Fraunhofer

RESEARCH NEWS

01 | 2012

Fraunhofer Press
Franz Miller
Britta Widmann
Phone: 089 1205-1302
presse@zv.fraunhofer.de
www.fraunhofer.de/presse

1 Sky light sky bright – in the office

Working under the open sky – it sounds enticing, but it's seldom really a practical option. Now, a dynamic luminous ceiling brings the sky into office spaces by creating the effect of passing clouds. This kind of lighting generates a pleasant working environment.

2 Fewer animal experiments thanks to nanosensors

Experiments on animals have been the subject of criticism for decades, but there is no prospect of a move away from them any time soon. The number of tests involving laboratory animals has in fact gone up. Now, researchers have found an alternative approach: they hope sensor nanoparticles will reduce the need for animal testing.

3 Time recording up one's sleeve

Optimized operations are essential to globally competitive companies. Until now, inspectors have timed procedures, usually manually, in order to organize manual assembly operations efficiently – a method prone to error. A new system records times automatically and cuts costs for companies.

4 Simulating firefighting operations on a PC

Firefighters often put their lives at risk during operations, so it is essential they have reliable tools to help them do their job. Now, a modular simulation kit is set to help develop new information and communication technologies – and ensure they are tailored to firefighters' needs from the outset.

5 High-speed CMOS sensors provide better images

Conventional CMOS image sensors are not suitable for low-light applications such as fluorescence, since large pixels arranged in a matrix do not support high readout speeds. A new optoelectronic component speeds up this process. It has already been patented.

6 Film coatings made from whey

Convenience foods are growing in popularity, and the food they contain is usually protected by films based on petrochemicals. Now researchers have not only developed a biomaterial from whey protein, they have also come up with a commercially viable method of producing multifunctional films on an industrial scale.

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 60 Fraunhofer Institutes at over 40 different locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of around 18,000, who work with an annual research budget totaling 1,66 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.

Editorial notes:
Research News | Frequency: monthly | ISSN 09 48 - 83 83
Published by Fraunhofer-Gesellschaft | Press Office | Hansastraße 27 | 80686 München |
Telefon +49 89 1205-1333 | presse@zv.fraunhofer.de
Editorial Staff: Franz Miller, Janine van Ackeren, Britta Widmann | Reprints free of charge.
We encourage you to favor the online version and newsletter via www.fraunhofer.de/fhg/EN/press
This bulletin is also available in German as “Mediendienst”.

Fraunhofer

Sky light sky bright – in the office

Research News
01-2012 I Topic 1

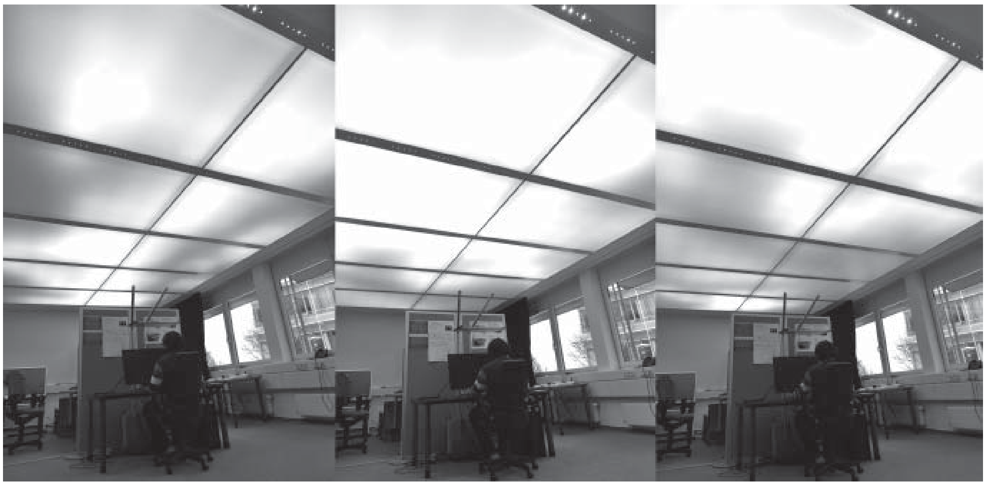
As the wind swiftly blows clouds across the sky, the light is in a constant state of change. The feeling of spaciousness and freedom we experience outdoors is exactly what researchers from the Stuttgart-based Fraunhofer Institute for Industrial Engineering IAO replicate indoors: a luminous ceiling that extends across the entire room simulates lighting conditions which resemble those produced by passing clouds – conveying the impression that you are sitting outdoors.

