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## **1 Bone-hard biomaterial**

Screws used in surgical operations are often made of titanium. They usually have to be removed after a while or replaced by new ones. A new biomaterial makes this unnecessary. It promotes bone growth and is biodegradable.

## **2 Pressure sensors on alert**

Vacuum panels are particularly good for insulating buildings – as long as the vacuum does not leak. A tiny pressure sensor constantly checks the condition of the vacuum and indicates whether the insulation effect is still present.

## **3 Microbe detective seeks out germs**

Microorganisms are everywhere and most of them are harmless, but they can do a lot of damage in the manufacture of pharmaceuticals or in tissue transplants. With the aid of a new device, germs can be detected in artificial cartilage within a few hours.

## **4 City tours by mouse click**

Cities have to come up with creative ideas to attract investors. Specially developed software provides support and sends interested companies on a virtual tour of an industrial park. Residents can use the tool to explore their city as well.

## **5 A mini-laboratory for all cases**

Many illnesses can be reliably diagnosed through laboratory tests, but these in vitro analyses often use up valuable time. A system developed by Fraunhofer research scientists, which can carry out complex analyses on the spot, will soon be ready for the market.

## **6 Printable sensors**

In future every home will have one: electronic devices that you can control just by pointing a finger. To turn this vision into reality the 3Plast research consortium is developing special sensors that can be printed onto plastic film and affixed to objects.

## **7 Analytical eye: viewing through the data jungle**

Unmanageable volumes of data accumulate in our digitized working world. Scientists are developing analytical techniques that make use of our ability to identify complex data relationships by means of pictorial images.



© Fraunhofer IFAM

Surgeons use interferential screws to fasten cruciate ligaments in the knee. From the left: made of polylactic acid, hydroxylapatite and medical stainless steel.

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## **Bone-hard biomaterial**

Football players, skiers, tennis players – they all fear a crucial ligament rupture. If the knee ligaments are damaged the patient usually has to undergo a surgery to restore the stability of the joint. In the surgical procedure the torn ligament is replaced by a piece of tendon from the leg, which is fixed to the bone by means of an interferential screw. The problem is that the screws are made of titanium. After a certain time the patient has to undergo a further surgery so that the material can be removed.

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Researchers at the Fraunhofer Institute for Manufacturing Engineering and Applied Materials Research (IFAM) in Bremen want to spare cruciate ligament victims and other bone patients this additional procedure. They have therefore developed a screw which is biocompatible and also biodegradable over time. »We have modified biomaterials in such a way that they can be formed into robust bioactive and resorbable screws by means of a special injection molding process,« explains Dr. Philipp Imgrund, head of the biomaterial technology department at IFAM. »Depending on the composition they biodegrade in 24 months.« Biodegradable screws made of polylactic acid are already used in the medical field, but they have the disadvantage that when they degrade they can leave holes in the bone. The IFAM researchers have therefore improved the material and developed a moldable composite made of polylactic acid and hydroxylapatite, a ceramic which is the main constituent of the bone mineral. »This composite possesses a higher proportion of hydroxylapatite and promotes the growth of bone into the implant,« says Imgrund.

The engineers at IFAM have developed a granulate from the biomaterials which can be precision-processed using conventional injection molding methods, obviating the need for any post-processing such as milling. The complex geometry is achieved in a net-shape process, producing a robust screw. The properties of this prototype come very close to those of real bone. Its compressive strength is more than 130 newtons per square millimeter, whereas real bone can withstand between 130 and 180. What's more, the injection molding process has a positive side effect. Normally, the powder injection molded part has to be compressed at very high temperatures of up to 1400° Celsius. »We only need 140 degrees for our composite materials,« says Imgrund. In future the engineers intend to develop other bioimplants using their energy-saving process.



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A pressure sensor inside the vacuum insulation panel constantly checks whether the vacuum is still present.

