discovered

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Valuable Resources

HZDR

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COVER IMAGE: Solar thermal power plants like this one with 3,200 parabolic trough collectors, owned and operated by Spanish global leader Abengoa Solar and located near Gila Bend, USA, take the heat energy from sunlight and convert it to electricity using relatively simple technical means. On pages 4 through 8 of this issue, you'll read about different research projects HZDR scientists are currently working on in an effort to optimize solar thermal facility efficiency. Photo: Abengoa Solar, S.A.

DEAR READER,

which resource is most important to you? Is it spare time, personal skills, money? For some, it's natural resources – like a landscape that hasn't been tampered with or the sea with its plethora of living things – that hold great value. As soon as resources become an object of research, scientists begin to focus intensively on them, often over many years. They search for new approaches to improving availability of these resources or optimizing efficiency during their use. Take renewable energies, for instance: today, sunlight, wind, and water are all wonderful suppliers of vast amounts of electricity, yet we are still a far cry from having created suitable means of temporarily storing this electricity and from the desired yield. In addition, many industrial processes hold tremendous hidden potential. Here, research can help optimize and thereby save important resources like time, energy, and cost.

Over the last few years, the HZDR has substantially increased research in the areas of energy and resources, for example, through its new Helmholtz Institute Freiberg for Resource Technology (HIF). We will introduce you to one of the HIF's projects on helicopter based remote sensing and the project's coordinator, Richard Gloaguen, in this issue of *discovered*. No fewer than three stories are dealing with applied research on solar facilities. However, without long-term basic research, the topics we're presenting to you in this issue, would have been all but impossible. This also goes for projects involving optimization of industrial processes and products. Materials researcher Sibylle Gemming draws on the ion beam center's repertoire and long-standing know-how to modify materials for use in combustion engines so as to minimize friction while optimizing energy efficiency. To take another example: In the chemical industry, large containers are often used, inside of which certain chemical reactions take place. These cannot simply be scaled from test tube to chemical reactor and they don't readily lend themselves to direct observation or measurement. Process engineer Markus Schubert is eager to better understand these complex reaction sequences and contribute to saving resources on an industrial scale.

To allow them to chart ever new territory using highly sophisticated experimental protocols, researchers themselves are often times using up costly and scarce resources. As such, the Dresden High Magnetic Field Laboratory at the HZDR recently faced a drastic shortage when the noble gas helium was running low. In an interview, physicist Thomas Herrmannsdörfer talks about the steps his institute took in response to this shortage.

Expert knowledge has become a vital resource in many areas, from research to industry, even politics and society. Our scientists are using their own energies for the generation and dissemination of knowledge. Each new research finding thus becomes a building block in the construction of a most immense knowledge and resource library our prosperity is based on in no small part.

Wishing you an enlightening read,

Christine Bohnet
HZDR Department of Communications and Media Relations

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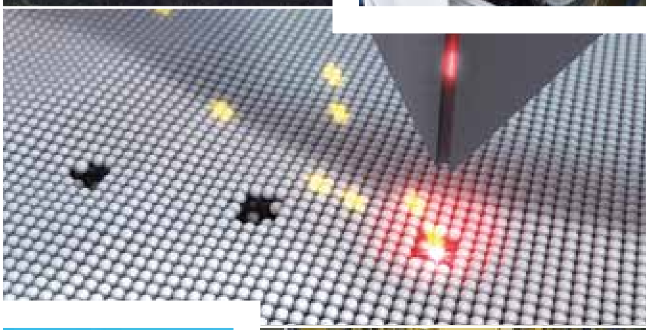

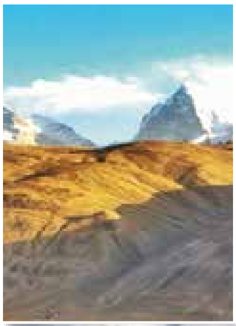

// Experts in reactor safety at HZDR are researching how to make solar power plants more efficient.

WITHOUT ANY LOSSES: At the DUKE test facility, steam is generated directly inside the parabolic troughs' tubes for subsequent power production. Photo: DLR

SIMULATED FLOWS

_TEXT . Roland Knauer

As usual, the devil is in the details. For the energy turnaround, scientists and politicians have committed to solar power plants, which use rays focused from the sun to generate steam, and therefore operate just like coal-fired or nuclear-powered turbines and generators. The electricity produced in this way is largely carbon-neutral because the steam is generated by solar power instead of fossil fuels. The German Aerospace Center (DLR) is researching a promising variant to this technology close to the Spanish city of Almeria. Concave mirrors there concentrate the sun's rays onto long tubes in which this concentrated energy converts water directly into steam. In principle, the physics is very simple. Looked at in detail, however, the flow of this mixture of water and steam contained in the absorber tube can be quite unstable. Since these instabilities in two-phase flows can have an impact on the cooling system and thereby place greater demands on the materials, engineers would naturally like to avoid them. And best right from the start. The doctoral dissertation by Alexander Hoffmann at HZDR should help with exactly this problem.

For a young engineer, working on a future technology right off in your dissertation is a dream job, of course. Even if the task is considerably more complicated than it appears at first glance. This is because the absorbing tube is no drinking straw – it has an interior diameter of five centimeters (two inches) and is made up of different segments, referred to as collectors, that are about a kilometer long in total. While quite ordinary water flows through this long component, the water is subjected to extreme conditions compared to usual ones found otherwise on Earth.

