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RESEARCH NEWS

05 | 2012 ||

1 Mini-projector for smartphones

Their very small displays sometimes make smartphones difficult to operate. In the future, a projector will help: if the cell phone is standing on a table, for instance, it can project a large-format display onto the table surface. The user will have the option of operating the smartphone via the projection function or from the display screen itself.

2 Optimal planning of solar power plants

The photovoltaics industry is booming, and the market for solar farms is growing quickly all over the world. Yet, the task of planning PV power plants to make them as efficient as possible is far from trivial. Fraunhofer researchers, working with Siemens Energy Photovoltaics, have developed software that simplifies conceptual design.

3 Flying 3D eye-bots

They can be deployed as additional surveillance resources during major events, or as high-resolution 3D street imaging systems. Intelligent swarms of aerial drones are a universally useful tool for police, crisis managers and urban planners. Special 3D sensors developed by Fraunhofer researchers ensure flawless aerobatics and prevent collisions.

4 Hip implant for long-term use

Hip replacement is one of the most frequent operations carried out in Germany. Each year, doctors implant some 200,000 artificial hip joints. Often the artificial hips need to be replaced just ten years later. In the future, a new implant currently being developed using high technology materials could help prevent premature revision surgeries.

5 Analyzing energy potential

Sensors, radio transmitters and GPS modules all feature low power consumption. All it takes is a few milliwatts to run them. Energy from the environment – from sources such as light or vibrations – may be enough to meet these requirements. A new measurement device can determine whether or not the energy potential is high enough.

6 Rapid testing of food quality

Whether fruit, meat or cheese – the quality of food is not always as consumers would like it to be. But, in future, a spectrometer will allow them to gage the quality of food before they buy it. No bigger than a sugar cube, the device is inexpensive to manufacture and could one day even be installed in smartphones.

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 20,000, who work with an annual research budget totaling 1,8 billion euros. Roughly two thirds of this sum is generated through contract research on behalf of industry and publicly funded research projects. Branches in the USA and Asia serve to promote international cooperation.

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Mini-projector for smartphones

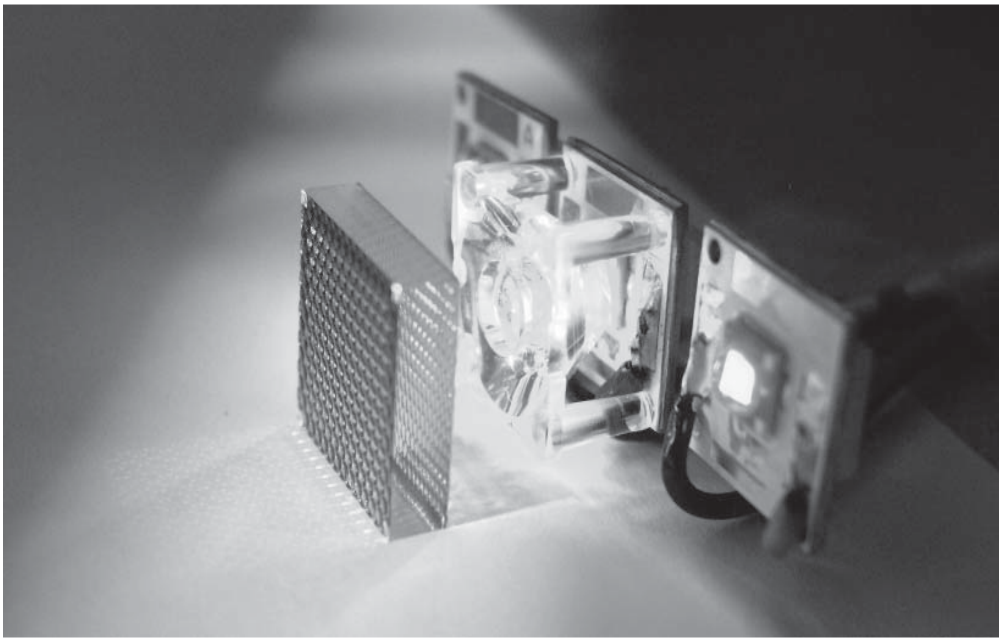
RESEARCH NEWS
05 | 2012 || Topic 1

It's convenient to be able to show people vacation snapshots on a smartphone. But picture details are often hard to make out – the display is simply too small. A new LED projector could help: You position the smartphone in a small cradle on a coffee table, for instance, and it projects the image onto the table top: crisp, bright and DIN A4 size. If a user wants to zoom in on a portion of the picture, they can swipe the projection with their finger the same way they would swipe a display screen – the projected image can be controlled using the same principle as the display itself.

