Fraunhofer

Research News

No. 5 – 2009

Fraunhofer Press
Phone: +49 89 1205-1302
presse@zv.fraunhofer.de
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1 Underwater robot with a sense of touch

Maintenance of offshore drilling rigs or underwater cables, taking samples of sediment – underwater robots perform a variety of deep-sea tasks. Research scientists now aim to equip robots with tactile capability so that they can orientate themselves better under the sea.

2 Mini helicopters as disaster helpers

In the aftermath of an earthquake or chemical incident, every minute counts: the rescue team has to quickly gain an overview. Mini helicopters can help in future, investigating collapsed buildings from the inside, singly or as a swarm.

3 Lactate test made easy

The lactate value indicates levels of fitness. At present, athletes have to visit a doctor to have it measured. A new analytical device will make things easier in future: athletes can wear it and check their lactate readings during training.

4 Optimal trip and load planning

How can companies maximize truck capacity utilization and at the same time plan trips so that the burden on the environment and transport costs are reduced? A new software system couples cargo space utilization and trip planning.

5 Non-wovens as scaffolds for artificial tissue

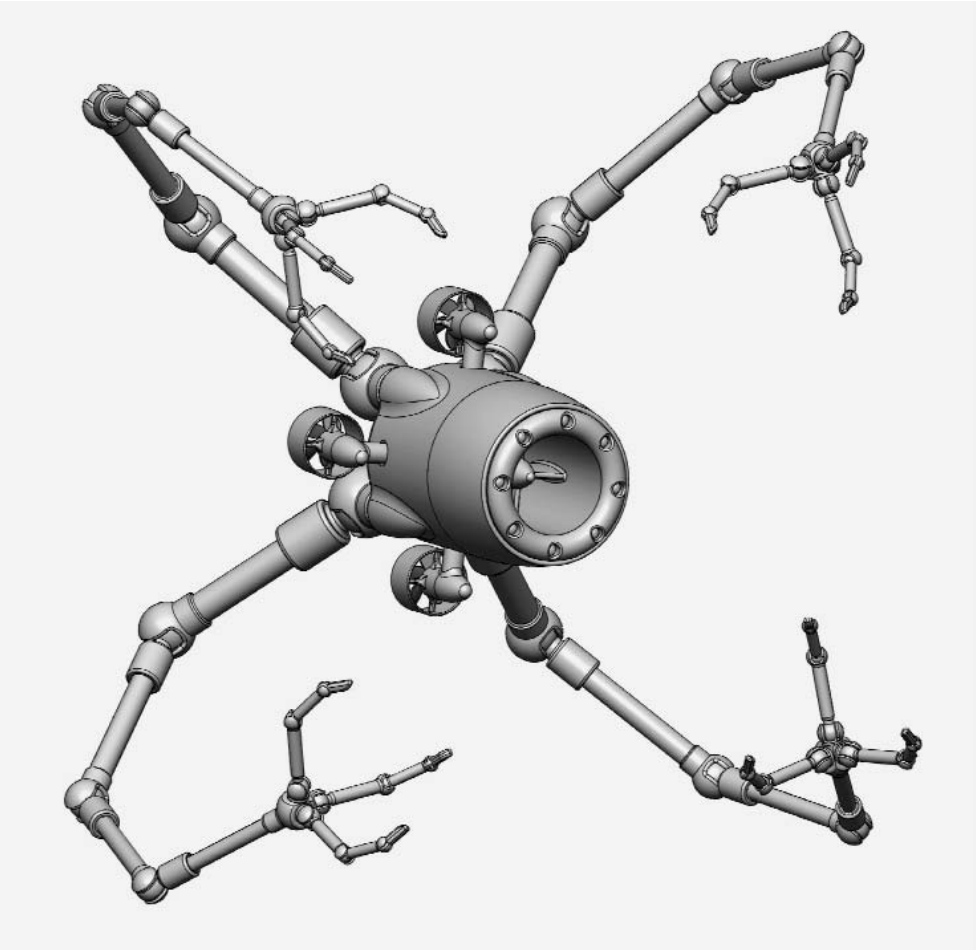
In future, cartilage, tendon and blood vessel tissue will be produced in the laboratory, with cells being grown on a porous frame, such as non-wovens. A new software program helps to characterize and optimize the non-wovens.