The innovative luminous ceiling, which was developed by the Fraunhofer researchers in close collaboration with their partners at LEiDs GmbH, consists of 50cm by 50cm tiles. "Each tile comprises an LED board with 288 light emitting diodes (LEDs)," states Dr. Matthias Bues, head of department at the IAO. "The board is mounted on the ceiling. A diffuser film in matt white is attached approximately 30cm beneath the LEDs and ensures that the individual points of light are not perceived as such. This diffuser film creates homogenous lighting that illuminates the room throughout." The researchers use a combination of red, blue, green and white LEDs in order to produce the full light spectrum. This combination makes it possible to generate more than 16 million hues. What's more, the white LEDs are more energy efficient than the colored lights, which keeps the energy costs to a minimum.

The main focus in developing the virtual sky was to simulate natural lighting conditions on a cloudy day. To achieve this goal, the researchers carefully examined natural light to find out how – and how quickly – the light spectrum changes when clouds move across the sky. "The LEDs allow us to simulate these dynamic changes in lighting in a way that is not directly obvious to the naked eye. Otherwise the lighting might distract people from their work. But it does need to fluctuate enough to promote concentration and heighten alertness," says Bues. The results of a preliminary study indicate that users find this dynamic lighting to be extremely pleasant. The study involved ten volunteers who carried out their daily work over the course of four days under these lighting conditions with a lighting surface of 30cm by 60cm. Throughout the first day, the lighting remained static. On the second day, it fluctuated gently, and on the third day the fluctuations were rapid. On the fourth day, the participants could choose which type of lighting they wanted, and 80 percent opted for the fast, dynamic lighting.

A prototype of this virtual sky has now been developed that contains a total of 34,560 LEDs spanning an area of 34 square meters. At full power, the "sky" lights up with an intensity of more than 3,000 lux, but 500 to 1,000 lux is sufficient to create a comfortable level of lighting.

From March 6 -10, 2012 at the CeBIT trade fair in Hannover, the researchers will be exhibiting a 2.8m by 2.8m virtual sky at the joint Fraunhofer booth in Hall 9, Booth E 08. Initial inquiries regarding the new lighting have already come in, mainly for use in conference rooms. The virtual sky currently costs approximately 1,000 euros per square meter, but this price will come down, since the more units are produced, the more cost-effective each luminous ceiling will be.



The dynamic luminous ceiling gives office staff the pleasant feeling that they are working under the open sky. (© Fraunhofer IAO)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Industrial Engineering IAO
Nobelstr. 12 l 70569 Stuttgart, Germany l www.iao.fraunhofer.de
Contact: Dr.-Ing. Matthias Bues l Phone +49 711 970-2232 l matthias.bues@iao.fraunhofer.de
Press: Dipl. rer. com. Claudia Garád l Phone +49 711 970-2124 l presse@iao.fraunhofer.de

Fraunhofer

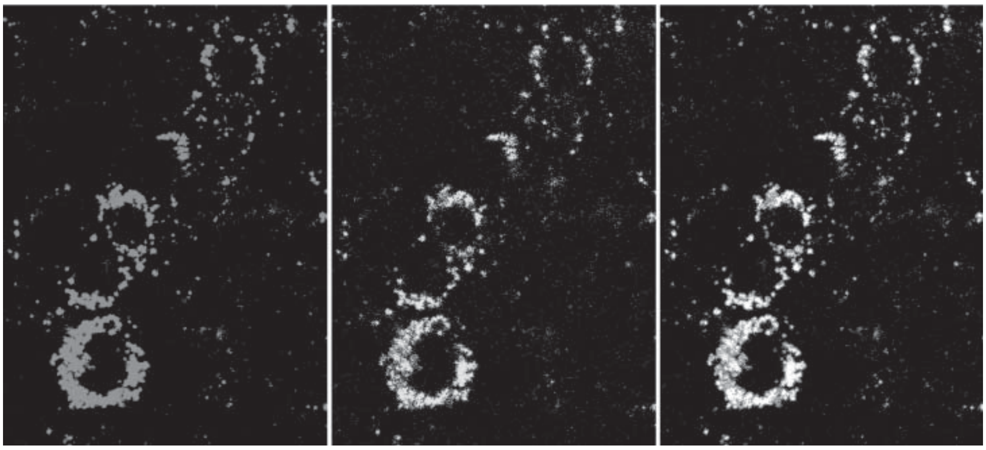
Fewer animal experiments thanks to nanosensors