Modeled after compound eyes in insects

The special thing about the LED projector: the entire image displayed, such as a vacation snapshot, is crisp and clear – even if projected at a very flat angle with the beams striking the table surface at a diagonal. Usually, this would distort the picture and make it blurry in places. The researchers who developed the projector at the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena were able to solve this problem, though: "Our projector consists of hundreds of tiny microprojectors in an array, each of which generates a complete image," explains Marcel Sieler, a scientist at IOF. "This technology, known as ‚array projection,' is modeled on nature – on the compound eye found in some insects – and with it for the first time we can create very thin and bright LED projection systems with tremendous imaging properties." In the simplest case of vertical projection onto a level surface, each of these tiny projectors casts the same image onto the viewing surface. Hundreds of individual images overlap to create a sharp and bright overall picture. But if the device is positioned at an angle to the "screen," each little projector shines a slightly different image. Just how these individual images will have to look in order to create a sharp overall picture is a function of the angle at which the image is projected, and of the geometry of the "screen" itself. This is because each projector in the array has a slightly different perspective of the overall scene. The large depth of focus of the micro lenses enables these key features: even free-form screen geometries such as curved surfaces can be used. The experts refer to this as the projector's "tailored focus" capability. Each of the individual images is computed using software the researchers have developed: the position sensor and the smartphone's camera could deliver the geometric information, which the software uses to perform its calculations and compute the individual images along with their focus setting.

The optics were manufactured on wafers containing around 300 chips, each in turn housing 200 lenses for the microprojectors. "The manufacturing process is suitable for mass production, and that makes the devices economical to make," Sieler points out. The sensors that tell the smartphone whether and how the user has used the projection as a control field are already state-of-the-art technology: "The image is overlaid with infrared lines invisible to the user. If the user's finger breaks one of these lines with a swipe motion, for instance, the sensor registers this and advances to the next image," Sieler explains. It will still be another three or four years before the projectors appear on the market: the new projection technology requires a high pixel density on the part of the digital imaging system. The researchers will premiere their prototype of the new LED projector at the Optatec trade fair being held May 22-25 in Frankfurt; the prototype is suitable for initial use on static images. The device itself measures just 2 x 2 cm in size (Hall 3, Booth D50 + D51).



The LED projector consists of an array of hundreds of tiny microprojectors.
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Optimal planning of solar power plants

RESEARCH NEWS
05 | 2012 || Topic 2

The share of renewable energies in the overall energy mix is rising rapidly worldwide. With three-figure growth rates, photovoltaics (PV) play a major role. According to market research organizations, the PV market grew by 139 percent in the year 2010. Germany is among the world's leaders in this technology that uses solar cells to convert sunlight straight into electrical energy. Yet the task of planning large-scale PV power plants spanning several square kilometers is a complex one. With customer specifications, regulations and government subsidy programs to consider, designers must also account for numerous other factors including weather, climate, topography and location. These factors, in turn, influence the selection and placement of the individual components which include the PV arrays with their solar modules, inverters and wiring, not to mention access roads. Until now, engineers have designed solar power plants using CAD programs, with every layout and every variation painstakingly generated separately. This is a very time-consuming approach. To improve a planned power plant in terms of certain criteria, or to compare different concepts with one another, oftentimes the entire planning process has to be repeated.