6 Seeing invisible resin

When manufacturing chipboards, it is important to correctly distribute the resin on the wood shavings. Researchers are now developing a measuring technique that makes it possible to monitor the application of the resin during production.

7 Planning factories the right way

The new factory hall has just been completed when the owner realizes that several things have gone wrong. The doors should be on the other side and production will need more space. A new planning guideline will prevent such annoying design faults in the future.



The applications are numerous. Underwater robots with tactile capability can maintain offshore drilling rigs or collect sediment samples. The researchers hope that in future the sensor will be able to distinguish between the current and an obstacle.

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Fraunhofer Institute for Manufacturing Technology and Applied Materials Research IFAM
Wiener Strasse 12
28359 Bremen, Germany
Press contact:
Martina Ohle
Phone +49 421 2246-212
Fax +49 421 2246-300
ohle@ifam.fraunhofer.de
www.ifam.fraunhofer.de

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Topic 1

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Underwater robot with a sense of touch

The robot dives into the sea, swims to the submerged cable and carries out the necessary repairs, but the person controlling the robot does not have an easy task. It is pitch dark and the robot's lamp does not help much. What's more, the current keeps pulling the robot away from where it needs to carry out the work.

For further information:
Marcus Maiwald
Phone +49 421 2246-124
marcus.maiwald@ifam.fraunhofer.de

In future, the robot could find its own way. A sensor will endow it with a sense of touch and help it to detect its undersea environment autonomously. "One component in this tactile capability is a strain gauge," says Marcus Maiwald, project manager at the Fraunhofer Institute for Manufacturing Technology and Applied Materials Research IFAM in Bremen. Together with his Fraunhofer colleagues and staff at the German Research Center for Artificial Intelligence DFKI, Bremen Laboratory, he has developed the model of an underwater robot with a sense of touch. "If the robot encounters an obstacle, the strain gauge is distorted and the electrical resistance changes. The special feature of our strain gauge is that it is not glued but printed on – which means we can apply the sensor to curved surfaces of the robot." The single printed strip is just a few ten micrometers wide, i.e. about half the width of a human hair. As a result, the strain gauges can be applied close to each other and the robot can identify precisely where it is touching an obstacle. The sensor is protected from the salt water by encapsulation.

To produce the strain gauges, the research scientists atomize a solution with nanoparticles to create an aerosol. A software system guides the aerosol stream to the right position. Focusing gas shrouds the beam and ensures that it does not fan out. At the Sensor and Test trade show from May 26 to 28 in Nuremberg, the research scientists are presenting an octopus-shaped underwater robot which is fitted with a printed sensor (Hall 12, Stand 12-688).

A research scientist tests a mini helicopter. In future they will be used to provide rescue teams with a speedy overview in the aftermath of a disaster.

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Fraunhofer Institute for Information and Data Processing IITB
Fraunhoferstrasse 1
76131 Karlsruhe, Germany
Press contact:
Sibylle Wirth
Phone +49 721 6091-300
Fax +49 721 6091-413
wirth@iitb.fraunhofer.de
www.iitb.fraunhofer.de

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Research News
Topic 2

No. 5 – 2009

Mini helicopters as disaster helpers

For further information:
Dr.-Ing. Axel Bürkle
Phone +49 721 6091-552
axel.buerkle@iitb.fraunhofer.de

The collapse of the Cologne city archive building triggered a race against time for the rescue workers. After such disasters, detailed information is needed in order to select the appropriate course of action. For example, it is necessary to know if and where people are trapped and if adjacent buildings are in danger of collapse. An unmanned mini helicopter can handle this dangerous reconnaissance work for the emergency services. The "quadrocopter" has a diameter of one meter and, thanks to its maneuverability, can negotiate collapsed buildings. At present the flying disaster helper operates solo, but it could soon be joined by reinforcements: Fraunhofer research scientists are working on their deployment in swarms. Currently this would only be possible with considerable manpower effort – the helicopters cannot communicate with each other and each one would have to be individually controlled.