Instabilities in the tube

Even right at the inlet of this installation, the water can be about 260 degree C (500 degree F). In order for it to remain in liquid state, the pressure in the tube is eighty times higher than air pressure at sea level. Over the first hundred or so meters of tubing, the focused solar radiation increasingly heats up the water until it begins to turn to steam. At that point, even the high pressure is no longer sufficient to prevent →

A DIFFERENT KIND OF POWER PLANT: Parabolic trough power plants use focusing mirrors to concentrate sunlight onto an absorber tube. The heat energy that is captured within the tube is then used to produce steam to power a turbine. Photo: DLR

the transition from liquid to vapor. However, this does not happen all at once, but gradually instead. Over a stretch of more than half a kilometer (> 500 yards), the focused solar radiation adds energy to the liquid that no longer increases its temperature, but instead transforms the liquid increasingly into steam. Only after about three-quarters of a kilometer has the water been completely converted to steam. The sun's rays further heat this steam over the remaining about 200 meters. The higher the temperature becomes, the more efficiently the turbines operate and the higher the effectiveness and thus the yield of electricity.

The devil is in the intervening half kilometer, where increasingly more steam is developed in the water-steam mix. "Instabilities can arise due this two-phase flow for various reasons," explains Alexander Hoffmann. In the simplest case, they occur when the sun penetrates the cloud cover again after a period of time. More focused solar energy reaches the tubing then, which vaporizes more water, and thereby shortens the stretch over which the water/steam mixture is travelling. The engineers can imagine a whole series of conditions under which these kinds of instabilities can arise and stress the material, and thereby reduce its durability and operating life. Even worse: it is possible for instabilities to arise that have not yet been observed at all.

Nuclear know-how for solar power plants

To better understand the processes, you can simulate the flow conditions of the steam-water mixture on a computer. To develop software for this would far exceed the scope of a doctoral dissertation. However, the Gesellschaft für Anlagen- und Reaktorsicherheit GRS (Association of Plant and Reactor Safety) in Garching, near Munich, Germany, has already developed and successfully used simulation software for an entirely unrelated, but very similar problem. Two-phase flows of steam and water can circulate, namely, in the cooling circuits of a nuclear power plant. HZDR engineers rely on this ATHLET software from GRS. They are very familiar with the simulation program as well as the flow behavior in nuclear power plants. Alexander Hoffmann based his research precisely on this transfer of know-how.

In applying the software, he does not want to find out just whether there are as-yet unobserved instabilities. He primarily would like to investigate under what conditions reliable operation is feasible. Furthermore, one could also use the software for improved control over the entire solar power plant. Using this knowledge, which researchers at DLR will also in part be testing in practical experiments, the parabolic trough power plants should be able to be operated not just better, but also more economically.

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// Materials scientists at the HZDR and at Spanish global leader Abengoa are investigating how solar facility efficiency may be optimized.

REALIZING POTENTIAL: Together with their colleagues at Abengoa Solar, the company which operates this parabolic trough facility near Seville, Spain, HZDR materials scientists are working on increasing solar thermal power plant efficiency. Photo: Abengoa Solar, S.A.

HARVESTING SUNLIGHT

_TEXT . Uta Bilow

Day in and day out, the sun is shining in the sky. Its rays transmit light and heat to Earth and the total of this energy surpasses global energy consumption many times over. That explains why much research has gone into figuring out just how this incredible gift may be exploited. Photovoltaics and solar thermal energy conversion can be used to harvest sunlight and generate electricity and heat in an environmentally-friendly and emission-free manner. One option is given by solar thermal power plants which today are found in many of Earth's sunnier regions. These plants include parabolic trough facilities that capture sunlight by means of curved mirrors and concentrate it onto a centrally positioned, fluid-containing pipe. The fluid heats up and powers turbines that are coupled to a generator. The World's largest facility was opened in Abu Dhabi in March 2013. Covering an area the size of 350 soccer fields combined, the facility consists of a quarter of a million mirrors and supplies electricity to some 20,000 Emirate households. Yet another option is the solar tower facility, where a plethora of planar and repositionable mirrors focus sunlight onto a tall tower containing a heat transfer medium, which then takes up and transmits this energy.

The truth though is that we've not even begun to tap the inherent potential of these types of facilities. In order to increase efficiency, Helmholtz-Zentrum Dresden-Rossendorf scientists are working with their colleagues from the Spanish company Abengoa, a true pioneer in energy research. "We're looking for new, highly efficient materials capable of harvesting even greater quantities of sunlight," says Gintautas Abrasonis from HZDR. The goal is to use these materials as thin coatings on the central absorber unit to capture all of the visible light and convert it to heat that won't get reemitted. Therefore, the Dresden researchers are →

studying different kinds of materials to assess their potential to act as an absorber, including carbon and nitrides or oxide based nanocomposites that can be customized, produced, and modified at the ion beam center with its variety of experimental options.

The one thing all of these various efficient absorbers have in common is their color – black. "Really it's like your car's coat of paint: If it's black, it gets much hotter on the outside than does a light-colored one," the physicist explains. The HZDR researchers are able to take highly precise measurements of this everyday phenomenon. To this end, a new facility – called a cluster tool – was installed at the ion beam center. Covering an area of a few square meters, stainless steel chambers are interconnected by tubes. Samples can be introduced into this vacuum system through a small gate and passed from one chamber to the next. The cluster tool offers scientists unprecedented possibilities. Different kinds of atoms can be specifically introduced into a sample. "This basically allows us to define the material's properties," explains Gintautas Abrasonis. At the same time, using ion beam analytics, measurements of the distribution of different chemical elements within the layers can be obtained and their optical and thermal properties adjusted.