Several hundred plant designs at the push of a button

In the future, this approach will be improved considerably: researchers at the Fraunhofer Institute for Industrial Mathematics ITWM in Kaiserslautern, in collaboration with Siemens Energy Photovoltaics, have developed a new planning software that makes it possible to build solar power plants better and more quickly. "Our algorithms programmed exclusively for the Siemens PVplanet (PV Plant Engineering Toolbox) software provide engineers with several hundred different plant designs in a single operation. It takes less than a minute of computation time," ITWM researcher Dr. Ingmar Schüle points out. The only user inputs are parameters such as the topography of the construction site and the module and inverter types that will be used. The user can also change a number of parameters – such as the orientation, spacing and inclination of the solar arrays – to study the impact on the quality of the planning result.

Cost estimates and income calculations included

To evaluate the designed PV power plants, an income calculation is performed that includes a simulation of the weather in the region in question, the course of the sun throughout the year and the physical module performance including shading effects. With the results of this computation and an estimate of the investment and operating costs, the planning tool can come up with a figure for the LCOE (levelized cost of energy). By comparing the plant with a large number of similar configurations, the planners can investigate the sensitivity of the various parameters to find the right solution from a large array of options. "The software assists the expert with decision-making and helps with the design of the best possible PV power plant for the site involved. Which one is 'best' depends on a number of aspects – from the customer's objectives to the site and environmental conditions, but also on the financing concept and the financial incentives for photovoltaics in the target region. All of these criteria are taken into account." Schüle points out. Dr. Martin Bischoff, project manager at Siemens AG, Energy Sector, is also convinced of this approach: "Aside savings, more than anything else the planning tool provides an overview of the scope for optimization. This provides the best possible support for planning the most cost-efficient systems. There has been no other planning software with this scope or level of detail until now." Interested individuals can get an impression of the successful teamwork between ITWM and Siemens Energy Photovoltaics at the Intersolar Europe trade fair in Munich, June 13-15, 2012: the software celebrates its public premiere at the Siemens booth in Hall B4, Booth B4.380.

In the future, large PV plants such as the Siemens solar farm that went into operation in 2011 in Les Mées, France, can be planned quickly and efficiently using the PVplanet software solution. (© Siemens AG) | Picture in color and printing quality: www.fraunhofer.de/press

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Flying 3D eye-bots

RESEARCH NEWS
05 | 2012 || Topic 3

Like a well-rehearsed formation team, a flock of flying robots rises slowly into the air with a loud buzzing noise. A good two dozen in number, they perform an intricate dance in the sky above the seething hordes of soccer fans. Rowdy hooligans have stormed the field and set off flares. Fights are breaking out all over, smoke is hindering visibility, and chaos is the order of the day. Only the swarm of flying drones can maintain an overview of the situation. These unmanned aerial vehicles (UAVs) are a kind of mini-helicopter, with a wingspan of around two meters. They have a propeller on each of their two variable-geometry side wings, which lends them rapid and precise maneuverability. In operation over the playing field, their cameras and sensors capture urgently-needed images and data, and transmit them to the control center. Where are the most seriously injured people? What's the best way to separate the rival gangs? The information provided by the drones allows the head of operations to make important decisions more quickly, while the robots form up to go about their business above the arena autonomously – and without ever colliding with each other, or with any other obstacles.

A CMOS sensor developed by researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg lies at the heart of the anti-collision technology. "The sensor can measure three-dimensional distances very efficiently," says Werner Brockherde, head of the development department. Just as in a black and white camera, every pixel on the sensor is given a gray value. "But on top of that," he explains, "each pixel is also assigned a distance value." This enables the drones to accurately determine their position in relation to other objects around them.