Countless mice, rats and rabbits die every year in the name of science – and the situation is getting worse. While German laboratories used some 2.41 million animals for scientific research in 2005, by 2009 this number had grown to 2.79 million. One third were destined for fundamental biology research, and the majority were used for researching diseases and developing medical compounds and devices. People demand medicines that are safe and therapies that are tolerable, but hardly anyone is happy to accept the need for animal testing. This is why scientists have spent years looking for methods that can replace them. Now researchers at the Fraunhofer Research Institution for Modular Solid State Technologies EMFT in Munich have found an alternative: they hope to use novel nanosensors to reduce the number of experiments that are carried out on animals. "We're basically using a test tube to study the effects of chemicals and their potential risks. What we do is take living cells, which were isolated from human and animal tissue and grown in cell cultures, and expose them to the substance under investigation," explains Dr. Jennifer Schmidt of the EMFT. If a given concentration of the substance is poisonous to the cell, it will die. This change in "well-being" can be rendered visible by the sensor nanoparticles developed by Dr. Schmidt and her team.

Cells – the tiniest living things – that are healthy store energy in the form of adenosine triphosphate (ATP). High levels of ATP are indicative of high levels of metabolic activity in cells. If a cell is severely damaged, it becomes less active, storing less energy and consequently producing less ATP. "Our nanosensors allow us to detect adenosine triphosphate and determine the state of health of cells. This makes it possible to assess the cell-damaging effects of medical compounds or chemicals," says Schmidt.

In order for the nanoparticles to register the ATP, researchers give them two fluorescent dyes: a green indicator dye that is sensitive to ATP, and a red reference dye that does not change color. Next, the scientists introduce the particles to living cells and observe them under a fluorescence microscope. The degree to which the particles light up depends on the quantity of ATP present. The more yellow is visible in the overlay image, the more active are the cells. If their health were impaired, the overlay image would appear much redder. "We could in future use cancer cells to test the effectiveness of newly developed chemotherapy agents. If the nanosensors detect a low concentration of ATP in the cells, we'll know that the new treatment is either inhibiting tumor cell growth or even killing them," says Schmidt. "The most promising agents could then be studied further."

The EMFT researchers' nanoparticles are extremely well suited to the task at hand: they are not poisonous to cells, they can easily pass through cell membranes, and they can even be directed to particular points where the effect of the test substance is of most interest. But before this procedure can be applied, it must first be approved by the regulatory authorities – so the EMFT experts have a long journey ahead of them to gain approvals from various official bodies. This prospect has not, however, stopped the researchers from refining the technology and coming up with new applications for it – for instance to test the quality of packaged meat and its fitness for consumption. To this end they have developed nanosensors that can determine concentrations of oxygen and toxic amines.



The yellow nanosensor signal in the overlay image (right) shows that the cells are active. If they were unhealthy, they would appear much redder. Center: the indicator dye signal. Left: the reference dye signal. (© Fraunhofer EMFT)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Research Institution for Modular Solid State Technologies EMFT
Hansastr. 27c l 80686 München, Germany l www.emft.fraunhofer.de
Contact: PD Dr. Gerhard Mohr l Phone +49 941 943-5726 l gerhard.mohr@emft.fraunhofer.de
Press: Pirjo Larima-Bellinghoven l Phone +49 89 54759-542 l pirjo.larima-Bellinghoven@emft.fraunhofer.de

Fraunhofer

Time recording up one's sleeve

Handling tools, assembling , inserting, joining and bolting parts, painting components, operating equipment – innumerable procedures must be executed before a product can be packaged and shipped. How much time do employees need for individual procedures? How long does manual assembly take? Industrial manufacturers have to analyze and optimize their employees' operations continually in order to remain competitive. They must record the times of operations if they wish to analyze the individual procedures. This enables them to identify long handling distances, impractically located components, overly frequent tool changes or irregular and superfluous movements, which waste time and make production processes inefficient.