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## Pressure sensors on alert

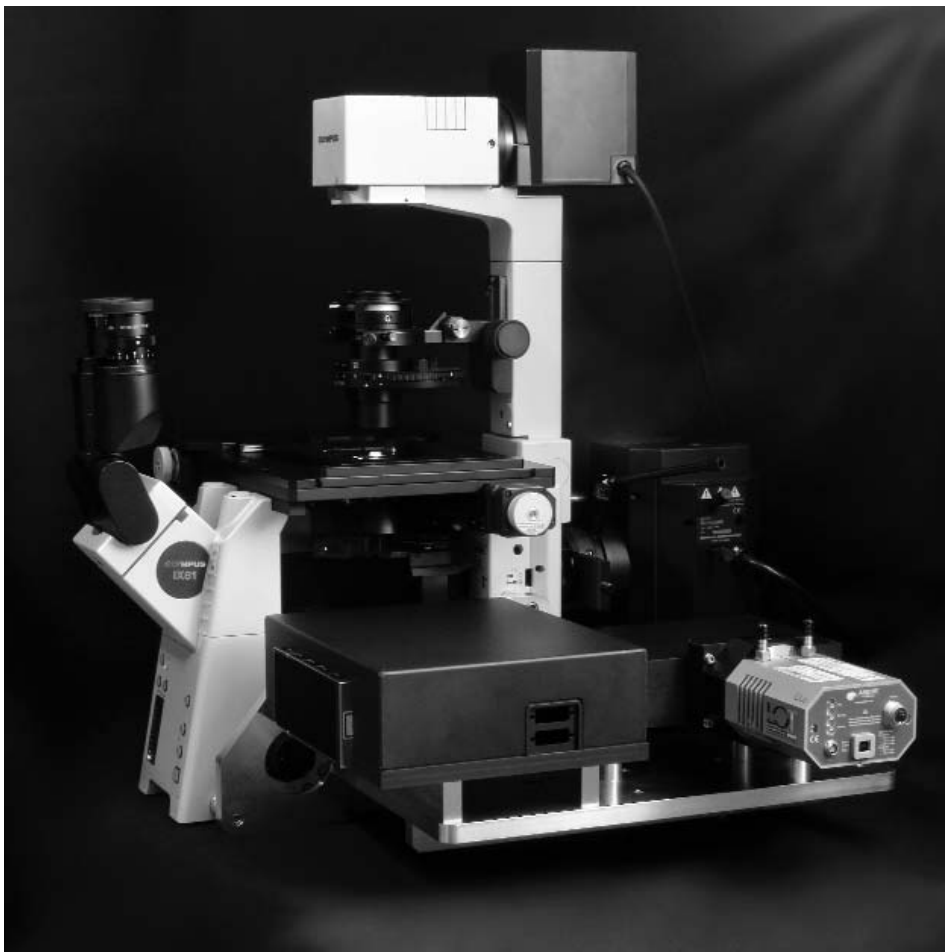
Mrs Miller is happy. Since she moved to the new apartment building she has not had any nasty surprises on her heating bills. This is because the building is insulated with a new material which exhibits particularly low thermal conductivity and therefore high energy efficiency. Vacuum insulation panels consist of a tightly sealed shell and porous core material made of silicic acid. This serves to support the vacuum in the insulation panel. Because a vacuum is a very good thermal insulator, the insulation value of the vacuum panels is five to ten times higher than that of conventional panels, for instance those made of polystyrene.

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The panels are sensitive, however. Over the years the airtight film loses its insulating effect and the vacuum leaks. Experts put the increase in gas pressure at 1 millibar per year. Another problem is that because the film is very thin it can be damaged during transport. Before being installed the panels therefore have to be checked to see whether the vacuum and insulating effect are still present. So that the condition of the panels can be determined at any time, research scientists at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg have developed a tiny pressure sensor. »The pressure sensor is placed in a recess inside the panel. On the board next to the microchip there is a transponder with a coil which transmits the measured data through the film without any hard wire connection. A reader on the outer wall of the panel receives the measured data and supplies the transponder with energy using a second coil,« explains Dr. Hoc Khiem Trieu, head of department at the IMS. »The sensor consumes very little energy and is extremely small, measuring only around 20 square millimeters. A further special feature of the tiny sensor is that it draws its energy from the reader's radio signal even through thin metal layers. It is therefore also suitable for measuring the vacuum in refrigerators, where low thermal conductivity is likewise essential.«

The sensor is used in the medical field, for instance to measure blood or eye pressure. It has now been developed further for the construction sector. »The sensor is presently at the prototype stage. The aim is to put it into series production in one to two years' time,« states Trieu. The IMS will be showcasing the sensor at Euro ID, the trade fair for automatic identification, in Cologne from May 4 to 6 (Stand A12).