COLLABORATING PARTNERS: Spanish solar company Abengoa's Campus Palmas Altas headquarters in Seville, Spain. Photo: Abengoa Solar, S.A.

Running tests on black layers under environmental conditions

The cluster tool's main piece is a chamber, inside of which real-life conditions can be simulated. During the day, it gets rather hot in those locations where most solar facilities are found, whereas at night, temperatures tend to plummet. Wherever the focused sunlight lands, temperatures higher than 1,000 degrees C may result. In addition, the layering has to be mechanically stable so that a sandstorm is not able to scratch it up. And the normal environment – air, oxygen, water vapors – should not be able to harm the absorber film either. In other words, the material has to be able to withstand a

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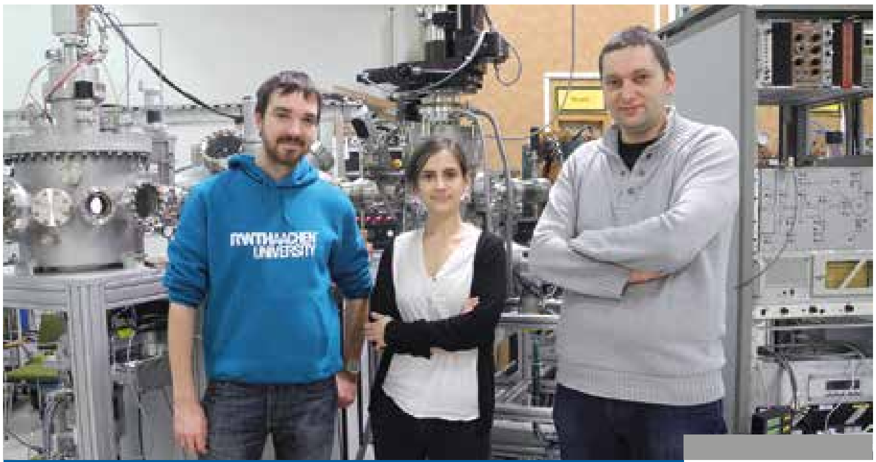
AIMING HIGH: The World's first commercial solar tower facility near Seville, Spain, produces enough energy to power 6,000 households. Photo: Abengoa Solar, S.A.



A JOINT AFFAIR: Irene Heras Pérez of Abengoa Research (center) with HZDR researchers Gintautas Abrasonis (right) and Erik Schumann.

host of different stresses and strains. The new environmental chamber allows scientists to simulate conditions ranging from an arid desert environment to one of high humidity, and to obtain measurements of different material properties under these extreme conditions.

A second project the HZDR researchers are working on with their Spanish colleagues involves photovoltaics, the direct conversion of sunlight to electricity. The focus is on silicon based thin-film solar cells whose efficiency the researchers are hoping to optimize. The HZDR researchers are focusing on an innovative concept: Nanostructures are supposed to make silicon a more efficient material. "Using special thermal treatment, we're able to produce silicon based nanocomposites," says Gintautas Abrasonis. Next, the physicist examines the samples' properties, in other words, their optical properties and the electrical transport within the material. Initial results suggest that these nanostructures are superior to traditional silicon. The Abengoa collaboration got started at the end of 2012: in Spain and Dresden, a team of two scientists and three Ph.D. students are together working on the project. This is exactly why Gintautas Abrasonis is confident that through team effort, ways will be found to more efficiently harvest sunlight.

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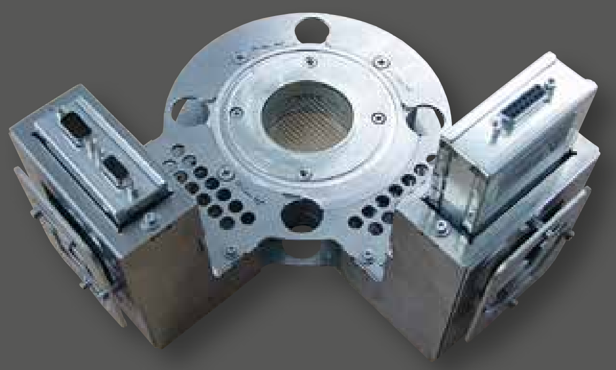
Unique measurement technology for solar thermal energy

In solar thermal power plants, like parabolic-trough power plants, sunlight is bundled inside a pipe with the help of curved mirrors to convert the water inside the pipe into steam for powering turbines. Such mixtures made up of gas and liquid parts are known as multiphase flows.

Wire-mesh sensors from HZDR positioned across the diameter along the absorbing tube are able to measure the flow's structure and the steam content of multiphase flows at high spatial and temporal resolutions. The information thus obtained can help to assess a parabolic-trough power plant's efficiency. At the same time, the measurements yield valuable information for use in basic experiments as well as for the design and layout of the facility. HZDR systems are designed to withstand temperatures of up to 300 degrees C and pressures of up to 70 bar – a field of application which is still unparalleled in the area of high-resolution multiphase measuring techniques.



Wire-mesh sensors developed at HZDR for employment at high pressures and temperatures.