Until now, every individual movement has usually been timed by someone with a stopwatch or with digital time boards manned by employees. This approach is not really objective, however. It is replete with errors and disadvantageous for everyone involved: The stress factor for employees is extremely high and they might not execute their jobs at their usual speed. For companies, this requires quite a lot of work from staff and thus incurs high costs. There is therefore great need for more precise, automated and cost effective solutions. Contracted by the engineering firm DR. GRUENDLER® in Magdeburg, researchers at the Fraunhofer Institute for Factory Operation and Automation IFF have developed such a system.

Three matchbox-sized sensors integrated in a sleeve record hand and arm movements precisely and measure the start and end of individual actions, e.g. reaching, grasping, setting up, joining, checking or releasing. The interlinked sensor modules are positioned on the upper and lower arm and the hand. Employees merely have to put on the two sleeves. They are snug like a second skin yet comfortable and do not impede the wearer. "The present stopwatch method only allows a process organizer to time five individuals simultaneously, depending on the situation. Our solution makes it possible to record time simultaneously, even at several workplaces, without requiring additional labor. The system's greater precision and objectivity is crucial," says Martin Woitag, research manager at the Fraunhofer IFF. Woitag and his team relied on inertial sensors for their solution. They measure the acceleration and angular velocities of arms and hands in the X, Y and Z axes. Unlike other motion tracking systems, such as GPS, the inertial measurement system functions without any other infrastructure. The inertial sensors independently detect objects' positions in space. "What is more, our solution doesn't require complex calibration. A tool that teaches in the measuring points directly at the assembly workplace one time is all that is needed," according to

Woitag. A PC application completes the system. The software calculates and reconstructs the motion sequences based on the sensor data. It breaks processes down into motion segments and ascertains the related times.

At present, the sleeves can be used for assembly jobs at sitting workplaces in logistics and manufacturing. In the next stage, the researchers in Magdeburg intend to configure the system to also analyze assembly operations during which workers stand or move around. They additionally plan to use the sensors to detect posture and thus analyze workplace ergonomics.

Inertial sensors are small and lightweight. Employees wear them in specially made, breathable sleeves that do not impede their movements. (© Lintje GbR)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Factory Operation and Automation IFF
Sandtorstr. 22 l 39106 Magdeburg, Germany l www.iff.fraunhofer.de
Contact: Dipl.-Wirt.-Ing. Martin Woitag l Phone +49 391 4090-231 l martin.woitag@iff.fraunhofer.de
Press: René Maresch l Phone ++49 391 4090-446 l rene.maresch@iff.fraunhofer.de

Simulating firefighting operations on a PC

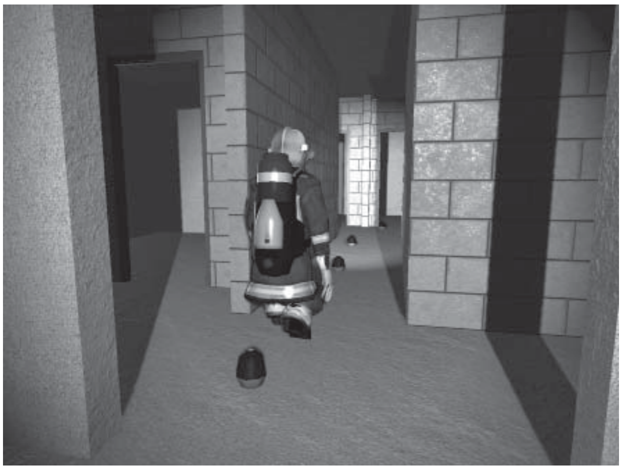
It takes the highest levels of concentration for emergency workers to fight their way through smoke-filled buildings wearing breathing apparatus and protective suits. What is the location of the casualties? Where is the nearest exit, in case the crews need to get to safety? Up to now, they have used ropes to retrace their steps, but these can get caught up or wrap themselves around obstacles. Chalk is used to mark which rooms have already been searched, but these markings are often difficult to see through the smoke. What is needed are new technologies such as sensor-based systems to support the emergency crews during operations where visibility is limited. But such systems, too, carry their own risks: having too much information to hand might confuse crews and be a hindrance. That is why researchers at the Fraunhofer Institute for Applied Information Technology FIT in Sankt Agustin have now developed a set of special simulation methods and tools. These will allow emergency services to test technologies in a realistic environment while they are still in the development phase, so they can tailor them to their specific requirements long before they are needed in earnest. It also gives crews the chance to get used to unfamiliar sources of information while on safe ground. The FireSim method kit is made up of four simulation modules.

