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Research News

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special issue

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Prize profiles

The annual conference of the Fraunhofer-Gesellschaft will see the presentation of three Joseph von Fraunhofer prizes and three Hugo Geiger prizes. The Technology Prize for 'human-centered technology' is awarded in honor of developments that improve the quality of life.

1 Artificial liver for drug tests

The liver is one of the most important metabolizing organs in humans. Fraunhofer researchers have developed a model of the liver, which is viable outside the body and which is suitable for testing drugs.

2 Explosives prevent technology theft

Product piracy causes billions worth of damage worldwide. A combination of visible and invisible copy protection is really effective against this. Explosive embossing is an economical procedure and can be used for mass-produced goods.

3 Fitting squares into circles

Particle filters are standard in the basic fittings for cars. Construction machines, city buses and garbage trucks must now follow suit. This can be achieved effectively and inexpensively thanks to a new material and design for ceramic filters developed by Fraunhofer researchers.

4 Getting the most out of gemstones

Emeralds, rubies and the likes are referred to as colored gemstones by experts. They sparkle and shine with varying intensity, depending on the cut. A new machine can achieve the best possible cut and extract up to 30 per cent more precious stone from the raw material.

5 Virus filters for medical diagnosis

In biomedicine and biotechnology the smallest, complex, compound sample quantities must be reliably processed. Microsystems with new mechanisms of action for pumping, filtering and separating will manage this task with great efficiency in the future.

6 Effective solar cells and sensitive bioanalysis

A new simulation program optimizes the structure and configuration of the metallic contact fingers in concentrator solar cells, thereby improving the efficiency factor, and a highly-sensitive method of producing cDNA fragments from biological sample material has been developed.

Prize profiles

Technology Prize – human-centered technology
This prize is offered by former executive board members and institute directors of the Fraunhofer-Gesellschaft and their associated external sponsors. It is awarded biennially – alternating with the Stifterverband Science Prize – to members of staff whose research and development work has made a significant contribution to the quality of life, enabling people to remain fit and active in their daily lives up to an advanced age. Endowed with 10,000 euros, the prize will be awarded on June 23 on the occasion of the Fraunhofer-Gesellschaft annual conference in Munich.

Joseph von Fraunhofer Prize – research with a practical orientation
This prize has been awarded by the Fraunhofer-Gesellschaft every year since 1978, in recognition of outstanding scientific work by members of its staff leading to the solution of application-oriented problems. Over 200 researchers have meanwhile seen their work honored in this way. This year, three prizes will be awarded – each valued at 20,000 euros. An additional coveted trophy is the silver lapel pin bearing the effigy of the man for whom the award is named (seen here in the logo accompanying topics 2, 3 und 4).

Hugo Geiger Prize – promoting talented young scientists
The Bavarian government instituted this prize in 1999 to mark the 50th anniversary of the Fraunhofer-Gesellschaft. It is named for former Bavarian secretary of state Hugo Geiger – patron of the inaugural assembly of the Fraunhofer-Gesellschaft on March 26 1949. The Hugo Geiger Prize is awarded for outstanding, application-oriented doctoral theses or dissertations – up to now only in the life sciences. From this year on, prizes will also be awarded for papers that cover other research areas of the Fraunhofer-Gesellschaft. The prizewinning papers are selected on the basis of scientific quality, industrial or economic relevance, novelty and an interdisciplinary approach. The work must be directly related to a Fraunhofer Institute or have been written at one. This year, the first-placed winner (see topic 5) will receive 5000 euros in prize money, the second winner 3000 euros and the third 2000 euros (see topic 6).

Dr. Johanna Schanz und Prof. Heike Mertsching (f.l.t.r.).