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WASTE THAT IS BRIMMING WITH ENERGY

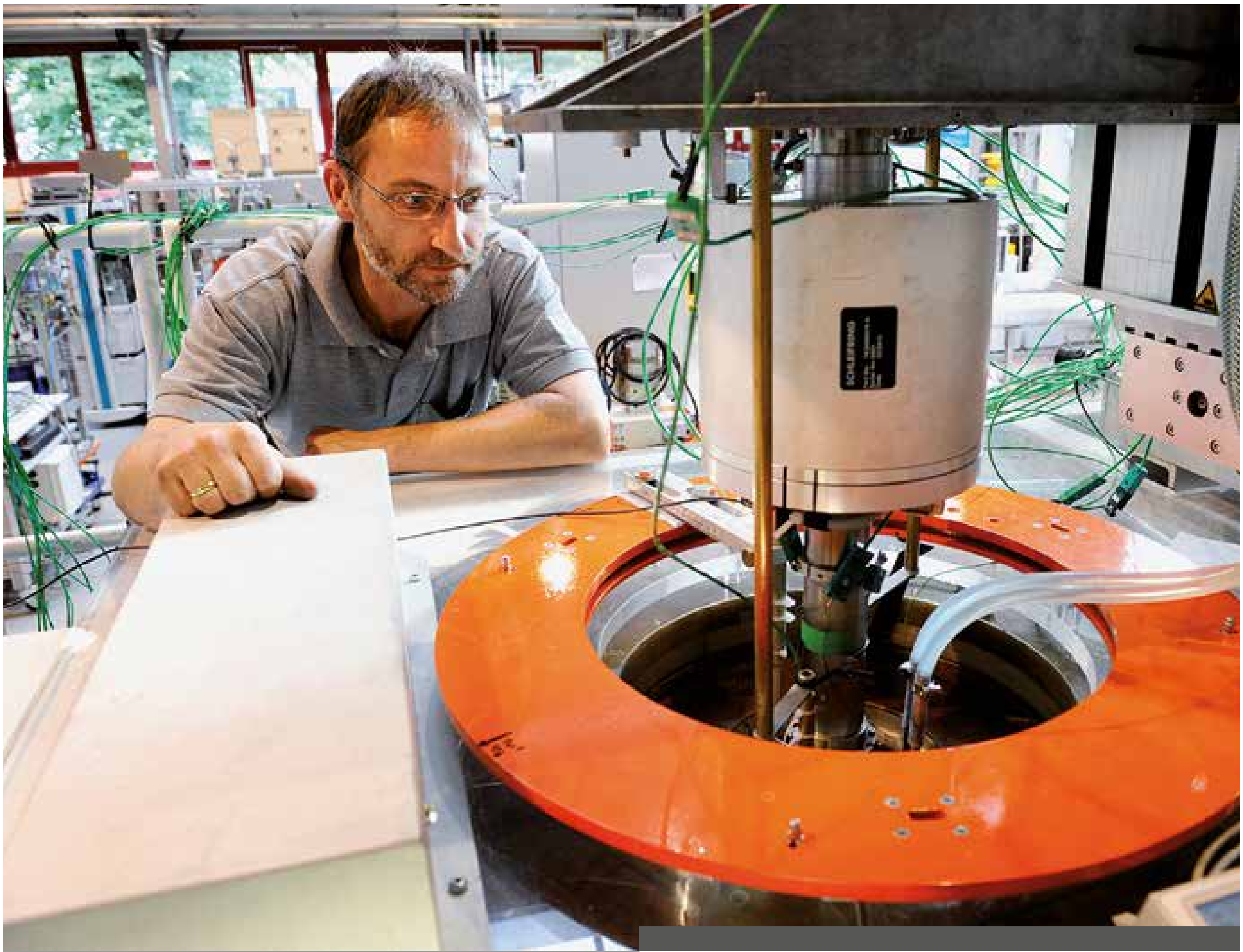
_TEXT . Christine Bohnet

Photo: © il-fede – fotolia.de

// It's a well-known fact that the energy yield from solar modules like the ones found in large energy parks or on the rooftops of private homes all across the country is decidedly small while the energy investment required for their production is all the bigger. Production waste recycling just might turn out to be a real magic spell.

The semiconducting material silicon is found on our rooftops in ultrathin slices, packaged inside solar modules that for the most part were cheaply produced in Asia. A substantial portion of this silicon, which was won at the expense of high energy input, is lost as early as the wafer production process. When slicing large blocks of silicon, fine silicon powder is produced as a by-product. What is frustrating is the fact that just as much raw material ends up being wasted as the amount of material that ultimately ends up as part of the slice. This is due to the fact that the saw that is used - a wire made from silicon carbide or even from diamond - is almost as thick as the slice itself. What if it were possible to capture the sawdust, re-melt it, and, in doing so, substantially increase the material and energy efficiency of solar silicon? Such was the question asked by the Italian company GARBO and physicist Sven Eckert of the Helmholtz-Zentrum Dresden-Rossendorf, who recently took on the role of coordinator of the EU project SIKELOR, which the Universities of Greenwich, UK, and Padua, Italy, as well as Chemnitz-based EAAT, a medium-size German company, are all involved in as well.

Sven Eckert describes the challenges the EU partners are finding themselves faced with in terms of raw material processing as follows: "The silicon chippings that end up →



WITHOUT A SINGLE TOUCH: Magnetic fields stir liquid metals but they are also capable of flow deceleration and acceleration. Josef Pal is seen here conducting an experiment at the HZDR's MULTIMAG (Multi Purpose Magnetic Field System). Photo: Frank Bierstedt

as part of the sawdust ought to be re-molten, ideally separated out by type. Which is why we have to first separate them from the fluid that is used as part of the sawing process. Next, the dust is condensed and molten. However, the resulting dust contains impurities. Since the chippings' surface is large compared to their volume, oxidation takes place such that a lot of silicon dioxide is allowed to build up. In addition, carbon particles end up in the sawdust and, during melting, silicon carbide is produced as an unwanted waste product. Our goal is to come up with an economically feasible process for industrial recycling of silicon waste."

