cultivate various types of cells on the first substrates to be coated using the new system. The demonstrator production plant is now also available for developing printing processes tailored to customer requirements. The maximum film width is currently 30 centimeters, and the smallest printable structures are in the range of 10 to 20 micrometers. For the next step, Velten and his team want to print conductive structures using the roll-to-roll process and combine them with the protein patterns. "In the long term, this will make it possible to produce complete biosensors by printing," says Velten. What's more, the scientists already have definite applications in mind for this technology. Two research projects are already underway: one to develop sensors for validating antiviral substances, and another to devise a cost-effective, film-based analysis system – referred to as lab-on-a-foil – for localized measurement of a blood glucose marker.



Proteins are printed onto large-area film substrates using roll-to-roll processing methods.
(© Fraunhofer IBMT) | Picture in color and printing quality: www.fraunhofer.de/press

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Smart anti-icing system for rotor blades

A number of companies shy away from building wind-powered systems in northern regions, even though the wind blows with great power there. To begin with, weather conditions represent a Herculean challenge: Aerodynamic properties deteriorate when an ice layer forms on the rotor blades as temperatures drop to the below-zero range under freezing storm conditions. The turbines produce less energy. The inexorable redistribution of the loads disturbs the overall balance, which furthermore means the blades might breakdown faster. On top of this is the safety risk associated with icicles breaking off. When the risk of ice formation arises, the operators will immediately shut down the systems. Annual power production becomes markedly diminished – the ice accumulations cause power losses ranging anywhere from 14 to 20 percent. Despite the vast potential, wind turbines are consequently much less likely to be constructed in cold climate regions. This is where the EU's "Windheat Project" steps in: Working in joint collaboration with six corporations from four EU states, researchers at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart are developing an energy-efficient ice detection and anti-icing (or de-icing) system for small wind turbine power generators. Periods of weather-related downtimes should be avoided this way.

Carbon nanotube coating causes the ice to melt

Existing anti-icing systems are energy-intensive, since they have to heat up the entire rotor blade – regardless of whether entire blade is actually affected. But with "Windheat," the project partners are taking a different route: This rotor blade is divided in to a variety of zones that were each finished with a carbon nanotube (CNT) coating. Then, a separate ice detector is integrated into each individual CNT layer. "Our carbon nanotube coating only heats those zones that are actually iced up. These are the edges of the rotor blade, first and foremost," says Anne Gerten, scientist at IPA.

These tiny, sensitive probes are constantly measuring temperature and humidity at the surface, react to the slightest fluctuations, and detect when water freezes. If ice is detected, then, in a matter of seconds, the detectors switch on the heat element that supplies the corresponding CNT layer. Once the ice has melted, the heat is automatically switched off. "With the combination made out of CNT coating and sensors, we can target and heat the iced-up zones and essentially, only when it is actually required," adds Gerten. The goal of the project is to increase energy efficiency by at least 18 percent, using this de-icing strategy.

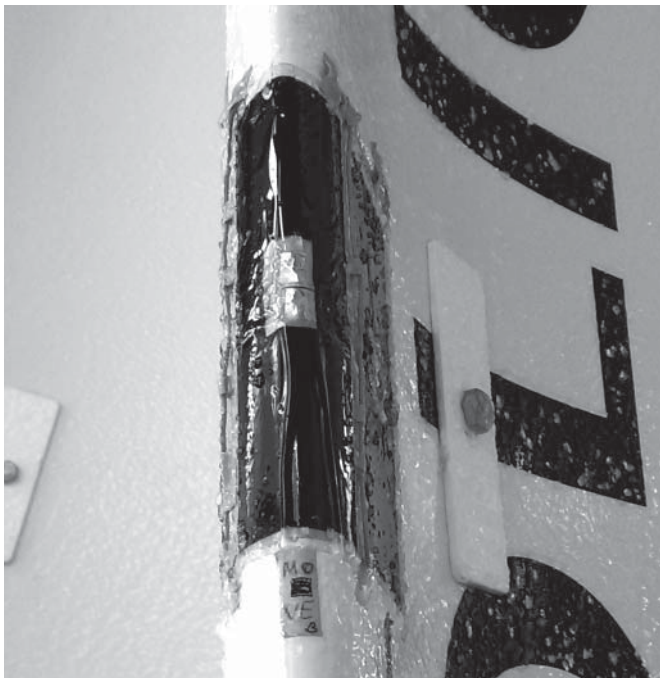
The CNT layer, just a few micrometers thick, can be applied to the rotor blade with ease. It is applied by spraying CNT onto a self-adhesive polymer film. Clear-coat insulates the coating and additionally protects it from humidity and mechanical effects. The researchers selected this material because of its excellent mechanical properties. "In