The first comprises a role-playing board game which emergency workers can use to play out operations. Players move around on a map of the emergency scene, and the new technologies are represented by special tokens. This allows crews to try out new ideas with a minimum of effort.

The second module is like a computer game. Various firefighters each sit at a PC, and on the screen they see the emergency scene from a first-person perspective. The players move through virtual space, opening doors and rescuing the injured, and trying out virtual prototypes of novel support systems – such as sensor nodes that mark out the paths that have already been followed and which rooms have been searched. "These simulations allow us to make rapid changes to prototypes and put them to the test in complex deployment scenarios. Since we want to take the whole hierarchy into account, we recreate all communication and coordination processes in the simulation as far as we can," says FIT project manager Markus Valle-Klann.

The third simulation module blends the virtual and the real, with emergency crews playing out a scenario in a real environment, for instance to rescue someone from a smoke-filled building. They carry with them a system that is integrated into their suit, such as a display in their helmet or on their arm, and provides details of their location and bearings. Meanwhile, a virtual simulation runs in parallel, with helpers reenacting all the emergency workers' real actions. New technologies such as the sensor nodes are simulated and the results sent by radio to the firefighters' displays. In this way, systems of which no physical prototype has yet been built can already be tested in a real environment.

But to evaluate new technologies in a major fire event involving many emergency workers and bystanders, these methods will not suffice, so the researchers have developed a further module. "We take the behavior of individuals as our starting point. How does a firefighter behave, and how about members of the public? We convert these into behavioral models – or agents – and then a computer calculates how a major emergency operation will play out, taking these behavioral models into account," explains Valle-Klann. Emergency workers can validate the results by taking part in these simulations. Some of them direct an avatar on a PC, while others move around in the real fire scene. The FIT researchers will be presenting the modular methods kit at the CeBIT trade fair in Hannover from March 6 -10, 2012 (Hall 9, Booth E 08).



Firefighters can simulate realistic emergency operations on the computer and test new technology in safety. (© Fraunhofer FIT)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Applied Information Technology FIT
Schloss Birlinghoven | 53757 Sankt Augustin, Germany | www.fit.fraunhofer.de
Contact: Markus Valle-Klann | Phone +49 2241 14-2152 | markus.klann@fit.fraunhofer.de
Press: Alex Deeg | Phone +49 2241 14-2208 | alexander.deeg@fit.fraunhofer.de

Fraunhofer

High-speed CMOS sensors provide better images

Research News
01-2012 I Topic 5

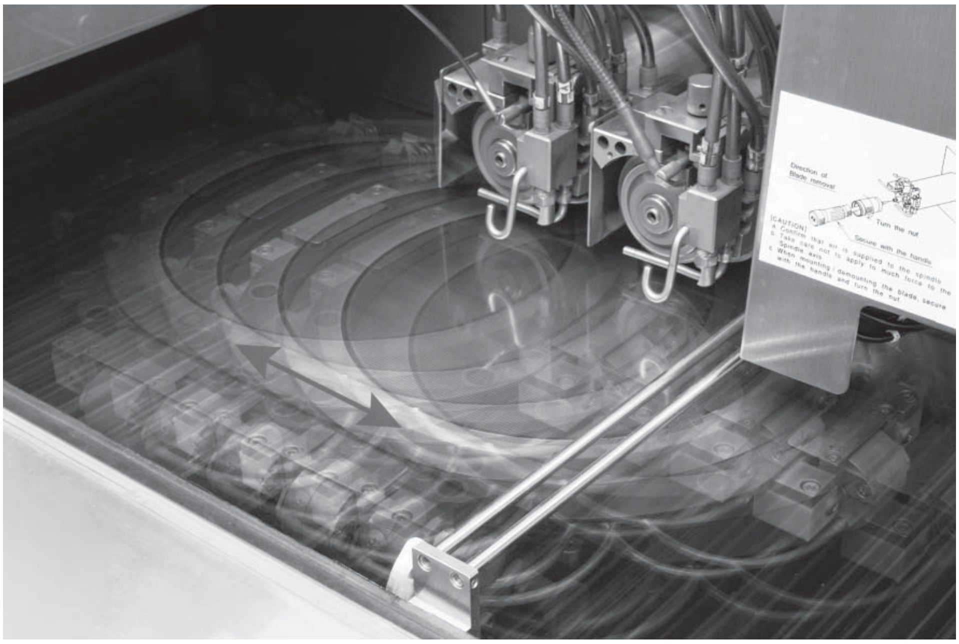
CMOS image sensors have long since been the solution of choice for digital photography. They are much cheaper to produce than existing sensors, and they are also superior in terms of power consumption and handling. Consequently, leading manufacturers of cell-phone and digital cameras fit CMOS chips in their products almost without exception. This not only reduces the demands made of the battery, it also makes increasingly smaller cameras possible.