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Research News
Topic 1

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Artificial liver for drug tests

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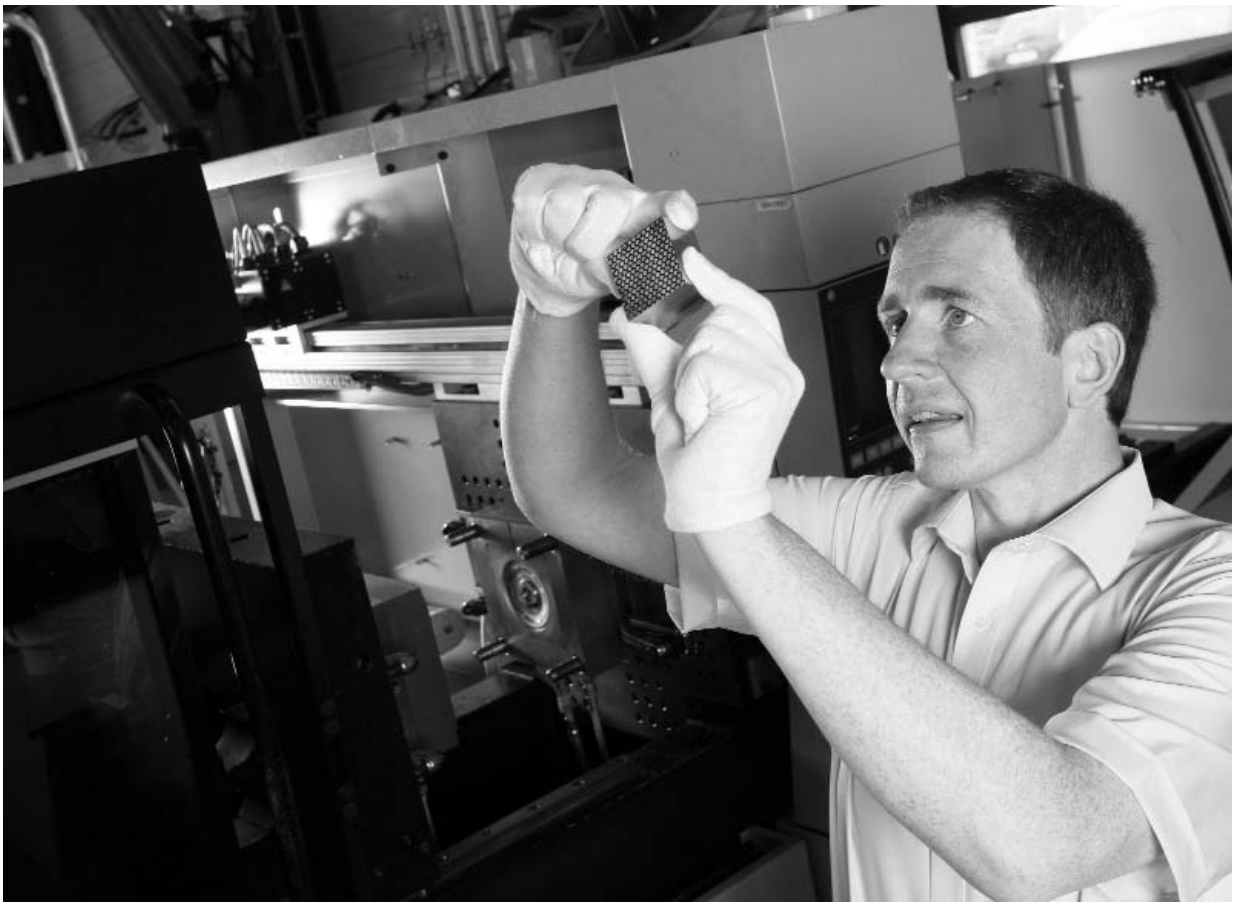
If you have hay fever, headaches or a cold, it's only a short way to the nearest chemist. The drugs, on the other hand, can take eight to ten years to develop. Until now animal experiments have been an essential step, yet they continue to raise ethical issues. "Our artificial organ systems are aimed at offering an alternative to animal experiments," says Professor Heike Mertsching of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart. "Particularly as humans and animals have different metabolisms. 30 per cent of all side effects come to light in clinical trials." The test system, which Professor Mertsching has developed jointly with Dr. Johanna Schanz, should in future give pharmaceutical companies greater security and shorten the path to new drugs. Both researchers received the "Human-centered Technology" prize for their work.