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The Raman spectrometer makes it possible to detect germs, for example in tissue transplants.

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## **Microbe detective seeks out germs**

We are surrounded by microorganisms. They inhabit our skin, the air we breathe, the surfaces we touch. In most cases this is not a problem, but there are situations in which these constant companions can be dangerous or even life-threatening. They are unwelcome, for example, on medical instruments, in culture fluids or on laboratory-grown tissue transplants such as cartilage. Constant sterility checks are therefore required during the production of artificial cartilage. Conventional testing methods for detecting germs are, however, time-consuming. Specimens have to be taken and then cultivated and reproduced in culture fluid because bacteria and fungi can only be detected in large quantities.

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Research scientists at the Fraunhofer Institute for Physical Measurement Techniques (IPM) in Freiburg, working in collaboration with the Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB) and the Fraunhofer Institute for Biomedical Engineering (IBMT), have succeeded in drastically shortening this process. Within just a few hours the experts can identify contaminations; one single germ is enough. »Using conventional methods it takes up to two weeks to test the purity of specimens, for example autologous tissue grown in a culture medium. The patient is given an implant although the sterility check has not been completed,« explains Carsten Bolwien, project manager at the IPM. »With our automated Raman system we can check specimens immediately before they are implanted. We tested this on artificial knee cartilage. Our device combines a microscope with a Raman spectrometer. The aqueous solution containing the piece of cartilage is first filtered through a micromembrane. Only particles exhibiting a suspicious size are trapped in the tiny holes of the micromembrane, and we examine them spectroscopically. In comparison with the known spectra the Raman spectra enable the particles to be identified and contaminations by bacteria or fungi can be detected.«

A demonstration Raman spectrometer has already been built and can be seen at the Analytica trade show in Munich from March 23 to 26 (Hall A1, Stand 471). Initial blind tests checked by health agencies are scheduled to take place this year. The research scientists will examine artificially infected cartilage cultures and detect the contaminations. If everything goes well, the testing method will be officially approved.



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The residents of Stassfurt can take a virtual tour of their city by mouse click.

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## City tours by mouse click

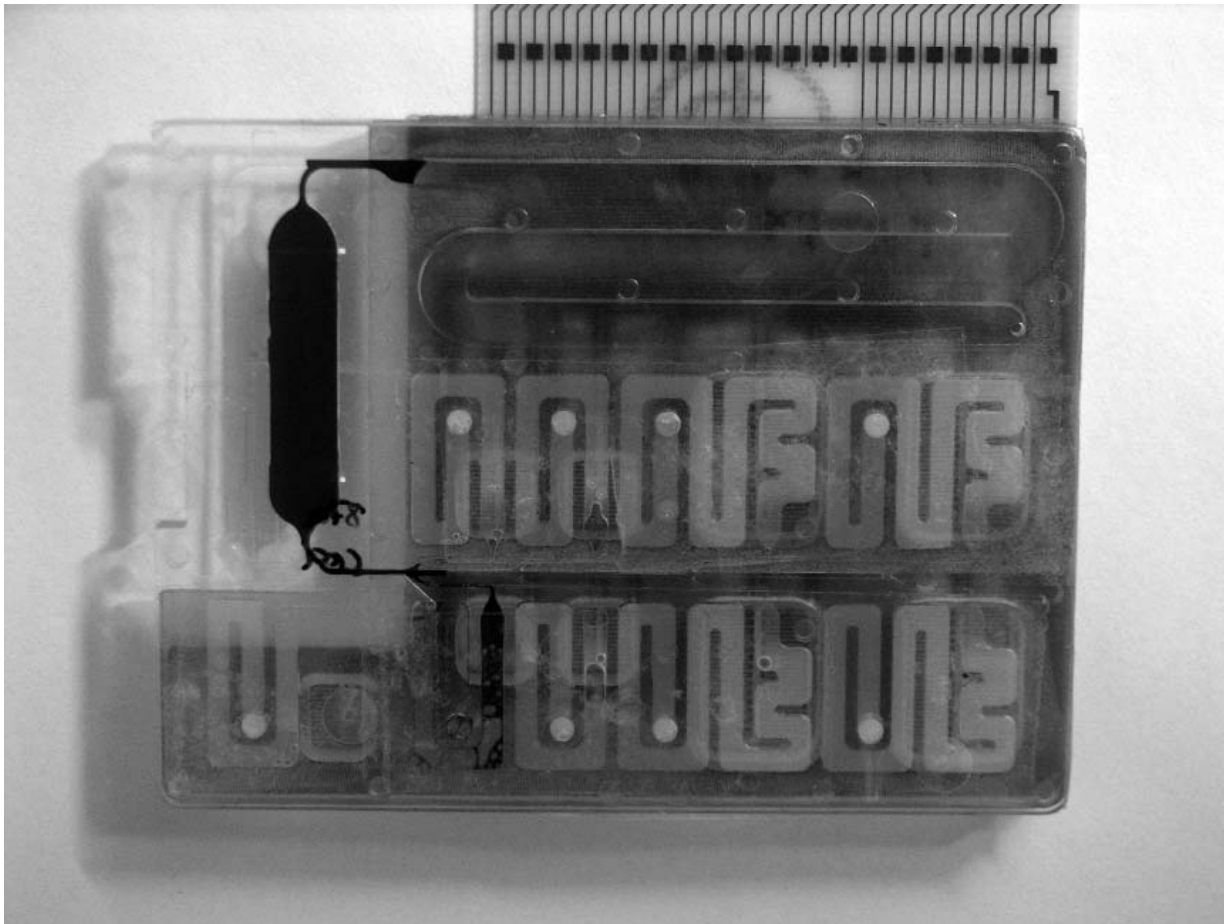
The residents of Stassfurt in Saxony-Anhalt are lucky. They are able to voice opinions about construction plans even before redevelopment commences. This is made possible by software from the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg, which represents open lots, individual buildings, neighborhoods and even complete industrial parks true-to-scale and photorealistically in virtual 3-D projections.