principle, these carbon nanotubes are wrapped layers of graphite that touch each other in various places. At these contact points, the electrical current is converted into heat," the researcher explains.

Tests in wind tunnel

Which areas of the rotor blades are especially susceptible to ice build-up? In the project, they used computer simulations to figure this out. Above all, the edges of the blades turn out to be the neuralgic points. The IPA researchers were able to confirm these findings through tests in the wind tunnel. At minus 30 degrees Celsius, in ice, rain, and with wind speeds of up to 120 km/h various prototypes were tested under real-life conditions. Among other things, the scientists outfitted the rotor blade of a small wind turbine generator with the CNT coating. "We have applied affordable materials to both the sensors and the heating elements. That is an important precondition to making the anti-icing system feasible for serial production," explains Dipl.-Ing. Sascha Getto, a colleague of Anne Gerten's at IPA and researcher in charge of the wind tunnel tests. "We designed and built the prototypes for small wind turbine systems, but they are absolutely suitable for upscale retrofit." Getto considers aviation to also be a potential field of application for the Windheat System – which could deice airplane wings.

Additional information: www.windheat.eu



The area on the rotor blade heated by the CNT-coating remains free of ice. (© Fraunhofer IPA) | Picture in color and printing quality: www.fraunhofer.de/press

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The flying inventory assistant

"Dear customers: the store is closed today for our regularly scheduled inventory work." Anyone who has ever encountered this or a similarly worded sign knows that "patience is a virtue" especially while shopping, while in the background, an army of employees mill about, preoccupied with numbers. The manual inspection of a goods warehouse is a fundamental component of the legally proscribed annual inventory. The conventional procedure is time-consuming and paralyzes a majority of the warehouse operations. Even the barcodes and RFID tags pervasively used today are of little help. The entire process still demands a vast amount of personnel and time.

Marco Freund is keenly familiar with the problems that must be confronted when running an inventory. The certified logistics specialist heads the InventAIRy Project at Fraunhofer Institute for Material Flow and Logistics IML in Dortmund. His vision of an optimized inventory system looks like this: "The person in charge is sitting at his desk and at the press of a button, can inspect inventories or perhaps search for a specific item – without incurring any staffing or logistics costs." To ensure this becomes reality in the not-too-distant future, Freund and his colleagues engineered a "dynamically animated records system" that distinguishes itself – on one rather critical point – from commonly available solutions currently in use today: "Goods and pallets can already be tracked automatically, via RFID for instance. In doing so, the antennas that the chips read out are permanently mounted to the shelf. The chips are located on the products and are recorded if they pass the readout device. With InventAIRy, exactly the opposite applies: The radio chips remain in their fixed position, the antenna is moved by its integration into a flying robot. "The Inventory Assistants, which the scientists have in mind, are autonomous robots that move throughout the warehouses by flying.