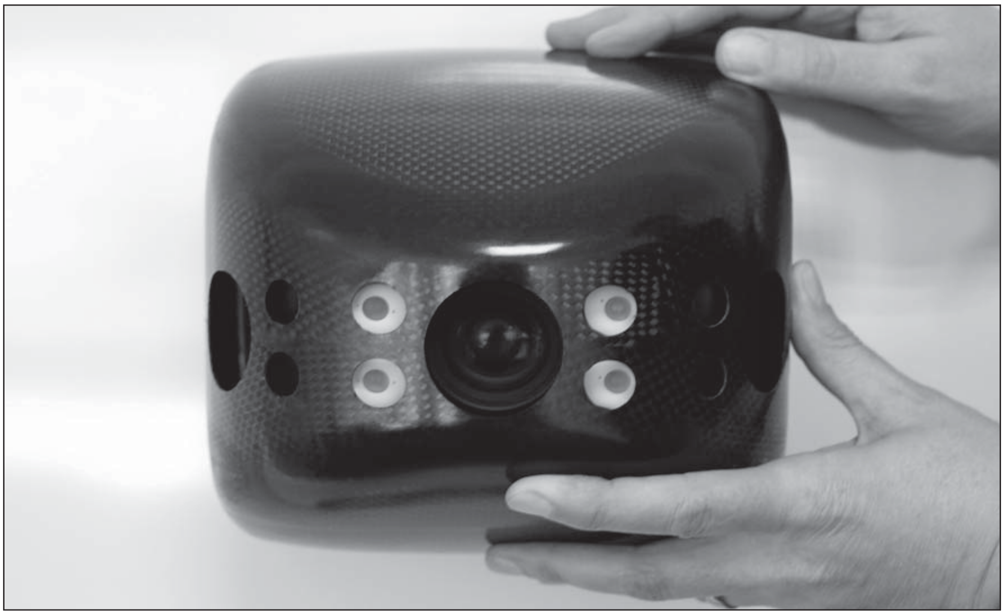
Sensor has a higher resolution than radar

The distance sensor developed by the IMS offers significant advantages over radar, which measures distances using reflected echoes. "The sensor has a much higher local resolution," says Brockherde. "Given the near-field operating conditions, radar images would be far too coarse." The flying robots are capable of identifying even small objects measuring 20 by 15 centimeters at ranges of up to 7.5 meters. Moreover, this distance information is then transmitted at the very impressive rate of 12 images per second.

Even when there is interfering light, for example when a drone is flying directly into the sun, the sensor will deliver accurate images. It operates according to the time-of-flight (TOF) process, whereby light sources emit short pulses that are reflected by objects and bounced back to the sensor. In order to prevent over-bright ambient light from masking the signal, the electronic shutter only opens for a few nanoseconds. In addition, the sensor also takes differential measurements, in which the first image is captured using ambient light only, a second is taken using the light pulse as well, and the difference between the two determines the required output signal. "All of this happens in real time," adds Brockherde.

The 3D distance sensors are built into cameras manufactured by TriDiCam, a spin-off company of Fraunhofer IMS. Jochen Noell, TriDiCam's managing director, admits: "This research project has presented us with new challenges as regards ambient operating conditions and the safety of the sensor technology." The work falls under the AVIGLE project, one of the winners of the 'Hightech.NRW' cutting-edge technology competition which receives funding from both the Land of North Rhine-Westphalia and the EU. The IMS engineers will be presenting their sensor technology at the Fraunhofer CMOS Imaging Workshop in Duisburg on June 12 and 13 this year.

Conducting intelligent aerial surveillance of major events is not the only intended use for flying robots. They could also be of benefit to disaster relief workers, and likewise to urban planners, who could utilize them to produce detailed 3D models of streets or to inspect roofs in order to establish their suitability for solar installations. Whether deployed to create virtual maps of difficult-to-access areas, to monitor construction sites or to measure contamination at nuclear power plants, these mini UAVs could potentially be used in a wide range of applications, obviating the need for expensive aerial photography and/or satellite imaging.



The 3D camera in the flying robot can identify small objects measuring 20 by 15 centimeters from seven meters away. (© Fraunhofer IMS) | Picture in color and printing quality: www.fraunhofer.de/press

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Hip implant for long-term use

Thanks to artificial hips, people with irreparable damage to the joint have been able to lead active, pain-free lives for the past 50 years. Still, some hip replacements do not function completely as intended, and metal-on-metal implants in particular, demand accurate positioning in surgery and implants positioned non optimally are often susceptible to premature failure notably in small female patients. Physicians are even calling for a prohibition on the use of artificial joints made of cobalt-chromium alloys in which the joint's metal ball rubs against its metal socket whenever the wearer walks. Poorly designed or positioned metal on metal implants can lead to higher wear rates and this releases elevated cobalt-chromium ion levels that spread out through the blood and lymph, potentially damaging organs and triggering inflammation. Metal ions are also suspected carcinogens. Because these hip replacements are so robust, however, to date they have often been implanted in young, active patients.

