Fraunhofer

RESEARCH NEWS – SPECIAL ISSUE

05 | 2012 ||

Profiles of the awards

The Stifterverband award recognizes outstanding joint projects in applied research. Also presented at the annual conference of Fraunhofer Gesellschaft were four Joseph-von-Fraunhofer prizes and three Hugo-Geiger prize.

1 Ultra-short laser pulses for science and industry

The shorter the pulse duration, the more precisely the laser tool operates. Ultra-short laser pulses of outstanding high average power are opening the doors to new applications in high throughput materials processing.

2 Functional coatings from the plasma nozzle

These coatings offer protection against rust, scratches and moisture and improve adhesion: Surfaces with a nano coating. A new plasma process enables these coatings to be applied more easily and cost-efficiently – on an industrial scale

3 Performance boost for microchips

The semiconductor industry is faced with the challenge of supplying ever faster and more powerful chips. The Next-Generation Lithography with EUV radiation will help meeting that challenge. Fraunhofer researchers have developed key components.

4 Improved lubrication without oil

Running nicely – this applies even more to aqueous biopolymer solutions than to oil. These solutions are used as a cooling lubricant for machining hard metals and for tool-making machinery on which tools are manufactured.

5 Laser scan at full speed

Is a contact wire missing or is it faulty? What's the situation in front of the entrance to a railway station or a tunnel? A 3D laser scanner can increase the train's safety and reliability.

6 Outstanding young scientists

The following have received Hugo-Geiger awards: Sven Rademacher in recognition of a mobile measuring device for emission monitoring (1st prize), Harry Kummer for his new heat exchanger coating system (2nd prize) and Anna Marie Kruspe for her automated world music classification process (3rd prize).

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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The profiles of the awards

Stifterverband science prize
In 1920, representatives from the business world established the Stifterverband at the suggestion of German academies, universities and scientific associations. Its re-foundation after the Second World War is closely linked with the re-foundation of the »Notgemeinschaft der deutschen Wissenschaft« [Emergency Association of German Science] on 11 January 1949. The Stifterverband is still considered to be the mediator between industry and science today.

For ten years, the organization has awarded the Fraunhofer Gesellschaft with a prize worth 50,000 euro. The prize is awarded in recognition of outstanding joint applied research projects, on which Fraunhofer institutes work together with businesses and/or other research organizations (article 1). This and the prize „Technik für den Menschen" [prize for human-centered technology] are awarded in alternate years.

Joseph-von-Fraunhofer prize – research for practical applications
Since 1978, Fraunhofer-Gesellschaft has awarded the annual prizes for outstanding scientific achievements of its employees that resolve application-related problems. To date, more than 200 researchers have won this prize. This year, four prizes worth 20,000 euro each will be awarded. The prize winners will also receive a silver pin with the facial profile of the patron saint as it appears in the logo of articles 2 to 5.

Hugo-Geiger prize – promoting young researchers
The Bavarian state government founded this award in 1999 to mark the 50-year anniversary of the Fraunhofer-Gesellschaft. The patron is Hugo Geiger, who led the inaugural meeting on 26 March 1949. This award is given in recognition of outstanding and application-related theses for Bachelor, Master's and Doctorate degrees - from all research fields of Fraunhofer Gesellschaft. The criteria assessed are: scientific quality, economic relevance, uniqueness and interdisciplinarity of the approaches used. The work must be closely related to or have been developed in a Fraunhofer institute. The first prize winner receives 5,000 euro, the second 3,000 euro and the third 2,000 euro (article 6).

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Ultra-short laser pulses for science and industry