To ensure that, in future, one person can control all the helicopters deployed, the scientists at the Fraunhofer Institute for Information and Data Processing IITB in Karlsruhe have developed a software which functions as a director of operations. "Our program enables the quadrocopters to coordinate their activities themselves," explains Dr. Axel Bürkle, project manager at the IITB. "One of them can fly up close to victims to investigate their injuries while another reconnoiters the fastest route for getting them out."

The program consists of individual modules, the software agents, which can be programmed with a repertoire of tasks. One software agent is assigned to each quadrocopter. The miniature flying machines are equipped with various sensors such as cameras, infrared cameras, laser measurement equipment and sniffer devices for identifying hazardous substances. They can also radio images, videos and other data to the ground station, where the software agents assess the information and, via an interface, send instructions for action to the quadrocopters. The special factor is that the software agents are able to network with each other independently and exchange information. This means that they can harmonize their commands to the quadrocopters. What's more, software agents are able to learn. They memorize what happened in particular situations and respond more quickly the next time. The development engineers are currently examining the use of the system in simulations of various scenarios. They have further applications in mind, such as monitoring of premises. The first quadrocopter swarms could be ready for service in about a year.

Fitness levels are indicated by the lactate value. At present, athletes have to pedal on a cycle ergometer while a doctor takes blood samples. Things will be easier in future.

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Fraunhofer Institute for Microelectronic Circuits and Systems IMS
Finkenstraße 61
47057 Duisburg, Germany
Press contact:
Martin van Ackeren
Phone +49 203 3783-130
Fax +49 203 3783-266
martin.vanackeren@
ims.fraunhofer.de
www.ims.fraunhofer.de

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Topic 3

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Lactate test made easy

Performance athletes need to know their blood lactate level. It indicates how much lactic acid has collected in their blood as a result of physical exertion and enables conclusions to be drawn about their fitness. Professional athletes therefore regularly have to attend performance diagnosis sessions. As they pedal a cycle ergometer at various levels of exertion, a doctor takes blood samples from an earlobe. A special device then measures the concentration of lactate in the blood.

For further information:
Thomas van den Boom
Phone +49 203 3783-207
thomas.van.den.boom@
ims.fraunhofer.de

Such scenarios will soon be a thing of the past. Using a miniaturized measuring system, performance and leisure athletes will in future be able to monitor their lactate readings themselves – including during training. Normally the analytical devices are quite big and cost several thousand euros. "We have found a way of miniaturizing the measurement system so that it can be accommodated in an ear clip. The results could be radioed by the ear clip to a training wristwatch or a cellphone," says Thomas van den Boom, group manager at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg. An electrochemical method is used to measure the lactate value. In a chemical reaction, an enzyme triggers a redox flow from the lactate which can be measured using electrodes. The measurement system, which could be installed for example in an ear clip, consists of two microchips: the innovative nanopotentiostat fits on a chip measuring just two by three millimeters and costs less than one euro. "The second chip incorporates microelectrodes which we have developed for this purpose and which we can couple with the nanopotentiostat," explains van den Boom. One of the microelectrodes is coated with a thin layer of gel containing the enzyme. There are altogether three microelectrodes on the chip, which are activated by the nanopotentiostat. Two serve the purpose of electrochemical measurement while the third keeps the electrochemical potential constant end thus ensures a stable voltage.

The engineers can coat the electrode with different enzymes so that, apart from lactate measurement, various other analyses can be performed in the blood or other electrolytes. The advantage is that the electrodes are very small and cheap – and the analyses can be carried out in a mobile environment. A first demonstrator of the nanopotentiostat for lactate measurement (without earclip) has already been produced.