The researchers from the Fraunhofer IFF have created a 3-D scenario specifically for Stassfurt. Mining caused the downtown to sink. A lake with recreational zones was laid out in and around the pit. The bank zone is going to be expanded now and the residents of Stassfurt have already been able to stroll through the new layout virtually. »We created the terrain model based on two-dimensional and additional elevation data from a laser scan. Afterward we combined the lots with digital photographs taken on site and integrated the thusly created 3-D building models in the virtual environment,« explains Andreas Höpfner, a research manager at the Fraunhofer IFF.

Municipalities, cities and districts intend to use the new software for more than urban planning. The program will also be employed for regional marketing to attract potential investors for instance. On a virtual excursion, they may switch locations and their view of the 3-D model – to an industrial park for instance – at any time and interactively retrieve supplementary information on open lots, lot sizes, prices, maximum construction heights, soil quality and distance by mouse click. When necessary, real estate master data is interactively uploaded from a real estate database. Siting factors such as the companies based in the area are important to investors. »Our software can even be used to retrieve background information on local companies, thus enabling investors to find out if potential partners are based at a location. No other virtual reality software can do this in this way,« says Höpfner. The Fraunhofer IFF created a 3-D model of Piesteritz Agro-Chemical Park for Lutherstadt Wittenberg, which can be used as a marketing tool. The city models will be exhibited at the Internationale Handwerksmesse in Munich on March 3 to 9, 2010 and at the International Building Exhibition in Saxony-Anhalt in April.

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With the disposable cartridge, all diagnosis steps take place automatically, from collection of the specimen to data analysis.

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## **A mini-laboratory for all cases**

»We'll just have to wait for the results of the laboratory tests.« These words are familiar to many patients. It then usually takes several days for specimens to be sent to the laboratory and analyzed and for the doctor to receive the results. For many illnesses, however, a speedy diagnosis is crucial if the treatment is to be successful. In future, the patient might only have to sit in the waiting room for a few minutes until the results are ready. In a joint project, researchers from seven Fraunhofer institutes have developed a modular platform for in vitro diagnosis which enables various types of bioanalysis – of blood and saliva for example – to be conducted in the doctor's surgery. »Thanks to its modular design our IVD platform is so flexible that it can be used for all possible bioanalytical tasks,« states Dr. Eva Ehrentreich-Förster from the Fraunhofer Institute for Biomedical Engineering (IBMT) in Potsdam-Golm.