"The special feature, in our liver model for example, is a functioning system of blood vessels," says Dr. Schanz. "This creates a natural environment for cells." Traditional models do not have this, and the cells become inactive. "We don't build artificial blood vessels for this, but use existing ones – from a piece of pig's intestine." All of the pig cells are removed, but the blood vessels are preserved. Human cells are then seeded onto this structure – hepatocytes, which, as in the body, are responsible for transforming and breaking down drugs, and endothelial cells, which act as a barrier between blood and tissue cells. In order to simulate blood and circulation, the researchers put the model into a computer-controlled bioreactor with flexible tube pump, developed by the IGB. This enables the nutrient solution to be fed in and carried away in the same way as in veins and arteries in humans. "The cells were active for up to three weeks," says Dr. Schanz. "This time was sufficient to analyze and evaluate the functions. A longer period of activity is possible, however." The researchers established that the cells work in a similar way to those in the body. They detoxify, break down drugs and build up proteins. These are important pre-conditions for drug tests or transplants, as the effect of a substance can change when transformed or broken down – many drugs are only metabolized into their therapeutic active form in the liver, while others can develop poisonous substances. The researchers have demonstrated the basic possibilities for use of the tissue models – liver, skin, intestine and windpipe. At the moment, the test system is being examined. Within two years it could provide a safer alternative to animal experiments.



Dipl.-Ing. Günter Helferich.

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Research News
Topic 2

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Explosives prevent technology theft

The holographic structure on the frisbee glistens colorfully. It is unique to this batch and makes the product forgery-proof. Explosives are used to emboss the original pattern into the injection moulding tool. This method can be used to give copy protection to industrial goods, and also mass-produced goods such as DVDs or medical pills and tablets. The patented technology was developed by Günter Helferich of the Fraunhofer Institute for Chemical Technology ICT in Pfinztal. He will receive one of the 2009 Joseph von Fraunhofer prizes for developing an explosive embossing method for the holographic nano-structuring of steel surfaces, as a protection against plagiarism. The necessity for this is obvious – forged products account for approximately 10 per cent of total world trade volume. This not only destroys jobs – approximately 70,000 per year in Germany, according to the German Chamber of Industry and Commerce – but is also relevant to the question of product liability.

Explosive embossing makes it possible to imprint structures directly onto metal surfaces. This method can even be used to transfer the structures of soft holographic embossing templates – nickel shims – into mould inserts for injection moulding. Moulds structured in this way enable plastic products to be produced for the mass market with a clearly visible hologram as a copy protection. This can be done during the production process of the original and without an additional production step. All components can be clearly identified by the 'fingerprint' moulded into the plastic. In addition, the use of conventional galvanic baths or etching baths can be reduced.

"The procedure is simple to describe," says Günter Helferich. "For the structuring, the metal surface to be worked on is covered with the object that is to be imprinted, the original structure. A thin film of explosive material is placed on this. When this is detonated the structure of the original is imprinted, accurate in every detail, onto the metal. The shock wave causes an additional increase in the hardness of the embossed metal." Achieving this result was not quite so simple – it depends on the combination of many parameters, the type of explosive material and the type of metal, the detonator position and the plugging of the explosive material – just to name a few. The explosive embossing of holographic structure templates cannot be copied – even if identical templates are used. Forgers of products will never be able to carry out a "complex" procedure such as embossing by means of detonation with complete accuracy of detail, making it the ideal piracy protection.

Dipl.-Krist. Jörg Adler und Dr. Reinhard Lenk (v.l.n.r.).