Yet these optical semiconductor chips are now reaching their limits: while miniaturization in consumer electronics is leading to increasingly smaller pixels around 1 micrometer across, certain applications require larger pixels in excess of 10 micrometers. Particularly in areas where only minimal light is available, such as in X-ray photography or in astronomy, having a larger pixel area compensates for the lack of light. Pinned photodiodes (PPD) are used to convert the light signals into electrical pulses. These optoelectric components are crucial for image processing and are built into the CMOS chips. "Yet when the pixels exceed a certain size, the PPDs have a speed problem", explains Werner Brockherde, head of department at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS. Low-light applications tend to call for high image rates. "But the readout speed using PPD is too low", says Brockherde.

The Fraunhofer researchers have now come up with a solution to this problem – it is unique and has already been patented. The scientists have developed a new optoelectronic component, the lateral drift field photodetector (LDPD). "In this component, the charge carriers generated by the incident light move at high speed to the readout node," explains the researcher. With the PPD the electrons simply diffuse to the exit; a comparatively slow process but which is sufficient for many applications. "But by integrating an internal electric field into the photoactive region of the component, we have managed to accelerate this process by a factor of up to a hundred."

To produce the new component, the Fraunhofer researchers improved upon the currently available CMOS chip manufacturing process based on the 0.35 µm standard: "The additional LDPD component must not be allowed to impair the properties of the other components," says Brockherde. Using simulation calculations the experts managed to meet these requirements – and a prototype of the new high-speed CMOS image sensors is already available. "We expect to get approval for series production next year," says Brockherde.

The high-speed CMOS sensors are ideal candidates for applications that require large pixels and a high readout speed: astronomy, spectroscopy or state-of-the-art X-ray photography are among the potential applications. But the sensors are also ideally suited for use as 3-D sensors based on the time-of-flight process, whereby light sources emit short pulses that are reflected by the objects. The time-of-flight of the reflected light is then recorded by a sensor and used to create a fully-fledged 3-D image. This technology is a compelling proposition for applications such as crash protection, as the sensors can precisely record their environment in three dimensions. The Fraunhofer researchers have already developed this kind of area sensor based on the unique pixel configuration for TriDiCam GmbH.



High-speed CMOS sensors are used here to control production machinery. (© Fraunhofer IMS)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Microelectronic Circuits and Systems IMS

Finkenstraße 61 | 47057 Duisburg, Germany | www.ims.fraunhofer.de

Contact: Werner Brockherde | Phone +49 203 3783-230 | werner.brockherde@ims.fraunhofer.de

Press: Martin van Ackeren | Phone +49 203 3783-130 | martin.van.ackeren@ims.fraunhofer.de