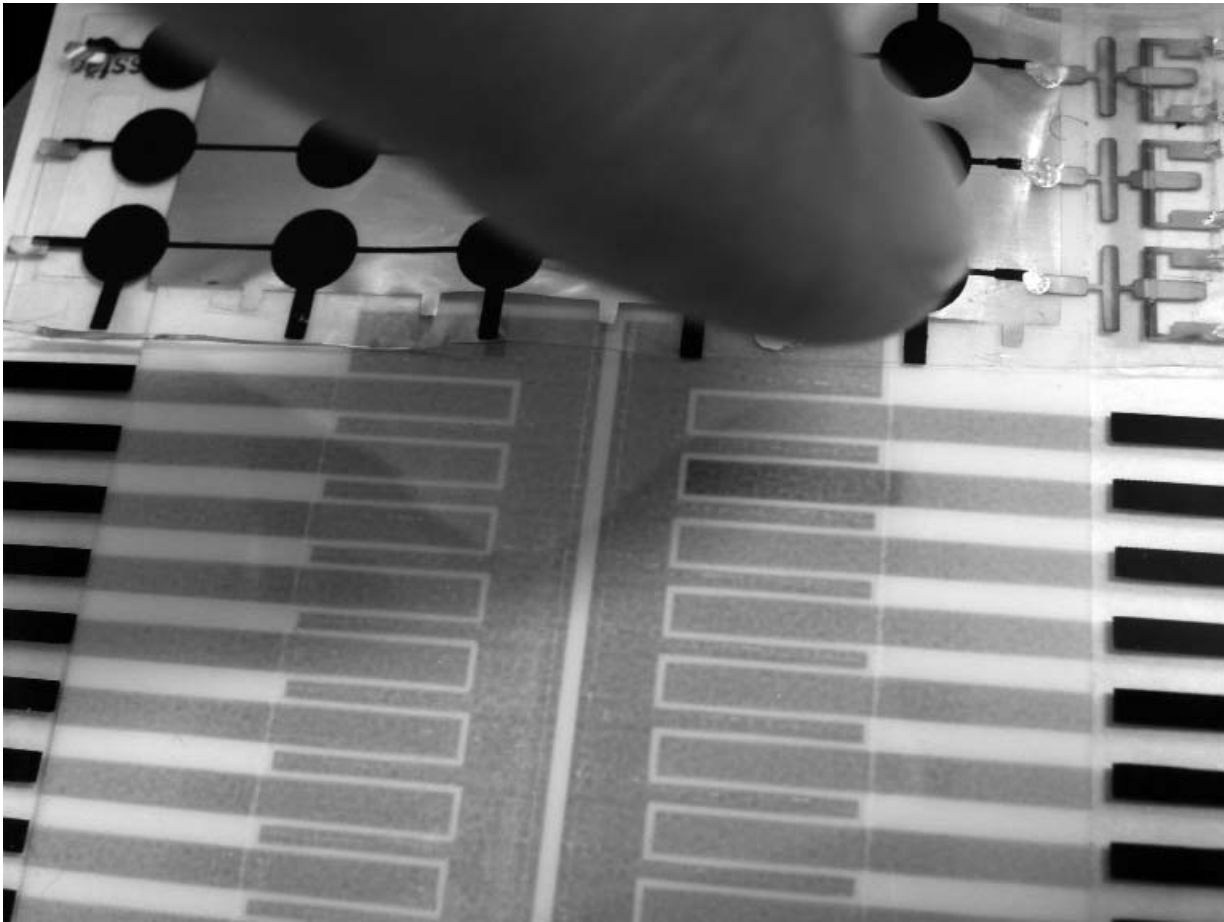
The core element of the mini-laboratory is a disposable cartridge made of plastic which can be fitted with various types of sensor. For an analysis the doctor fills the cartridge with reagents – binding agents which indicate the presence of certain substances such as antigens in the specimen material. Various tests or assays are available for different types of analysis. To perform an assay, the doctor only has to place the relevant substances in the cartridge and the test then takes place automatically. »We have optimized the assays so that up to 500 assay reactions can be conducted in parallel in a single analysis step,« explains Dr. Ehrentreich-Förster. Even in the case of complex analyses the doctor obtains a result within about 30 minutes. A new module on the reverse side of the cartridge also makes it possible to analyze the specimen material at DNA level.