The Efficient Load software will optimize cargo space utilization and trip planning at the same time.

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Fraunhofer Institute for Material Flow and Logistics IML
Joseph-von-Fraunhofer-Straße 2-4
44227 Dortmund, Germany
Press contact:
Ralf Neuhaus
Phone +49 231 9743-274
Fax +49 231 9743-215
r.neuhaus@iml.fraunhofer.de
www.iml.fraunhofer.de

Fraunhofer

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Topic 4

No. 5 – 2009

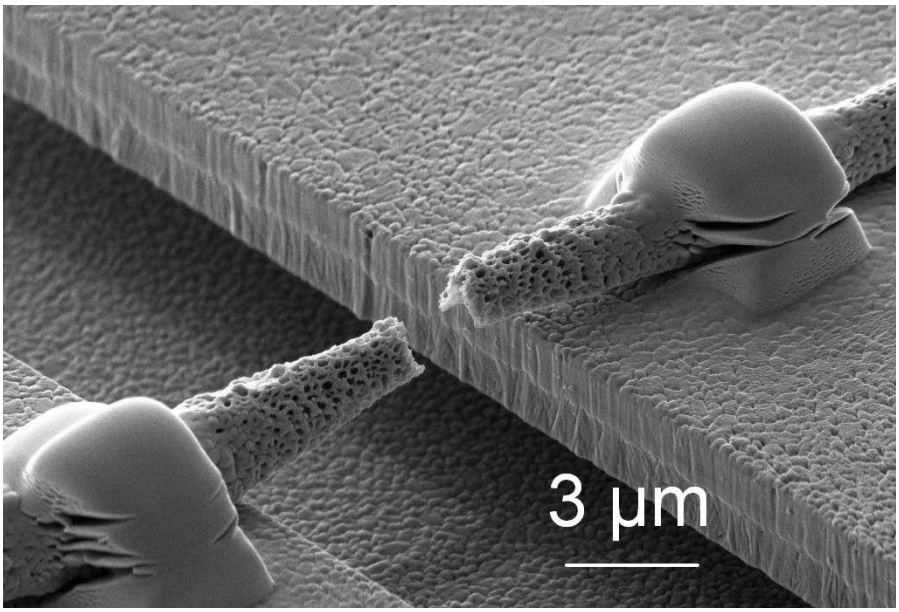
For further information:
Dr.-Ing. Bernhard van Bonn
Phone +49 231 9743-369
bernhard.van.bonn@
iml.fraunhofer.de

Optimal trip and load planning

A company wants to deliver paper to five customers in Bavaria. The trip planning software currently used calculates that one truck will be enough to cover the locations in central Bavaria if another truck on the Baden-Württemberg route takes over two of the deliveries. The problem is that, although the trips have been optimized, the trucks are not fully loaded. "At present, transport companies first compile the orders and then assign them to trips and vehicles. Truck capacity utilization is only optimized afterwards. This often means that optimal route planning is neglected," explains Dr.-Ing. Bernhard van Bonn, Deputy Head of Department at the Fraunhofer Institute for Material Flow and Logistics IML in Dortmund. The aim is to bring this dilemma to an end soon. In the Efficient Load project, logistics experts from the IML are working together with the industrial partners GEFCO and M-Real as well as the Berlin software company PSI on effectively combining cargo space utilization and route planning. This could considerably reduce transport costs in future.

"Although software tools for trip planning and cargo space utilization are used, they are not combined, which means that only one aspect is actually optimized," explains van Bonn. Efficient Load harmonizes capacity utilization and trip planning in a single step – and significantly improves truck use. The software optimizes transshipment, order combination, loading sequence and route planning. Stephan Sirrenberg from project partner M-Real expects the new system to reduce ton-kilometers by 15 to 20 per cent. Every month the paper manufacturer makes around 41,000 deliveries. 16,500 trucks transport around 345,000 tons of paper to customers in more than 100 countries. The effective combination of capacity and route optimization will reduce energy costs, as well as toll charges, considerably.