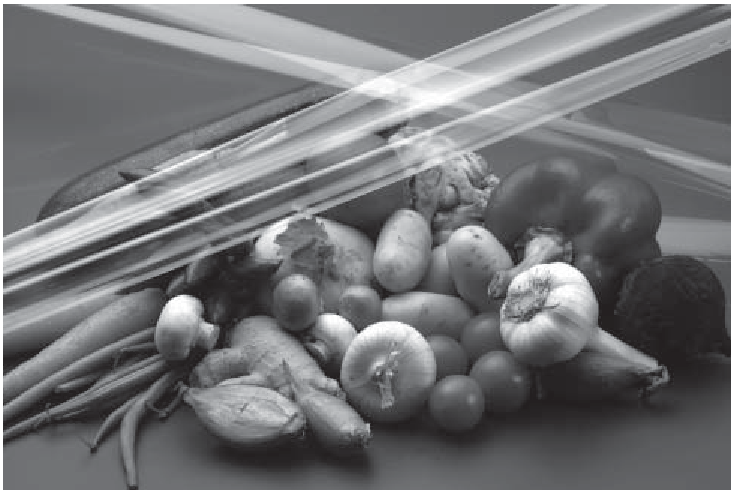
Fraunhofer

Film coatings made from whey

From pre-packed Camembert to shrink-wrapped meat loaf – choosing the right packaging is a key issue in the food industry. Companies need to protect food products from oxygen, moisture and chemical and biological contamination while keeping them fresh for as long as possible. Transparent multilayer films, in which each layer offers specific benefits, are frequently used to protect food from contamination. To minimize the amount of oxygen that penetrates the packaging, companies typically use expensive, petrochemical-based polymers such as ethylene vinyl alcohol (EVOH) copolymers as barrier materials. The German Society for Packaging Market Research (Gesellschaft für Verpackungsmarktforschung mbH) estimates that more than 640 square kilometers of composite materials employing EVOH as an oxygen barrier layer will be produced and used in Germany in 2014 – enough to completely cover Lake Constance. There is therefore a strong impetus to develop a sustainable packaging material which is both economical to produce and environmentally friendly. Researchers working on the EU's "Wheylayer" project have been using whey protein instead of petrochemical-based polymers. The natural ingredients in the whey extend the shelf life of food products, and the whey protein layer is biodegradable. The results of the research are promising. "We've managed to develop a whey protein formulation that can be used as the raw material for a film barrier layer. And we have also developed an economically viable process which can be used to produce the multifunctional films on an industrial scale," says Markus Schmid from the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising.

But how is it even possible to make a barrier layer from whey? The researchers from the IVV began by purifying sweet whey and sour whey and producing high purity whey protein isolates. They tested a range of different modification methods in order to obtain suitable proteins with outstanding film-forming properties. To enable these proteins to withstand the mechanical loads involved, they were subsequently mixed with differing concentrations of various softeners and other additives, which were also biobased. "All these additives are approved substances," says Schmid. The search for the perfect formula was a tricky process for the Freising-based researchers. For example, use too many softeners and the barrier effect against water vapor and oxygen decreases, which means that the food is no longer adequately protected. In the end, the researchers not only found the optimum formula, but also came up with a suitable, economically viable and industrial-scale method of applying whey protein coatings to plastic films and combining these with other films using different technologies. The overall process produces multilayer structures with barrier functions which can be used to produce flexible, transparent food packaging materials. "Our work at the IVV to manufacture a multilayer film of this kind using a roll-to-roll method is a world's first," Schmid notes. Companies that choose to make the switch to whey proteins in the future will only need to make minor modifications to their plants. The researchers have already applied for a patent on their new technology.

The IVV researchers are so convinced of whey proteins' future potential as an alternative packaging material that they have initiated their own project which goes one step further. According to a survey carried out by the German Society for Packaging Market Research, there is not only an increasing demand for composite films, but also an increasing need for thermoformable composites. Growing demand for prepared products in trays is expected to increase the volume of these composites from 76,497 tons in 2009 to 93,158 tons in 2014. The researchers are working hard to replace EVOH in thermoform composites with a barrier layer based on whey protein. This additional application for whey protein would likewise conserve resources and reduce the emission of carbon dioxide into the atmosphere.



Films coated with whey protein improve the barrier effect and sustainability of packaging. (© Fraunhofer IVV)

Picture in color and printing quality: www.fraunhofer.de/press

Fraunhofer Institute for Process Engineering and Packaging IVV
Giggenhauser Straße 35 | 85354 Freising, Germany | www.ivv.fraunhofer.de
Contact: Dr. Klaus Noller | Phone +49 8161 491-500 | klaus.noller@ivv.fraunhofer.de
Press: Karin Agulla | Phone +49 8161 491-120 | karin.agulla@ivv.fraunhofer.de