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Research News
Topic 3

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Fitting squares into circles

From 2011, new EU guidelines for emission values will apply. The aim is to reduce particle emissions by up to 95 per cent. Off-road vehicles such as diggers and fork-lift trucks, but also city buses and garbage trucks, will then have to be fitted with filters. Retrofitting is also worthwhile in view of the vehicles' long lives and high purchasing costs. Until now, such special engine variants have been catered for with basic geometric forms similar to those used for car filters, i.e. squares. The disadvantage is that in order to fit the square filters into the circular pipes, approximately 20 per cent of the material has to be cut away using expensive diamond cutters – costly waste. There's a better way of doing this, figured Jörg Adler and Dr. Reinhard Lenk from the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Dresden. Based on a material patented at the IKTS, a porous silicon carbide ceramic, they developed a highly efficient ceramic diesel particle filter for off-road applications together with HUSS Umwelttechnik GmbH. They will be awarded with one of the 2009 Joseph von Fraunhofer prizes for their work.

The material was adapted for use in a diesel particle filter in terms of size, distribution and volume of its pores. The raw materials are comparatively inexpensive and can be handled at lower temperatures as well. "We agonized over the basic shape of the filter segments," says Jörg Adler. A four-cornered trapezium was the result from which square-edged or circular surfaces can be fitted together without any wastage. The channels in the segments are three-cornered, not square, providing a larger filter surface. This means that, fitted behind the engine, it takes longer for sooty particles to accumulate in the individual channels and to reach the stage where they must be burnt off. Following the material and geometric form, it was then necessary to develop technologies suitable for series production. With a team of colleagues, the scientists tested all the work steps in a pilot production run at the institute and coordinated them with one another.

Clean Diesel Ceramics GmbH, a subsidiary of HUSS, was established to produce the ceramic filters. Sponsored by the Saxon State Ministry for Economic Affairs and Labor, the company started its operations in May 2008. "We have also thought about the series at all stages of the development and defined the conditions for it with our partner," says Dr. Lenk. "Some of the CDC staff members were initially directly involved in the project work at the institute, in order to simplify the transfer to production."

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Research News
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Getting the most out of gemstones

"We were astounded when our customer, Markus Wild, approached us and we were not at all certain whether mathematics could offer a solution for the very complex problem of volume optimization of gemstones," says Dr. Anton Winterfeld from the Fraunhofer Institute for Industrial Mathematics ITWM. Jointly with his colleague Dr. Peter Klein, he will receive one of the 2009 Joseph von Fraunhofer prizes for the development of GemOpt, a new industrial process for the volume-optimized utilization of colored gemstones.

In contrast to diamonds, there are innumerable combinations of types and proportions of cut, and types of facet patterns for colored gemstones. When chosen correctly, the interplay of these variables ensures the luster in the stone, its shine. Sometimes just a few facets are sufficient to make a gemstone sparkle, sometimes several hundred. The task was to set limits on what seemed to be infinite and to calculate the optimal volume. The mathematical approach, which finally resulted in a solution, originated from the area of general semi-infinite optimization. This involved a new type of algorithm, which had until now only been theoretically defined. The team at the ITWM continued to develop this approach and implemented it for this specific problem. The result is an outstanding achievement, also in scientific terms. The second essential part of GemOpt is process control, which Dr. Peter Klein has worked out. For this he ascertained precisely how raw gemstones behave when processed and transferred his findings to the control unit of the machine.

The machine runs fully automatically. First of all, the raw stone is measured. On the basis of these data, the computer calculates optimal embedments, proportions and facet patterns for different basic geometries. The customer then opts for one of the proposed solutions and the machine begins cutting. The process control unit is finely balanced, so that the machine does not split the stones as it cuts them. The system then moves seamlessly on to the polishing step. The 17 axes ensure that the stone can move along any desired path. The machine cuts the facets to ten micrometers exactly – the stones are therefore perfectly geometric. A further advantage is that the machine can produce identical stones – ideal for necklaces. Cutting with the machine can result in up to 30 per cent more weight. This puts a significantly higher price on the stone.

Richard Stein.