Once the cartridge has been prepared, the doctor places it in the measurement system. The results can be read out with either optical or electrochemical biosensors. The researchers have installed a readout window for both methods in the measurement system, which features a bypass through which the specimen is pumped.

In addition to medical applications, Dr. Ehrentreich-Förster has other markets in her sights. »The IVD platform is also suitable for food analysis and doping checks.« The mini-laboratory will soon be ready for the market. The scientists are presenting the IVD platform at the Analytica trade show in Munich from March 23 to 26.

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The sensor recognizes the finger's heat signal without being touched.

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## Printable sensors

The cellphone is switched off but immediately springs into action at the point of a finger. It is not necessary to touch the display. This touchless control is made possible by a polymer sensor affixed to the cellphone which, like human skin, reacts to the tiniest fluctuations in temperature and differences in pressure and recognizes the finger as it approaches.

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The scenario is fictitious at present but could become reality in a few years time thanks to the efforts of the research scientists involved in the EU project 3Plast, which stands for »Printable pyroelectrical and piezoelectrical large area sensor technology«. The companies and institutes involved from industry and research have set themselves the goal of mass producing pressure and temperature sensors which can be cheaply printed onto plastic film and flexibly affixed to a wide range of everyday objects, such as electronic equipment. The 2.2 million euro funded project is coordinated by the Fraunhofer Institute for Silicate Research ISC in Würzburg. »The sensor consists of pyroelectrical and piezoelectrical polymers which can now be processed in high volumes by screen printing, for example. The sensor is combined with an organic transistor, which strengthens the sensor signal. It's strongest where the finger is,« explains Gerhard Domann, who is in charge of the project. »The special thing about our sensor is that the transistor can also be printed.«

The production of polymer sensors still poses a number of challenges. To produce printable transistors, the insulation materials have to be very thin. The experts at the ISC have, however, succeeded in producing an insulator which is only 100 nanometers thick. The first sensors have already been printed onto film. The research scientists are currently working on optimized transistors which can amplify rapid changes in temperature and pressure.

»By providing everyday objects with information about their environment – for example whether a person is approaching – by means of pressure and temperature sensors, we can create and market new devices that can be controlled just by pointing a finger,« enthuses Domann. The research scientist envisions further applications for the technology in the automotive and construction industries as well as in robotics. »The project comes to an end in January 2011, but we think it will take a few more years before sensors can be printed on large surfaces.«



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Scientists at the Fraunhofer IGD are developing analytical techniques based on our ability to identify complex relationships with the aid of pictorial images.

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## **Analytical eye: viewing through the data jungle**

Every day vast amounts of information flood into business databases. To achieve their corporate objectives, companies try to evaluate information relevant to their activities as effectively as possible. In the day-to-day working environment they use business intelligence programs to collect, evaluate and present data. But many of the current analytical methods can only display information statically, as lists or reports. Visualization techniques help to present the information in a form that can be more easily understood. Dr. Jörn Kohlhammer, head of the department responsible for this project at the Fraunhofer Institute for Computer Graphics Research (IGD) in Darmstadt, explains: »With Visual Analytics we combine analytical methods and visualization techniques. The user and the computer interact closely, but the user is always in the forefront. He or she makes the decisions, not the system.«

Instead of tables of figures, the system can for example display a mosaic of colored surfaces. If columns of figures differ from the customary data, they are shown in a different color or with a different structure, so that they catch the eye immediately. By concentrating on these patterns, users can evaluate the data more accurately. Connections or relationships that could easily be overlooked also become more noticeable. This makes it easier to reach reliable decisions. Kohlhammer: »Visual Analytics has a lot to offer the financial market in particular. Trends and risks in global finance could be identified more quickly.«

The EU is aware of the importance of Visual Analytics for the European economy and has initiated the »VisMaster CA« project. Supervised by the Fraunhofer IGD, 26 European industrial companies and research institutes – including IBM and SAP – are cooperating on new approaches to master the flood of information. The Fraunhofer IGD will be presenting current developments in Visual Analytics in Hall 9, Stand B36 at this year's CeBIT trade fair, to be held from March 2 to 6 in Hanover, Germany.

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- Energy and construction technology, environmental and health research
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