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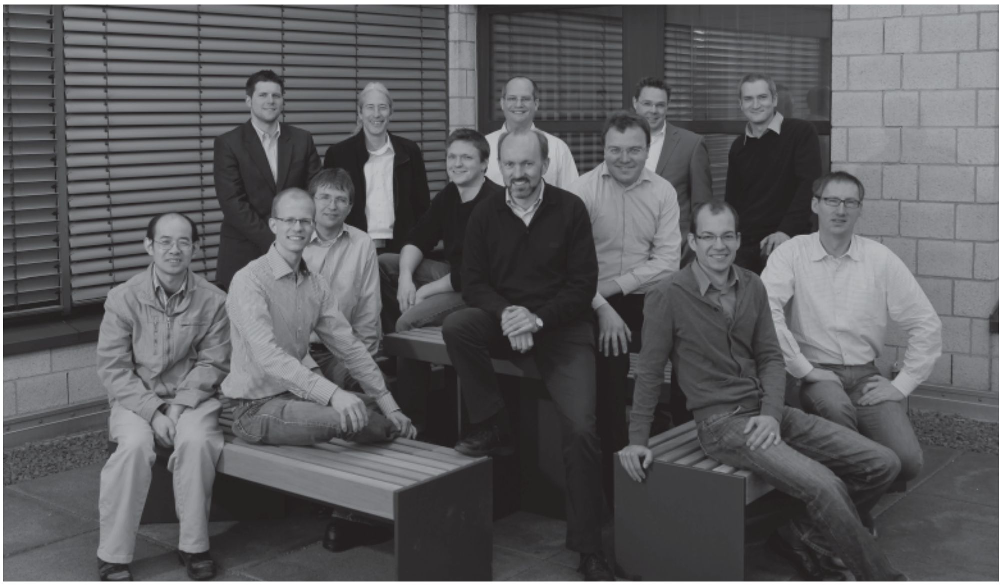
Laser technology uses light. Light can be rapidly and precisely deflected, shaped and focused. If we pulse laser light and reduce pulse duration more and more, the laser tool works even more precisely. A benefit: The material being processed heats up less and less. High-power, ultra-short pulses, then, are the ideal solution for medical applications, in brain surgery for instance, as the cerebral membrane is not damaged. Or for removing tumor tissue thereby conserving the surrounding tissue and blood vessels. This precision technology is also valued in the processing of materials, glass for instance: Lasers are able to cut narrow speaker ports in smartphone displays.

For years, ultra-short laser pulses have been used for the extremely precise and gentle processing of highly-sensitive materials. Until now though, they have often lacked in power. The newly developed laser platform solves this problem with the INNOSLAB amplifier as its core. Four mirrors surround a laser crystal plate – the slab. Pump radiation enters at the two opposite faces of the slab. Ultra-short laser pulses are repeatedly reflected by these mirrors and pass through the slab several times. Energy is transfered from the pump radiation to the laser pulse until the required power is achieved.

The INNOSLAB platform was developed by the Fraunhofer Institute for Laser Technology ILT in Aachen and refined further together with several partners from industry and science: the Chair for Laser Technology at RWTH Aachen University, the Max Planck Institute for Quantum Optics MPQ in Munich and the companies Jenoptik AG, EdgeWave and Amphos – the latter two being ILT spin-offs.

To develop new markets for laser systems with ultra-short wavelengths, the team of developers had to increase the mean laser output of ultra-short pulse beam sources – up to several hundred watts. Higher power makes high volume production in industrie and shorter measuring times during scientific experiments possible. Between 2008 and 2011, two joint projects revolved around developing the new beam source: The aim of the PIKOFLAT project, supported by the Federal Ministry for Education and Research BMBF, was to structure printing tools and embossing dies. The goal was to reduce processing times while significantly increasing quality. One of the results of this project is the production of embossing cylinders that are used to create extremely fine artificial leather surfaces for the automotive industry. In the second joint project, KORONA, Fraunhofer collaborated closely with the Max Planck Institute of Quantum Optics in Garching near Munich and with RWTH Aachen University. The scientists jointly developed a compact beam source whose ultra-short wavelengths makes it possible to examine nano-structures.

The team received the Stifterverband's science award in recognition of its outstanding cross-location, multi-disciplinary collaboration on the laser platform for scaling the power of ultra-short laser pulses.