The research scientists have been developing the software since early 2008 as a twelve-stage concept taking all the important parameters into account. By the end of 2009, GEFCO and M-REAL should have an up-and-running version which can be integrated without difficulty in their trip planning software. At the transport logistik trade show from May 12 to 15 in Munich, the researchers are presenting Efficient Load on the Fraunhofer joint stand in Hall B2, Stand 501/602.



Torn single fiber after a tensile test in the micro-testing machine

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FraunhoferInstitute for Mechanics of Materials IWM
Wöhlerstraße 11
79108 Freiburg, Germany
Press contact:
Thomas Götz
Phone +49 761 5142-153
Fax +49 761 5142-110
thomas.goetz@iwm.fraunhofer.de
www.iwm.fraunhofer.de

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Topic 5

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Non-wovens as scaffolds for artificial tissue

For further information:
Dr. Raimund Jaeger
Phone +49 761 5142-284
Raimund.jaeger@iwm.fraunhofer.de

When someone's knee hurts with every step it's a sign that the cartilage has been so badly damaged that the bones rub together when walking. Medical scientists are developing a technique to produce cartilage tissue artificially so that patients with such knee problems can walk free of pain again. The aim is also to make tendons and blood vessels in the laboratory. The research scientists place cells on a porous scaffold material, for example a non-woven made of polymer fibers. The cells can then grow on this frame and form tissue. Whether the cells will grow properly into tissue, however, depends on many factors. For instance, the cells only form cartilage if they are subjected to loads comparable with those in the body. To form cartilage the tissue needs to experience the pressure applied by every step. By contrast, blood vessel tissue needs the pulsation of the blood. The scientists reproduce these loads in the cell culture. When the artificial cartilage is inserted in the patient's knee the supporting scaffold is gradually resorbed and only the cartilage tissue remains.

While it is quite easy to produce npn-wovens from thin polymer fibers, it is difficult to describe these materials experimentally and theoretically. What forces do the cells experience when the non-woven is pulled or when a liquid passes through the fibre network? How do cells penetrate the non-woven? How do liquids permeate the non-woven? Research scientists at the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg and Halle have developed a simulation model which answers these questions and characterizes the fleeces. "The simulation reproduces the mechanical properties of the fleeces and the transport processes – the software can therefore also calculate how nutrients are transported to the cells and metabolic products are transported away from the cells when a liquid flows by," explains Dr. Raimund Jaeger, group manager at the IWM. "Understanding these processes can be helpful for cell culture." To produce the model, the research scientists initially studied the mechanical properties of the individual polymer fibers and for this purpose developed a special apparatus. On a silicon chip measuring one square centimeter, the scientists in Halle etched approximately 50 "microtesting machines". They then placed and fastened the fibers over the testing machines. Under the microscope the researchers were able to observe how the fibers behave when they are pulled, how far they stretch and when they snap. As fiber-like structures are frequently encountered in nature and technology, suitable experimental techniques and simulation methods have a wide range of applications.

Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut WKI
Bienroder Weg 54 E
38108 Braunschweig, Germany
Press contact:
Simone Peist
Phone +49 531 2155-208
Fax +49 531 2155-200
simone.peist@wki.fraunhofer.de
www.wki.fraunhofer.de

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Research News
Topic 6

No. 5 – 2009

Seeing invisible resin

Particleboards have multiple purposes: they can serve as attic floors, practical wall constructions or packaging material. Designers and interior decorators value their natural look. The boards are increasingly made of wood residues. If flakes of a defined size are used, the resulting boards are known as OSBs – short for "oriented strand boards". The strands are mixed with resin and scattered in several layers to form a mat, which is then fed into a press on an endless conveyor. The boards are produced under immense pressure and at high temperatures.