Magnetic fields are the key

The ultimate goal is to develop an industry-compatible process by the end of the three-year period the EU project is scheduled to last. Electromagnetic stirring and separating figures are prominently in the picture. Magnetic fields have long been used to grow crystals, for instance, in the production of silicon monocrystals with diameters of up to 300 millimeters, like those used in modern-day chip production. The effects of a non-contact, externally applied magnetic field on the flow of an electrically conductive molten metal is considerable: Molten metals can be stirred, calmed, decelerated, even swirled.

The HZDR researchers have several years' worth collective know-how under their belts, especially when it comes to dirt particles embedded within molten metals. "We're mostly preoccupied with the question of how the magnetic field and coil have to be configured in order to effectively stir the contaminated mixture. Imagine a bucket containing a liquid and flakes of dirt. You might try and stir it so the flakes get spread out evenly so that you could live with it. Or you try and separate out the dirt by stirring and allowing it to deposit on the edge where you're able to fish it out of the liquid," Sven Eckert explains. →

An initial proposal for compaction of the sawdust was submitted by the company GARBO. The compacted material has to be inductively heated and molten using high-frequency magnetic fields. Thereafter, it's important to collect the contaminants at the edge of the molten metal and separate them out. Due to differences as regards the electrical conductivity of silicon and silicon oxide or silicon carbide particles, an electromagnetic force acts on the dirt particles, which can be adjusted in such a way as to cause the contaminants to migrate towards the edge. At the same time, however, you have to make sure that the silicon flow, which is caused by the magnetic field, doesn't end up negating this separation effect through too intense mixing. In other words, you need a cunning combination of magnetic field parameters to bring about the desired results.

"That is what we're working on right now. MULTIMAG, our magnetic multi-function facility at the HZDR, allows us to set up different flow forms and speeds and we're counting on getting the hang of it," says liquid metal expert Eckert. As soon as the HZDR scientists are successful at proving this using their model alloy - which is liquid at room temperature - they're planning on building a demonstrator to help them even better understand the different steps of the process using their own measuring technique. Numeric models designed by their London colleagues at Greenwich University will also help with a better understanding.

But before they are transferred to the industrial setting, the worked-out steps of the process have to first be tested on silicon; after all, the metal won't melt until it has reached a temperature of 1,410 degrees C. Since scientists at Padua University are able to melt and process silicon, they will be able to build a demonstrator for use with the silicon in this process on the basis of insights from Dresden and London. The German company EAAT is planning and supplying the necessary power supply. The facility has to be able to drive different heating steps and set up different magnetic field frequencies. Unlike current heating processes, the EU project is using an induction process known from induction heating and its optimization, customized to the desired degree of particle segregation.

The partners from both science and industry have a clear-cut goal: To use a single process in partly parallel steps to compact and melt the expensive silicon waste, separate out the inevitable dirt particles - and all this from an ecological and economical perspective. Only then, Sven Eckert is certain, can the energy yield of photovoltaic silicon be improved by a substantial factor even when considering that for compacting and melting the silicon chips energy has to be put in as is true for electromagnetic stirring and separation.

Silicon – next steps

Silicon is the material of choice on a rapidly growing solar market as it is comparatively efficient at converting energy from sunlight into electricity. In Germany, some 32 gigawatts of performance are currently installed in photovoltaic modules and the sector's plan is to ultimately increase that number to more than 200 gigawatts. Then as now, new concepts are needed for continuously improving efficiency. If, in the context of the SIKELOR project, it were possible to process the raw material which accumulates as dust during wafer production, this could mean the solar industry would be able to save on expenses. Currently, the cost of silicon on the World market is around 18 US dollars per kilogram - experts, however, are projecting that this price will go up significantly within the next several years - the SIKELOR partners are projecting a cost of a mere 10 US dollars per kilogram of recyclable material for their recycling process.

Finally, even recycling worn-out solar modules could help continue to improve photovoltaics' energy balance. Sven Eckert and his HZDR colleagues are already thinking about whether or not - and, if so, then how - silicon waste might be recycled. Unlike during the manufacturing process, they would then be looking at large silicon wafer splinters and fragments. A novel but at the same time an exciting challenge.

TORNADO INSIDE THE LAB: Magnetic fields produce flows inside a fluid-filled cylinder that can be examined with the help of ultrasound technology. Photo: Rainer Weisflog

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// Using X-rays to understand flows, and to improve chemical processes.

FROM THE "TEST TUBE" TO THE CHEMICAL REACTOR

_TEXT . Roland Knauer

RAPID IMAGES: Electrical engineer Martina Bieberle is using images of liquid and gas flow mixtures taken with X-ray tomograph ROFEX. What makes them stand out is their unusually high temporal resolution. Photo: Rainer Weisflog

The trend towards environmental sustainability has not escaped the attention of chemical industry, of course. The production of important products often requires not just huge amounts of energy, but also consumes vast amounts of money. As a result, the industry has been committed to optimizing its manufacturing processes for a number of years. As liquids play an important role in many of these processes, the fluid flows in the reactors are crucial to the energy balance and to the product yield. It is precisely these processes that have hardly been investigated so far. Now, however, Markus Schubert from the Helmholtz-Zentrum Dresden-Rossendorf is pushing this basic research along with these kinds of specific applications in mind.

The process engineer is working on the transition from the test tube to large chemical reactors. Many reactions work very well in the laboratory, but their efficiency deteriorates considerably when they are scaled up. It stands to reason: As gases react with liquids in many of these reactions, the flows of both these phases also influence the reaction rates and energy consumption. In a test tube, the flows hardly play any role, while in considerably larger chemical reactors, their role is significant.