The platform for producing ultra-short pulses was developed by an interdisciplinary team from Fraunhofer together with several partners from science and industry:
1. row (from left to right):
Dr. Daijun Li, EdgeWave GmbH, Andreas Vernaleken, Max-Planck-Institut für Quantenoptik MPQ, Hans-Dieter Hoffmann, Fraunhofer ILT, Matthias Winzen, Fraunhofer ILT, Rudolf Meyer, Fraunhofer ILT,
2. row (from left to right): Dr. Peter Rußbüldt, Fraunhofer ILT, Dr. Jan Dolkemeyer, Amphos GmbH, Johannes Weitenberg, Fraunhofer ILT,
3. row (from left to right): Dr. Ioachim Pupeza, Max-Planck-Institut für Quantenoptik MPQ, Guido Rotarius, Fraunhofer ILT, Martin Traub, Fraunhofer ILT, Dr. Torsten Mans, Amphos GmbH, Marco Höfer, Fraunhofer ILT. (© Dirk Mahler/Fraunhofer) | Picture in color and printing quality: www.fraunhofer.de/press

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Functional coatings from the plasma nozzle

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When manufacturing products, the coating technology is a key innovation driver for almost all areas of daily life – for example, for making scratch-proof displays for smart phones or anti-bacterial surfaces in refrigerators. Other coatings protect components from corrosion or aging, for example in a solar cell module or a car engine, without the end user noticing their existence. In industry today, wet chemical processes or vacuum plasma processes are primarily used for coating applications. Both have drawbacks. Vacuum units are expensive, limited to smaller components and applying a coating takes a relatively long time. Wet chemical processes often involve high resource and energy consumption with the corresponding environmental damage and can also cause difficulties in the handling of material combinations for lightweight construction such as plastics/ metals or aluminum/steel.

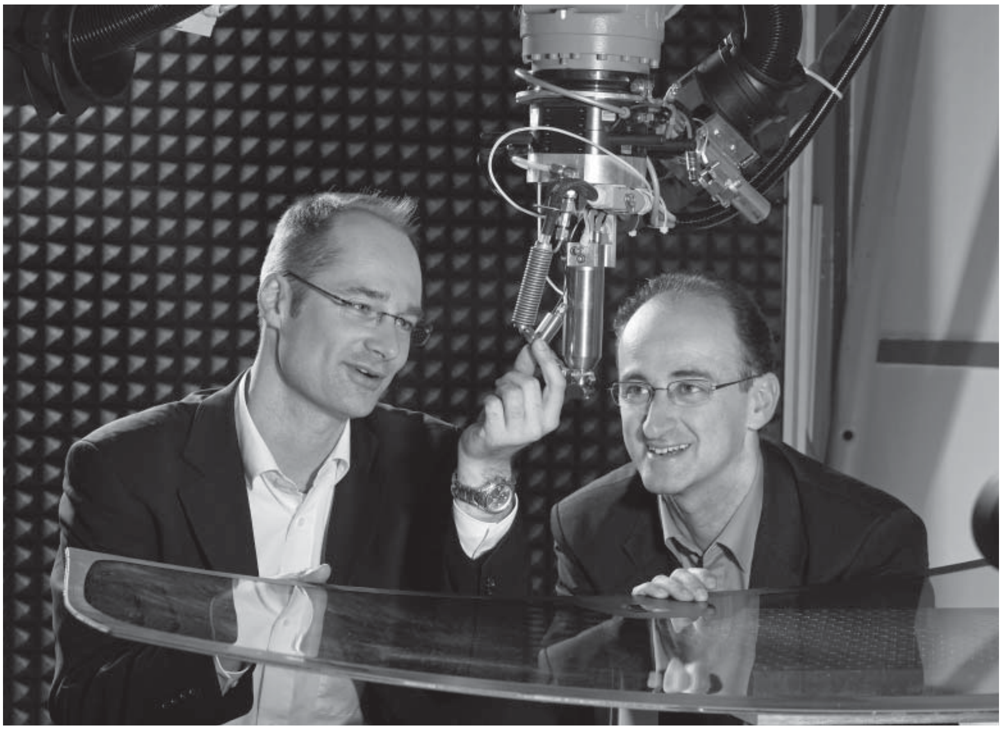
"There has to be another way", thought Dr. Jörg Ihde and Dr. Uwe Lommatzsch from the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Bremen. Together with Plasmatreat GmbH, the IFAM team developed a new kind of plasma coating process that works at ambient pressure, that is to say, in an open atmosphere. "And that poses a major challenge", explains Jörg Ihde. "Because the pressure is more than 10,000 times higher and the absence of a vacuum reactor, we had to stop unwanted particles from forming and embedding in the coating. That was the key to developing robust and efficient industrial processes using the new plasma system.