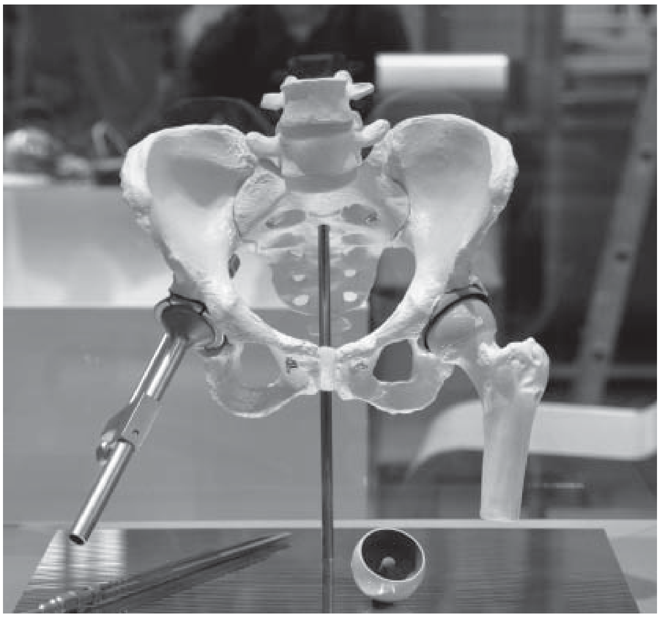
A metal-free composite

Researchers at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, partnering in an international team on an EC-funded project entitled "ENDURE" (Enhanced Durability Resurfacing Endoprosthesis), have now developed a new kind of hip implant that, unlike the conventional counterpart implants on the market today, provide a metal-free solution and bone-like elasticity. This is the result of a metal-free, high-tech composite: The hip socket is made of carbon fibre-reinforced PEEK – a high-strength, wear resistant, biocompatible polymer composite. For the femoral head, ceramic was used. In addition to this, a hydroxylapatite coating at the interface to the bone helps ensure that the bone tissue will fuse thoroughly with the surface structure of the implant. "The cobalt-chromium implants in use to date are very rigid, and the load transfer to the bone is non-optimal leading to potential adverse bone adaptation. Thanks to the new combination of materials, the transmission of force through the PEEK hip socket to the pelvic bone is modeled on natural conditions. And there are no metal ions released," notes IPA engineer Jasmin Hipp. The researcher and her team were able to confirm the good wear resistance in initial tests of the new hip replacement using a robot that simulated various series of movements such as walking or climbing and descending stairs. The experiments used a prototype of the implant.

Tiny pins protect bone tissue

The ENDURE implants follow the bone-preserving principle of hip resurfacing: they are thin-walled shells which replace the bearing surface of the joint articulation alone, instead of employing large metal stems for support, which require a substantial volume of bone to be removed. Researchers have also redesigned the way the prosthesis is mechanically attached to the bone. Without cement, and using a press-fit and an integral scaffold-type structure on the surfaces of the implant that contact the bone, the hemispherical ball and socket are tapped onto the prepared femoral head and into the acetabulum – the natural, concave surface of the pelvis – and anchored in place.

A team of physicians at the University of Newcastle have demonstrated in operations performed on cadavers, the new hip can be set in place and, if necessary, removed without any difficulties. Meanwhile, the preclinical studies have been completed, and final development work is being planned to allow clinical studies to commence. Partners in the EU-funded project are Aurora Medical, Medicoat, Hunt Developments, Ala Ortho, CeramTec, Invibio, Biomatech and the Universities of Gothenburg and Southampton.