Schubert is investigating fluid flows of gases and liquids in a bubble column reactor. Basically, this is a glass cylinder with a diameter of about 20 centimeter (almost eight inches), can stand a few meters in height, and contains water for the initial experiments. "Many industrial reactions are with organic liquids, but water is a reference system for which a relatively large number of results is available," the researcher explains about this choice. Later on, he will also examine organic liquids in detail, of course. →

Smaller bubbles for larger yield

The gas, required for the reaction, is fed through holes of a perforated plate at the bottom of the cylinder. As the gas flows through these holes, small bubbles form that rise upwards within the column. That does not happen in a straight line at all, however, which a glance at the air bubbles produced by an exhaling scuba diver demonstrate. Also, it does not happen uniformly. While rising, a gas bubble is displacing the liquid at its front end, of course, thereby creating a kind of wake for the adjacent little bubbles below. "The rising bubbles resemble the movement of a flock of birds a bit, with the whole thing looking like ordered chaos," says Schubert in describing this behavior.

"The rise of the gas bubbles also leads to backmixing of the liquids, of course, which influences the processes. The liquid flows primarily upwards in the middle of the tube, and circulates downwards again at the edges," the researcher explains further. Therefore, it is very important for a process engineer to carefully observe the structure of the two-phase flows. On top of that, he not only wants to know how large the individual bubbles are, but also how often two or more of them coalesce into a larger bubble. The more small bubbles exist in the liquid, the larger the surface area of the gas is. It is precisely this large surface area that is needed for the chemical reaction. Less big bubbles instead of many small bubbles, accordingly means lower yield and thus higher costs.

To determine the optimum operating conditions for individual reactions, Schubert analyses the fluid dynamics using ultrafast computed tomography developed at HZDR. The tomography equipment normally employed for diagnostics in hospitals cannot be operated rapidly enough for the high-speed imaging necessary here. For that reason, HZDR researchers use X-rays produced from electron beams hitting a tungsten target. The electrons can be steered very rapidly using focussing coils; the position of the produced X-rays then changes correspondingly quickly. These X-rays are attenuated by water more than by gas. Detectors subsequently measure how intense the X-ray radiation is still after passing through the flow. Sophisticated software programs then reconstruct the images of the bubbles in the liquid, similar to the images known from medical diagnostics. This technique can produce thousands of images per second of the flow in a cylinder without problem.

In parallel, Schubert is developing computer models to simulate the flows. Here, he is first considering water-air systems. In order to reliably simulate the flows of other liquids as well, a researcher would then just have to enter the commonly known properties of the liquid into these models. And surely, real experiments will follow later, using organic solvents for example. Eventually, the researcher wants to provide the industry with basic parameters and methods that enable them to reduce energy consumption for individual reactions. ⊣

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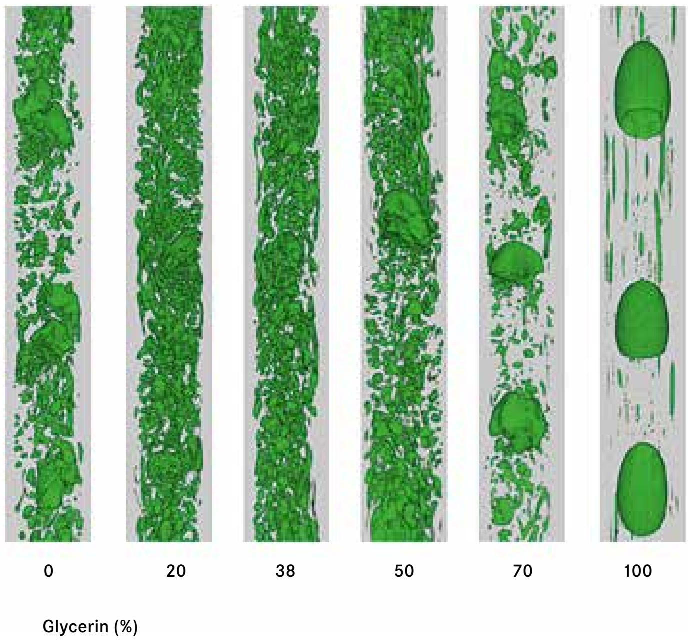
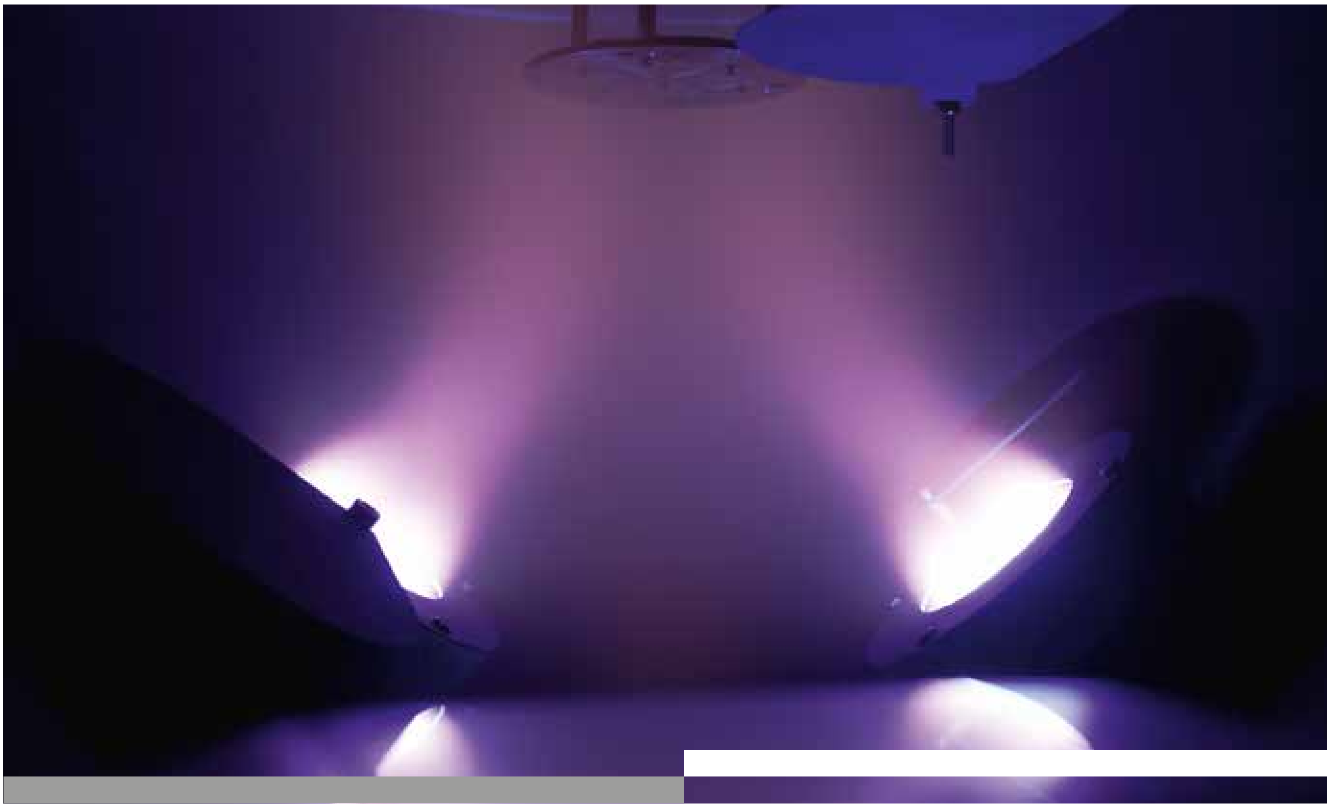
BUBBLE FLOW: This image nicely documents how flow structures can arise inside a narrow 70 mm diameter bubble column. Measurements were obtained using ultrafast X-ray computed tomography developed at the HZDR. The flow's multiple individual "sectional images" that were taken at a 1,000 Hz frequency (i.e. 1,000 images per second) are ultimately compiled into three-dimensional structures.