One nozzle – various functional coatings

The central element is a plasma nozzle. The nozzle is no bigger than a typical spray can. Yet it contains a highly complex coating system. "In the nozzle, an electrical discharge generates small flashes - a plasma that is expelled from the nozzle in the form of a jet. We systematically feed into the nozzle outlet those materials that are excited and fragmented in the plasma and then deposited out of the plasma jet as a functional nano-layer onto the surface", explains Uwe Lommatzsch. "We achieve extremely high deposition rates, enabling fast and cost-effective production processes to be realized."

The use of a nozzle allows the coating to be applied very precisely and only where it is needed, thus conserving resources. "We can control the processes so that the same nozzle can be used to apply coatings with various functionalities, for corrosion protection or for increasing or reducing adhesion, for instance", adds Jörg Ihde. Only very small amounts of coating material are required and practically all materials and material combinations can be coated. The process offers, in addition to the coating qualities and functionalities, even more benefits: it can be easily integrated into an inline production process, requires little space and is easy to automate, meaning it can be controlled via a robot. Yet another advantage: low investment costs and easy on the environment. The positive characteristics benefit industrial production: depositing an adhesion-promoting coating on a car window edge before gluing it in, to replace environmentally damaging chemicals or as a substitute for thick protective paint on printed circuit boards, which improves heat dissipation and hence prolongs service life. The process is already employed in the automotive industry and the energy sector to provide protection against corrosion and aging.

One of this year's Joseph-von-Fraunhofer prizes was awarded to Dr. Jörg Ihde and Dr. Uwe Lommatzsch for their development of a resource-efficient process for the high-rate deposition of functional nano-layers.



Dr. Jörg Ihde and Dr. Uwe Lommatzsch (from left to right) have developed a new coating process for functional nano-layers, using a plasma nozzle that works at atmospheric pressure. (© Dirk Mahler/Fraunhofer) | Picture in color and printing quality: www.fraunhofer.de/press

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Performance boost for microchips

Flat computers, powerful cell phones and tablets – the integrated circuits, our computers' power centers, are becoming increasingly smaller and more complex. The microchips in today's computers already contain some two billion transistors. To get the chip density right, the structures are exposed onto the chips by means of lithography. To be able to meet future requirements, the semi-conductor industry is planning to convert the exposure using a wavelength of 193 nm to a wavelength of just 13.5 nm. This can be achieved only with completely new radiation sources. The favorite of the Next-Generation lithography is EUV – light with wavelengths in the extreme ultraviolet range.

Dr. Klaus Bergmann, Dr. Stefan Braun and Dr. Torsten Feigl from the Fraunhofer Institutes for Laser Technology ILT Aachen, for Material and Beam Technology IWS Dresden and for Applied Optics and Precision Engineering IOF Jena, have developed, with their teams, key elements for EUV lithography: light sources (ILT), collector optics (IOF) and illumination and projection optics (IWS). They will receive a 2012 Joseph-von-Fraunhofer prize for their achievements in this strategic partnership.

Generating EUV radiation

The efficiency of the light source is key to the industrial use of EUV. The team around Klaus Bergmann at ILT developed the first prototypes of the EUV source as early as 2006. There is now a beta version that is already being used to expose chips in industrial applications. "The concept is based on the rapid, pulsed discharge of electrically stored energy. In the process, a small amount of tin is vaporized using a laser and excited with a high current to an emission at 13.5 nm – many thousands of times per second", explains Bergmann.