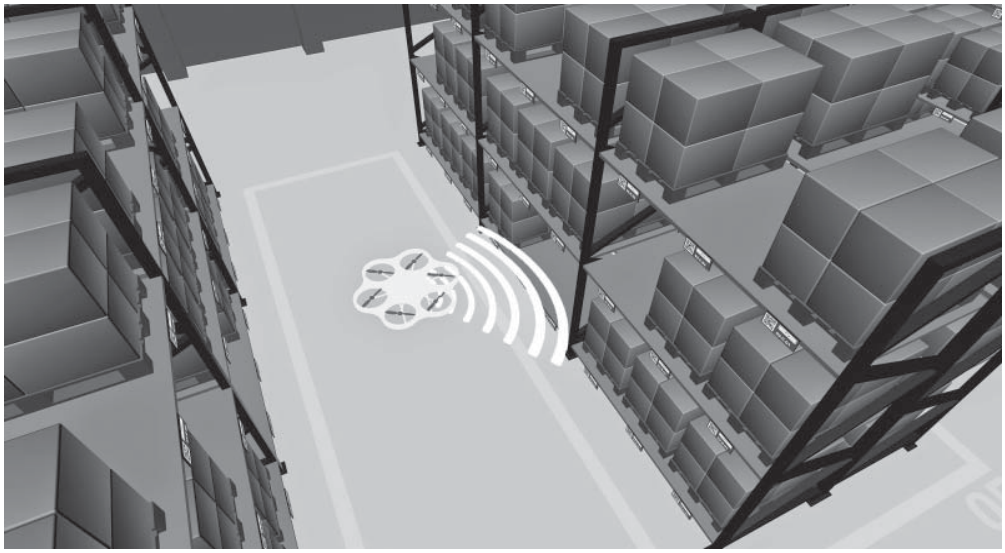
Putting wings to flying assistants

It is already a reality with driverless transportation systems, so it should also be possible to put them to flight with InventAIRy: In this project, the IML researchers are moving toward the goal of engineering autonomous flying robots that are capable of independently navigating and conducting inventory. These flying assistants should be able to localize objects both in the warehouses as well as the exterior area, and be able to track through barcodes and RFID tags. The advantage: These robots act independent of ground-based obstructions. Furthermore, they can move in any direction and see into hard-to-reach places, such as tall storage shelves.

The individual service robot, as an intelligent mobile object, perceives its environment dynamically on two levels: It detects how the warehouse is configured using motion and camera sensors, for instance, and can orient itself within the warehouse. GPS determines its position outside. In addition, the robot records the stored items in terms of content. The scientists accomplish this with the aid of optical sensors or radio

sensors. "We take a look at various key problem sets at the same time: robustly designed, lightweight flying robots that can reliably recognize their surroundings, as well as intelligent software for their route planning and coordination," the certified logistician explains. "To ensure this solution is also appealing to small- and medium-sized enterprises, we intentionally dispensed with the installation of an expensive local infrastructure that the robots can use to orient themselves. The researchers want to accomplish this with the aid of intelligent algorithms. The flying objects should prepare maps of the warehouse on a fully automated basis, and independently modify them if there are any changes. The basis for this are, for example, ultrasound sensors, 3D cameras, and laser scanners.

Current solutions are able to integrate collected inventory data automatically into existing warehouse administration systems, without requiring additional software development. InventAIRy researchers, by contrast, are working on smart interfaces that transmit data wirelessly into existing systems. This means commercial operations save time and money – and documentation errors decrease. Furthermore, the flying robots can continuously monitor warehouse inventories. "In this manner, it would be possible to identify materials bottlenecks at an early stage in production, and rectify them even before the shortfalls can occur," adds project manager Freund. The team's preliminary results are highly promising. "By mid-2015, we intend to start with a partially automated flight. In this phase, the robot equipped with the identification technology hovers – without having to be controlled via remote operation – at one position, and circumvents collisions with obstructions, such as shelves," the project manager explains.