For further information:
Dipl. Ing. Burkhard Plinke
Phone +49 531 2155-444
burkhard.plinke@wki.fraunhofer.de

Manufacturers of OSB always have to make sure the mixture is right. If they use too little resin, or if the resin is not distributed properly on the strands, the resulting boards are not firm enough. But the special resin is expensive and accounts for roughly one-third of the production costs, so using too much resin is a great waste of money. Researchers at the Fraunhofer Institute for Wood Research WKI and their colleagues at the Reutlingen Research Institute RRI are helping manufacturers to distribute the resin as efficiently as possible. "We use special optics to measure how well the resin is distributed," says WKI project manager Burkhard Plinke. At present, manufacturers use expensive dyes for this. They add the dyes to the glue and then check how it spreads inside the board. However, this method can only be used on random samples, whereas the new technique will enable continuous measurements during production. A line spectrograph, i.e. a camera with special integrated optics, scans the surface of the shavings mat before it enters the press, recording the image of a narrow section across the entire width of the forming line. The optics register the light of the near-infrared range. At these wavelengths, the resin can be distinguished from the wood. "A computer stores the data and analyzes them online before the mat is transported into the press. The data indicate where the strands are glued and where they are not," says Plinke.

Thanks to the new measuring technique, manufacturers of OSB will soon be able to monitor the distribution of the glue online and quickly detect any unevenness. This will help them to save costs and to further optimize their production processes. The researchers will be presenting the measuring principle at the Ligna trade fair in Hanover from May 18 to 22 (Hall 27, Stand J35).

Fraunhofer Institute for Manufacturing Engineering and Automation IPA
Nobelstrasse 12
70569 Stuttgart, Germany
Press contact:
Hubert Grosser, Jörg Walz
Phone +49 711 970-1177
Fax +49 711 970-1400
presse@ipa.fraunhofer.de
www.ipa.fraunhofer.de

Fraunhofer

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Topic 7

No. 5 – 2009

For further information:
Dr. Klaus Erlach
Phone +49 711 970-1293
klaus.erlach@ipa.fraunhofer.de

Planning factories the right way

Anyone planning a factory has to consider its interior layout beforehand. Where will the machines stand? How much space will they require, and how high do the ceilings need to be? Not until these factors have been decided should an architect begin to design the building. In reality, however, factories are often built before proper planning has been conducted. It is often the case that an additional hall is built and only afterwards is thought given to how the new space can best be used. "At this point, it is often discovered that a shorter, wider hall would have been better, for example," says Dr. Klaus Erlach, group manager at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart.

A working group led by Erlach has now laid down a set of guidelines in collaboration with representatives from prominent architectural and factory planning offices and the most important research institutes in the field. The guidelines describe the individual steps involved in planning a factory and facilitate coordination between the architects and the production planners. "This prevents the grid dimensions of the supports from being planned too tightly, for example, so that the machines manufactured in the hall don't have to be dismantled again before being delivered," says Erlach, quoting an example that is best avoided.

"We have presented the objectives and results of the individual tasks and explained the various terms used," says Erlach. This makes it easier to compare the services offered by different planners. The guidelines have been published as a directive of the Association of German Engineers (VDI) under the title "VDI 5200: Factory planning - Planning procedures". They are aimed at anyone planning to build or convert a factory. The same rules apply to extensions of existing factories as to new buildings. It is important to plan everything perfectly from the outset. Existing buildings are taken out of the picture completely, and only the new building is considered. Only then is an assessment made as to how the new production hall can best be integrated into the existing building complex. "If you free yourself of all restrictions, you hit on completely new ideas," explains Erlach. The guidelines are organized into milestones that should be achieved in the course of planning a factory – from setting the objectives of the factory to the phase in which production is up and running as planned. The publication was recently awarded the quality seal of "Guideline of the Month" by the VDI.

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80686 München, Germany

Press Office
Phone: +49 89 1205-1301
Fax: +49 89 1205-7515
presse@zv.fraunhofer.de

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