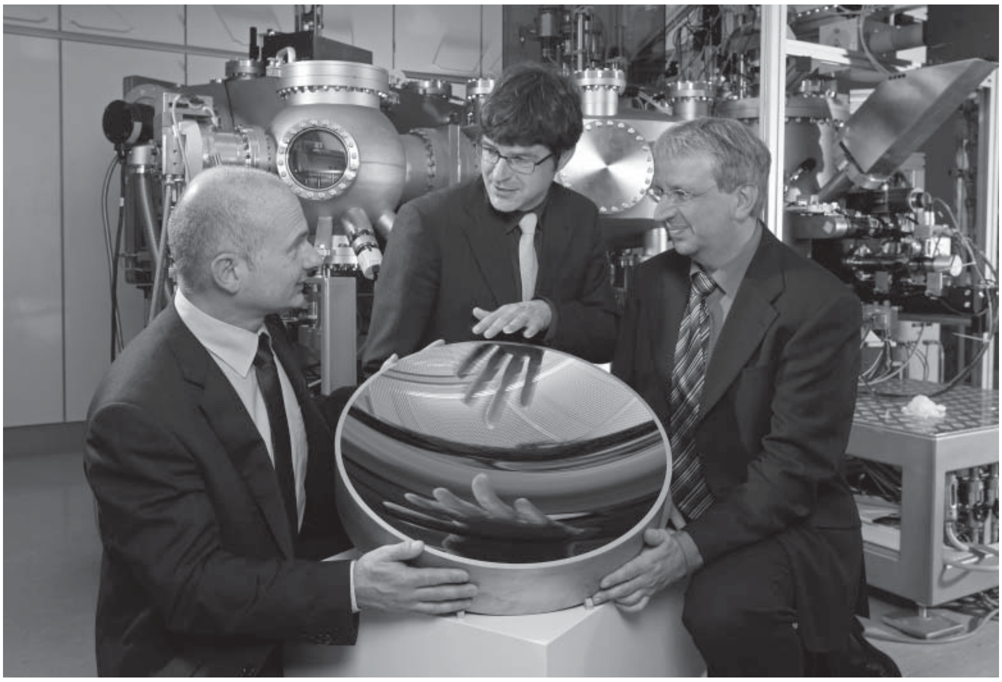
World's largest collector mirror for EUV lithography

The quality of the collector mirror is crucial to the radiation hitting the exposure mask in exactly the right place. The coating guarantees that the losses remain low and that the quality of the focused EUV radiation is high. "The challenge we faced was to develop and apply a multilayer coating system that combined high EUV reflectance with high thermal and radiation stability onto the strongly curved collector surface", said Torsten Feigl from IOF. The result is the world's largest multi-layer coated EUV mirror with a diameter of more than 660 millimeters.

Coating for optimized reflection on mirrors and lenses

Once the radiation passed the mask, it is exposed onto the chips via further projection mirrors. Stefan Braun and his team at IWS have devised the optimum reflection layer for these components. Magnetron sputtering ensures maximum layer accuracy, without additional polishing processes or in-situ thickness control being required. One machine type for large area precision coating is already in industrial use.

Germany is the pioneer of EUV technology. Three institutes have established themselves with their research work as key partners for the supplier industry both in and outside Europe. The new lithography technology is expected to start industrial production in 2015.



Jointly developed key components for EUV lithography: Dr. Torsten Feigl, Dr. Stefan Braun and Dr. Klaus Bergmann (from left to right) with a collector mirror.
(© Dirk Mahler/Fraunhofer) | Picture in color and printing quality: www.fraunhofer.de/press

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Improved lubrication without oil

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Metalworking plays a key role in industry. Drilling, milling, turning and grinding operations all use lubricants to prevent work pieces and tools from overheating and from excess wear. Standard lubricants today are based on mineral oil. This has drawbacks: fossil mineral oils come from finite resources, transport relatively little heat away from the work piece, are harmful to health and are flammable. All of this calls for extreme technical efforts, for occupational safety, fire safety and disposal, for example. So there's a need for alternative lubricants.

Renewable raw materials as a lubricant additive

The idea hatched by Andreas Malberg, Dr. Peter Eisner and Dr. Michael Menner from the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising sounds simple as well as surprising: lubricate with water, not oil. "At IVV here in Freising, we have been looking at the issue of cooling lubricants for some considerable time", explains Michael Menner. "In two projects supported by the Federal Ministry of Education and Research, we have successfully replaced oil with water. One surprising thing we found was that water is no worse a lubricant than oil, the key to it all being the additives." Adding natural polymers to water can dramatically improve its lubricating properties. The Freising-based researchers set about testing renewable raw materials such as celluloses, starches or bacterial polysaccharides and improving their use as lubricant additives. Their aim: to make water more viscous by adding biopolymers, so it lubricates better.