The ceramic femoral head fits perfectly into the PEEK hip socket. (© Fraunhofer IPA) | Picture in color and printing quality: www. fraunhofer.de/press

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Analyzing energy potential

RESEARCH NEWS
05 | 2012 || Topic 5

The freight train races through the landscape at high speed, the train cars clattering along the tracks. The cars are rudely shaken, back and forth. The rougher the tracks, the more severe the shaking. This vibration delivers enough energy to charge small electronic equipment: this is how the sensors that monitor temperatures in refrigerator cars, or GPS receivers, can receive the current they need to run.

Vibration replaces batteries

Experts refer to this underlying technology as "energy harvesting", where energy is derived from everyday sources such as temperature or pressure differences, air currents, mechanical movements or vibrations. But is this really enough to supply electronic microsystems? The answer is provided by a data logger that is also installed on board, a product by the Fraunhofer Institute for Integrated Circuits. This compact system analyzes and characterizes the potential of usable energy – in this case, the oscillations created during the ride. It measures key parameters of the source of the vibrations, such as the amplitude and the frequency spectrum of acceleration. "We can use the data collected to design vibration converters, such as the piezoelectric generators, to feed the sensors, radio transmission receivers, tracking systems and other low-power-consuming devices with enough energy to power them," explains the IIS group manager and engineer, Dr. Peter Spies. "The tracking systems in use to date run on just a battery. These batteries need constant replacement, but that involves a lot of effort and expense. Thanks to energy harvesting, we can replace the batteries and wiring." Logistics processes are not the only candidates, however. The energy "harvested" can be used for a great many other applications as well – to charge heart-rate monitors, sensors in washing machines and production plants, or measurement systems in cars to measure the air pressure in tires.

The elements of the data logger include an acceleration sensor, a GPS module, a micro-controller, an SD card and a WiFi interface. The sensor measures the freight train's acceleration along three axes. At the same time, the GPS module determines the vehicle's position and stores the data along with the acceleration values on the SD card. These parameters can be used to pinpoint the train's speed and the amount of energy available to it. "That way, we can fine-tune the energy converter and tailor it to the application involved," the researcher adds.

The data logger is already in use in freight cars, trucks and machinery. Spies and his team are currently working to develop a complete tracking system that includes not only a GSM module and a GPS receiver but also a vibration converter that turns mechanical energy into electrical energy. The researchers are showcasing a prototype of the IIS data logger at the Sensor+Test 2012 trade fair, May 22-24 in Nuremberg, in Hall 12, Booth 202.

Researchers attaching a data logger to a shipping container. (© Fraunhofer IIS) | Picture in color and printing quality: www.fraunhofer.de/press

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Rapid testing of food quality

RESEARCH NEWS
05 | 2012 || Topic 6

Is that pear ripe? Or will you be annoyed when you get home and discover that the one you bought is neither sweet nor juicy? And what about that meat? Does it contain too much water, which will make it turn tough when you cook it? Buying the right food is often a question of sheer luck for consumers. But all that is set to change. In future, all you will need to do is hold your smartphone near the product in question, activate the corresponding app, choose the food type from the menu – e.g. "pear" – and straight away the device will make a recommendation: the fructose content of the pear is high, so buy it! The application is based on a near infrared spectrometer which measures the amount of water, sugar, starch, fat and protein present in the products. The system "looks" several centimeters below the outer surface of the foodstuffs – which means it can detect, for instance, whether the core of an apple is already rotting. Thin packaging film is no problem for the device as it takes measurements straight through it.