The autonomous flying robot will soon be capable of independent navigation and inventory administration. (© Fraunhofer IML) | Picture in color and printing quality: www.fraunhofer.de/press

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Mobile radio passive radar makes harbors safer

Airports are now subject to careful security surveillance, but many coastal towns and ports are not; they often lack radar installations to keep track of small boats, meaning terrorists could easily use speedboats to approach the coastline and bring explosives on land. Now, researchers at the Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE in Bonn developed a passive surveillance system for littoral regions based on mobile radio illumination called Passive Coherent Location (PCL). It passively employs the continuous radio signals emitted by cell towers to detect suspicious boats, including those speedboats favored by pirates for approaching cargo ships. The fusion with electro-optical or infrared systems allows the classification of the different targets.

This new method works in much the same way as radar systems, which send electromagnetic signals toward an object and then collect the echo they return. Similarly, the PCL system detects boats based on reflected electromagnetic radiation from mobile networks. But it's much more difficult to evaluate radio signals than radar. A radar antenna transmits its own well-defined signals into a limited area. Echoes can be easily interpreted. The new sensor makes use of mobile network radio signals coming from different directions and from different cell towers. It receives a chaotic echo mix from which objects have to be carefully extracted. "One challenge is that our sensor system tends to pick up the strong signals from the cell towers themselves," says Reda Zemmari, project manager at the FKIE "The signal echoes reflected off the boats on the water are considerably weaker."

Versatile, mobile system

As a result, the researchers had to develop algorithms to compensate for this shortcoming. Now the software can suppress the strong radio signals coming directly from the cell towers. "It's handy that different cell towers use different frequencies," Zemmari continues, "because this allows the software to better differentiate between the various signals and echoes. What's more, the system can detect boats that are in motion based on their movement that causes a frequency shift. "Our system continuously checks whether it is correctly assigning signals and correctly interpreting the object's movements," says Zemmari. During tests off Eckernförde and Fehmarn, the researchers have already successfully tracked speedboats just a few meters in length from four kilometers away. "Our system can be transported on a small trailer, which means it can be deployed anywhere," says Zemmari – provided there is sufficient mobile network coverage. The research scientist emphasizes that the PCL system doesn't in any way read users' mobile data. "All we use is the transmitter's operating signal, which does not carry customers' data packets."

Preventing acts of terrorism is just one use for the technology. The researchers are currently working on a version for wind turbines. Tall turbine towers must be lit up at night with blinking lights to warn airplane and helicopter pilots. Unfortunately, the blinking bothers many people. Instead, wind turbines could be equipped with airplane detectors that switch the lights on only when a plane is approaching. Detectors that react to radio signals from airplanes already exist. "But we need a redundant system in case these break down – and PCL technology is well suited for that task," says Zemmari.

The PCL system also detects the motion of moving boats. (© Fraunhofer FKIE) | Picture in color and printing quality: www.fraunhofer.de/press

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Live images from inside materials

In medicine, X-rays provide high-resolution images of our insides to help doctors make a definitive diagnosis. Industry uses X-rays, too – as a reliable, non-destructive way of seeing what's hidden on inside materials and components and to check for cracks or irregularities. However industry additionally draws upon different technologies that are not used in the medical field. Whereas medical X-ray machines have been specifically designed for human test subjects, industrial X-ray machines are used to analyze objects that vary much more in their size and material composition. This calls for X-ray equipment that is correspondingly more flexible.