For the idea to become a marketable product, other partners were brought on board: the Institute for Machine Tool Engineering and Production Technology at the University of Braunschweig, and Carl Bechem GmbH - a lubricant manufacturer from Hagen, Germany. The basic fluid made by the IVV, the viscous water, was improved by adding water-soluble additives so it could be used as an anti-corrosion agent, for example. That's how it meets the requirements during processing: withstanding high temperatures and shearing stresses.

Benefits: Easy on the environment and on gentle to the skin, does not burn

In addition to the significantly lower impact on the environment and the high raw material efficiency, the new lubricant also offers technological benefits. It reduces wear and prolongs tool life, for example. The processed components are also easier to clean. This cuts costs and improves the cost-efficiency of the entire production process. Converting to the new lubricant is very easy for companies to carry out", explains Peter Eisner. "In principle, once thoroughly cleaned, the same machine tool circulation systems can be used." In addition, the use of the aqueous lubricant improves occupational health and safety and hygiene: no formation of oil mists, addition of fewer biocides, it smells better and is gentler on the skin.

For the mineral oil-free lubricant made of aqueous biopolymer solutions for use in metalworking applications, Dr. Peter Eisner, Dipl.-Ing. Andreas Malberg and Dr. Michael Menner will receive one of the 2012 Joseph-von-Fraunhofer awards. The newly developed lubricant is already being distributed by Carl Bechem GmbH under the product name of BERUFLUID and is in use in various metalworking companies in the manufacturing of tools, mechanical engineering, in the automotive and aviation industry and in medical technology.

Dr. Peter Eisner, Dr. Michael Menner and Andreas Malberg. Developed a cooling lubricant from aqueous biopolymers. Astonishing the lubricant industry by finding: "Water lubricates like oil". (© Dirk Mahler/Fraunhofer) | Picture in color and printing quality: www.fraunhofer.de/press

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Laser scan at full speed

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Laser systems can be used to implement highly precise and ultra-fast measuring processes. Railway measuring technology has a huge worldwide need here. One prerequisite for its use is that nobody is damaged or suffers irritations by the laser. Dr. Heinrich Höfler and Dipl.-Ing. Harald Wölfelschneider from the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg have worked with their team to develop a 3D laser scanner. It can be used outdoors without hesitation. Extremely fast and precise, it is able to spatially measure and monitor the position of the contact wire or the track from a train travelling at up to 100 kilometers (62 mph) per hour. If the scanner is stationary, it can capture passing trains and check for loads that might have slipped.

Heinrich Höfler explains how that works: "We send off a laser beam and wait until it returns. We measure the time in between and that tells us how far away an object is." The difficult part is capturing the returning beam. Often, only very little light comes back and what's more, the transmitted light beam is back in an extremely short space of time. The solution: A kind of slow motion. The laser beam is very rapidly switched on and off – modulated, as scientists would put it. The time shift of this modulation wave can be determined more quickly and precisely than is possible with a single laser pulse.

Capturing obstacles and constrictions during movement

The system measures, by default, one million times per second. "For Deutsche Bundesbahn (German Railway), we equipped a measurement train that scans the surroundings of the test track, using several laser beams and which delivers, taking four million measurements per second, a 3D image of what it scans", explains Harald Wölfelschneider. That allows even small obstacles and constrictions to be detected, or we can plan the route via which a heavy load can best be transported to its destination.

Another field of application is the measuring of passing trains. This requires the scanner to be permanently mounted, which, however, does increase the chance of someone looking into the laser beam for a longer period. To make the scanner safe for the human eye, the researchers had to develop a new wavelength range: infrared, which is harmless for our eyes. The consequence being that the entire system had to be fully reconfigured.

From railway to road – in global use

If we examine railways carefully, it makes sense that we then also examine other traffic routes, such as roads. The team at IPM has developed a 3D scanner, safe for the human eye, which is mounted onto a moving car and which scans the road from a height of about three meters. "We can now detect height differences of even 0.2 millimeters on the road, even at speeds of 80 kilometers per hour (approx. 50 mph)“, says Höfler. This is the first scanner approved for this purpose by the Federal Highway Research Institute. It is to detect lane grooves, potholes and water drainage potentials.