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Fraunhofer

Research News
Topic 5

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Virus filters for medical diagnosis

Providing reliable evidence of viruses in human blood presently requires time- and labor-intensive molecular-biological procedures. Established methods are particularly hard pushed to produce evidence when the viral burden is very low, for example during a phase of therapy. This could soon change. While developing new types of micropumps without movable parts, scientists from the Fraunhofer Institute for Biomedical Engineering IBMT came across an unexpected phenomenon: stable turbulence structures formed in the microscale pump channels. The nano- and microparticles actually intended to verify the pump effect accumulated in large quantities in the channels. The vortex patterns completely filled the whole microchannel, creating a virtually 100% trap for the particles that followed the generated flow profile, although there is a very large cross-section to flow through. "The development of flow vortices is nothing unusual on the macroscopic scale. However, in microchannels the flow lines almost run in parallel," explains Richard Stein from the IBMT. "The question, therefore, was, how is it possible for vortices to be formed from this which were sufficiently stable and effective for the concentration of nanoparticles?"

Experiments were not successful in determining the parameters by which the filter effect could be systematically controlled. This is because in the pump mechanism examined, high-frequency electrical traveling waves propel the fluid into the microchannels, superimposing a large number of effects on one another.

"In order to understand the complex procedures, there was a clear need for a theoretical description. My task was to describe the surprising phenomenon and to make it controllable," reflects Richard Stein. In his thesis "Mathematical modeling, analysis and numerical simulation of electrothermally driven micropumps", Richard Stein succeeded in explaining the development of the vortex pattern. To this end, he had to factor in all the relevant processes – of an electrical, thermal and hydrodynamic nature – in a three-dimensional model. Mr. Stein will receive the 1st Hugo Geiger Prize for this paper. The findings contained in the paper explain the observed effects completely, so that now both effective micropumps and efficient particle filters can be developed and built for many biomedical applications.

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Marc Steiner (left) und Christian Grumaz (right).

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Fraunhofer

Research News
Topic 6

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Effective solar cells and sensitive bioanalysis

The efficiency factor of solar cells is crucial for the success of generating electricity from sunlight. Systems in which light is concentrated 400-fold through lenses onto solar cells are proving to be particularly advantageous. This concentrator technology enables expensive semiconductor material to be replaced with cheaper lens systems, and greater efficiency to be achieved. In his thesis, physicist Marc Steiner from the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg presented a way of increasing the efficiency of these concentrator solar cells even more. The contacting of the semi-conductor layers plays a crucial role here, and Marc Steiner's new simulation program optimizes the structure and configuration of the metallic contact fingers. These calculations yielded unprecedented efficiency factors for concentrator solar cells. Marc Steiner will be awarded the 2nd Hugo Geiger Prize for his thesis "Minimization of serial resistance losses in III-V solar cells with the aid of a SPICE network simulation".

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Genes play an important role in every organism, particularly where its development and adaptation to the environment are concerned. Modern sequencing technology means that genomes can now be quickly mapped. However, it is still not entirely clear which genetic program is running during which phase of growth. Gene expression – that is, the analysis of which genes are switched on at any given point in time, and which are not – can supply the relevant answers. This helps to differentiate cells, and to understand biological systems on a molecular level. The aim of the thesis "Global methods for the analysis of metatranscriptions on the single-cell level" by Christian Grumaz from the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB was to establish a new, straightforward procedure that gets by with small sample quantities and enables a high throughput. "I was able to complete this plan successfully," says Christian Grumaz. The procedure is extremely sensitive, which means that it could potentially be applied in diagnostics, where biopsy material, for example, is usually only available in small quantities. A high throughput of samples is also possible, as parallel sequence technologies can be used. The analysis procedure is of interest for diagnosis, drug development and basic research. Christian Grumaz will be awarded the 3rd Hugo Geiger Prize for his paper.

The **Fraunhofer-Gesellschaft** is the leading organization for institutes of applied research in Europe, undertaking contract research on behalf of industry, the service sector and the government. Commissioned by customers in industry, it provides rapid, economical and immediately applicable solutions to technical and organizational problems.

The global alignment of industry and research has made international collaboration imperative. Furthermore, affiliate Fraunhofer Institutes in Europe, in the USA and Asia ensure contact to the most important current and future economic markets.

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