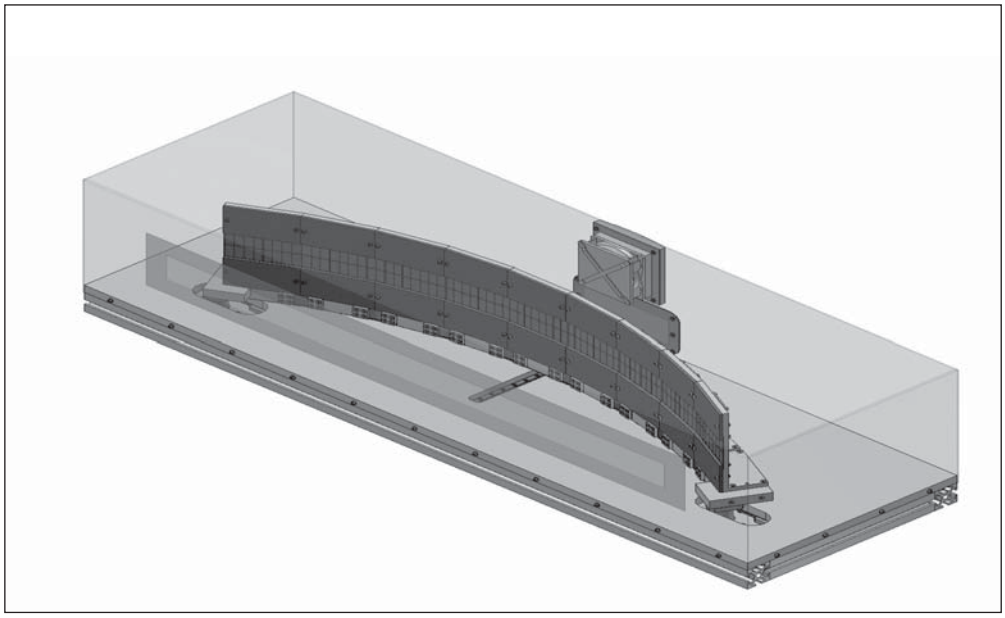
Researchers at the Development Center for X-Ray Technology EZRT, a division of the Fraunhofer Institute for Integrated Circuits IIS, have developed MULIX – an X-ray detector for industrial computed tomography (CT) based on the design of medical X-ray devices. "Our challenge was to combine high image quality with a high degree of flexibility," explains Frank Nachtrab from the EZRT. MULIX harnesses two concepts already in use, making it a kind of hybrid solution that incorporates elements of line and flat-panel detectors commonly used in industry. The researchers already know what they plan to achieve with their work: "We've had very promising results with our demonstrator and have shown that MULIX works. We're now looking for industrial partners to help develop a MULIX prototype," says Nachtrab.

Combining the benefits of two different methods

Single-line detectors use a fan-shaped beam to X-ray a certain section of the test object, whereas flat-panel detectors are working with a cone-shaped beam that encompasses the entire object. There are pros and cons to both solutions. A flat-panel detector will quickly give you a 2D image of the entire object. However, it causes scattered radiation – in other words, rays deflected by the test object – which greatly impairs image quality. A single-line detector is less sensitive for scatter and will therefore deliver extremely sharp images. But since it captures only a small portion of the test object, this scanning method is much more time-consuming. "We have combined the benefits of the two solutions," says Nachtrab. The new equipment is based on a detector with multiple lines, a design that until now has been used only in the medical field. Multiple-line detectors work according to the same principle as their single-line counterparts, but can also cover larger areas and thus radically reduce the scanning time. MULIX uses a total of 256 lines, allowing it to scan larger objects such as car body parts very quickly. What's really remarkable is that the new detector delivers images so fast, it becomes possible to use CT techniques to make a 3D-scan of the object almost in real time.

MULIX opens up new application opportunities in materials research and quality assurance, which would allow the automotive industry, aerospace and research institutions to observe processes going on within the materials they use. "When testing mechanical

properties such as tensile strength, we can use the images we get to see just how a compromising fault comes about," says Nachtrab. The researchers also came up with an innovative solution for the detector's mechanics: "This enhances the quality of the images further," says Nachtrab. Unlike commercially available detectors, it is possible to adjust MULIX's curvature. This ensures the flexibility that industrial CT needs to adapt the system to the various sizes and material properties of test objects.



The MULIX X-ray detector is designed to be integrated into industrial computed tomography systems. This hybrid solution combines the advantages of single-line and flat-panel detectors. Its adjustable curvature enhances the image quality while mainaining full flexibility. (© Fraunhofer EZRT) | Picture in color and printing quality: www.fraunhofer.de/press

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