The laser system has already been marketed and used successfully all over the world for rail traffic safety. Not only fast and precise, this system is also highly robust. Dr. Heinrich Höfler and Dipl.-Ing. Harald Wölfelschneider will receive one of the 2012 Joseph-von-Fraunhofer awards for this eye-safe 3D laser scanner.

Dr. Heinrich Höfler and Dipl.-Ing. Harald Wölfelschneider (from left to right) with a 3D laser scanner that improves safety and reliability on railroad tracks all over the world.
(© Dirk Mahler/Fraunhofer) | Picture in color and printing quality: www.fraunhofer.de/press

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Outstanding young scientists

RESEARCH NEWS
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Measuring emissions precisely and on the go: Sven Rademacher will receive the first Hugo-Geiger prize for his infrared optical filter photometer. Second prize goes to Harry Kummer for his new heat exchanger coating system. In third place: Anna Marie Kruspe for her automated world music classification process.

Reliably measuring air quality – on the go

In October 2008, environmental zones were introduced in many of Germany's cities. Vehicles with red discs have since been banned from city centers. Still, emission loads in cities and major population centers continue to be too high. The reason for this is the fact that pollutants don't just come from traffic, but also from heating systems, power stations, industrial plants and from the natural environment. To monitor compliance with the legal regulations, the authorities need solid measurement data - recorded precisely and flexibly. So far, this data has generally come from stationary measuring locations. But because they are not extensively distributed, the values do not fully reflect the actual air composition. Sven Rademacher developed the mobile, infrared optical filter photometer as part of this Master's thesis at the Fraunhofer Institute for Physical Measuring Technology IPM in Freiburg. Unlike commercially available systems, it detects several gases at the same time. What's more, the device's position can be fixed using GALILEO, the European satellite navigation system, which allows for the measurement data to be precisely localized. This in turn permits conclusions to be drawn on the sources of the pollution and specific countermeasures to be initiated, imposing local traffic restrictions for example. An online air pollutant chart is to make the measurements transparent for everyone.

Making thermally driven air-conditioning systems more economical

In industrialized countries, high rises with large glass fronts, will be part of the citys-cape. These buildings, however, require a great deal of energy for heating and cooling. Experts believe that the demand alone for cooling will triple by 2020. During summer, air-conditioning of rooms can be realised more efficiently by using thermally-driven adsorption cooling units. Water, as a non-poisonous coolant, silica gel and zeolites as adsorption materials are used here. Researchers must dramatically improve these technologies until they are economical and efficient and therefore suitable for daily use. In his diploma thesis at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Harry Kummer developed a highly promising coating system for use on heat exchangers integrated in these adsorption chillers. His coating system is flexible and suitable for new and optimized adsorption materials. It permits a higher power density of the units through faster adsorption cycles, making it possible to construct these units in a more economical and compact manner. There is a patent pending for the coating process, which is to be further optimized in a large-scale demonstration unit.

Automatically classifying “world music”

The music market is in a state of flux: Since the era of digital formats, music is being increasingly offered online to a globalized market. Automated processes help genres to be reliably classified and music archives to be managed affordably and efficiently. For that to happen, music databases must be pre-processed. Commercial solutions are already in place for standard music genres such as rock and pop, but not for world music. In her thesis at the Fraunhofer Institute for Digital Media Technology IDMT in Ilmenau, Anna Marie Kruspe developed an automated classification process for non-Western music genres. Using this process, she achieves an accuracy of 70 percent. This is equivalent to the existing systems for classifying Western music. So in future, ”world music” can also be integrated into the international music market - benefitting both composers and consumers alike. The thesis emerged as part of »GlobalMusic2one«, a project supported by the Federal Ministry of Education and Research.

The winners of the Hugo-Geiger awards: Sven Rademacher, Harry Kummer and Anna Marie Kruspe. (© Fraunhofer | Picture in color and printing quality: www.fraunhofer.de/press

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