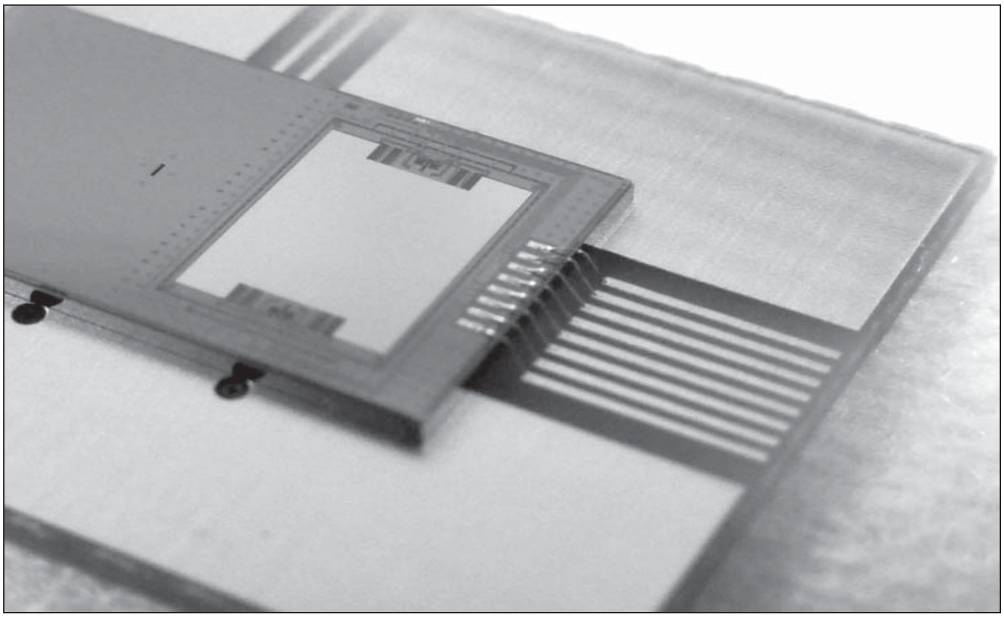
But how does the device actually work? By shining a broad-bandwidth light on the item to be tested – for instance a piece of meat. Depending on the meat's composition, it will reflect different wavelengths of light in the near infrared range with different intensities. The resulting spectrum tells scientists what amounts of which substances are present in the foodstuff.

Smaller than a sugar cube

The novel thing about this spectrometer is its size. With a volume of only 2.1 cc, it is 30 percent smaller than a sugar cube, and thus substantially more compact than its commercially available counterparts, which are around 350 times larger. Another advantage is that the devices are inexpensive to make and suitable for mass production. "We expect spectrometers to develop in the same way that digital cameras did," says Dr. Heinrich Grüger, who manages the relevant business unit at the Fraunhofer Institute for Photonic Microsystems IPMS in Dresden, where the system is being developed. "A camera that cost 500 euros ten years ago is far less capable than the ones you get virtually for free today in your cell phone."

Spectrometers are usually manufactured by assembling individual components: The mirrors, optical gaps, grating and detector each have to be put in place individually and properly aligned. The IMPS researchers instead manufacture the individual gratings and optical gaps directly on silicon wafers. But that's not all: The thin silicon wafers are large enough to hold the components of several hundred spectrometers, which means that hundreds of near infrared systems can be produced in one go. The scientists stack the wafers containing the integrated components on top of the ones bearing the optical components. They then align and bind the wafers, and isolate them to form individual spectrometers. This means the researchers do not need to position each component, but only the respective composite substrates. Another advantage of what is called Micro Electro Mechanical Systems (MEMS) technology is that the devices produced are much more robust than their handmade counterparts.

At the Sensor+Test tradeshow being held in Nuremberg from May 22 to 24, the IPMS research scientists will be exhibiting a prototype of the spectrometer (in Hall 12, Booth 202). The device could be ready for market launch in three to five years. The researchers are also working on creating a corresponding infrastructure. "We are developing intelligent algorithms that analyze the recorded spectrums immediately, compare them with the requirements and then advise the consumer whether or not to buy the item. This advice is based solely on quality features such as ripeness and water content. The system cannot carry out a microbiological or toxicological analysis." Potential application areas for the spectrometers are not limited to foodstuffs: The device can also detect forgeries, for example, and can verify whether a product is made of high-quality original materials or whether it is a cheap fake. It can also reveal whether parts of a vehicle's body have been repainted, as well as test the contents of drugs and cosmetic creams.



Complete with integrated diffraction grating, grating drive, position detector and optical gaps, the spectrometer is much more compact than those currently available in the market.
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