In this study, all liquids were aerated with the same amounts of air while their viscosity was increased from left to right. Viscous fluids, which are distinctly different from water, may arise during sewage treatment or inside bioreactors. Their viscosity affects their flow structure - from several smaller-sized bubbles to dense bubble flow all the way to regular large bubble formation.



// A car engine's moveable parts are exposed to considerable friction which leads to undesirable wear as well as energy losses. HZDR researchers develop functional coatings to reduce friction.



GASEOUS DISCHARGE: Whereas a fluorescent lamp's gas or glow discharge is what makes it light up, its job inside this coating chamber is to ionize argon atoms that emit a purple glow.
Photo: Jürgen Jeibmann

NEW COATING CONCEPTS TO OFFSET FRICTION

_TEXT . Uta Bilow

Today's cars are using considerably less fuel than they did only a decade or two ago. That's good news for drivers because it helps keeping expenses in check. Potential savings are, however, far from optimal. What many people are not aware of is that a substantial portion of fuel is not used to power the car but is in fact lost - which clearly is suboptimal. Whenever moveable parts such as the crank or piston are working, not only are forces being transmitted but friction, too, is produced. This friction is unwanted, because it means lost energy. It impedes motion, generates heat, and causes wear. Fuel consumption goes up as does carbon dioxide emission. "Friction lowers energy efficiency," says Sibylle Gemming of the Institute of Ion Beam Physics and Materials Research. "Whatever is lost due to friction is essentially wasted." At the Helmholtz-Zentrum Dresden-Rossendorf, the chemist works on developing new kinds of materials that are more energy efficient and thus help saving fuel and lubricants. Gemming's research in this area is one of a number of projects that together form the leading-edge technology cluster ECEMP (European Centre for Emerging Materials and Processes Dresden).

Six years ago, scientists at the TU Dresden, the HTW Dresden, the TU Bergakademie Freiberg, and various research institutes – including the HZDR – teamed up with Werner Hufenbach at the Institute of Lightweight Engineering and Polymer Technology as head of the group, to explore new types of materials and come up with new options for their application. "We're looking to develop multicomponent materials for use in energy and environmental technology, and lightweight construction," Gemming explains, outlining the cluster's scientific scope. The red thread is energy efficiency. For the last five years, the leading-edge technology cluster has been funded through the European Union and the →

Initiative of Excellence of the Free State of Saxony. According to Gemming, "Dresden is perceived as one of Germany's top materials research sites. In the cluster's 14 sub-projects, chemists, physicists, materials researchers, and engineers are all working side by side. The entire spectrum of expertise is represented."

Maximizing Saxony's knowledge potential

HZDR researchers coordinate the sub-project CarboFunctCoat. The abbreviation stands for "Carbon-based functional coatings for use in tribological applications." Within the project the researchers have specialized in components that are constantly exposed to motion and thus to great stresses like piston rings or pins, eccentric shafts, or parts of the fuel pump. "All these various parts of a car engine have very sophisticated three-dimensional geometries," says Sibylle Gemming. Especially the use of fuels from renewable sources places unique demands on coatings as the combustion chemistry of these biogenic fuels is much more diverse than that of fossil fuels. Until now, the researchers have identified two types of coatings that could help curb energy losses in moving engines. One of the coatings is based on so-called tetrahedral amorphous carbon (ta-C). The material is a version of what is known as diamond-like carbon (DLC), first described 20 years ago in this context and used extensively in different industrial settings. ta-C is even harder and denser than DLC, and also contains fewer hydrogen atoms, which positively affects its properties for the purpose of the project.

The other coating, which is investigated to offset friction, contains additional metals and exhibits a highly ordered nanostructure. Both coatings are very resilient – even in the face of high temperatures as they exist in a car engine –, act to offset friction, and thereby prevent excessive wear of the engine parts.

New kinds of carbon-based materials

"At the HZDR's ion beam center as well as at the site of our project partner, the Fraunhofer Institute for Material and Beam Technology (IWS, Eckhard Beyer), we have the option of coating engine components using carbon-based coats, thereby improving their friction behavior," explains Gemming. The ion beams that are used at the HZDR open up unique possibilities for material synthesis and modification. A new high-tech facility allows us to evenly coat even complex forms and thus eliminate surface inhomogeneities. Together with engineers at Dresden-based VON ARDENNE GmbH, Sibylle Gemming and her team have recently filed a patent application for a process allowing them to deposit even thicker coats without prolonging the coating process.

The coated components are regularly tested under real-life conditions. This testing takes place at TU Dresden's Institute of Automotive Technology lead by Hans Zellbeck, another partner within the ECEMP consortium. The engineers incorporate the coated components into several drag-test and fired benches. In this way they track how fuel consumption

HIGH-TECH COATING SYSTEM: Inside a specialized plasma chamber, HZDR scientists produce functional coats for high-impact engine parts. This is based on a sputter protocol for generating electrically charged argon atoms. If these are accelerated, atoms are being "knocked" out of a cathode, make their way to the material surface that is supposed to be coated, and upon their arrival produce the desired coat. Photo: Jürgen Jeibmann

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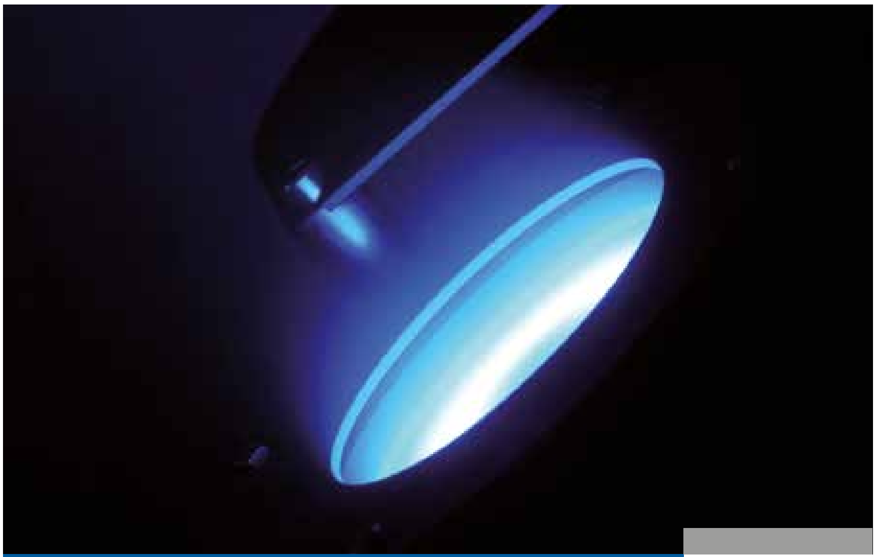

TITANIUM: The more titanium atoms that are ionized, the bluer the plasma inside the coating chamber looks. Photo: Jürgen Jeibmann

and CO_2 emission change as a result of the reduced friction. "The engine test benches are equipped with the latest metrology," says Sibylle Gemming. "They allow testing all relevant combinations of coatings, fuels, and lubricants."

Atomic-level simulations

From the atom to the complex component: that is the ECEMP's research motto. The scientists of CarboFunctCoat are not only interested in developing coating technologies or producing final components, they also aim at understanding phenomena such as friction on an atomic level. What happens at the time of contact between two components? How does friction between atoms develop? What are the consequences for the material? These are but a few of the questions the HZDR researchers are looking to answer together with theoretical chemist Gotthard Seifert at the TU Dresden. By way of simulations, they create a scenario where two uneven surfaces slide against each other. In the process, the scientists have discovered a number of interesting issues. For example, if two ta-C coats are in close contact with each other, the uppermost atomic layer's chemical structure changes in a very specific way. Thus, the material of the contact area becomes softer and the frictional impact drops. In addition, this structural change leads to a lubricant being able to dock to the surface particularly well. This helps explaining why ta-C coatings can reduce friction.

The results achieved in the context of CarboFunctCoat have recently created a new project to study the microscopic mechanisms of friction and wear in greater depth. To address this fundamental task, the tribology expertise of the project partners at the Institute of Manufacturing Technology is combined with expertise in the area of ion-beam materials modification and analysis at the HZDR's ion beam center. Here, scientists are able to use specialized equipment to simulate friction processes and immediately analyze their effects. This demonstrates once more the great versatility of ion beams as a research tool.

But the ECEMP cluster has a much broader success story. Every fall, the cluster organizes a highly popular colloquium. "Initially, it was rather centered around basic science research," Sibylle Gemming recalls. "But by now the program is very strongly application-oriented, with many international partners including several from industry." This demonstrates the outreach of the findings by CarboFunctCoat and the 13 other projects into industry.

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// Just in time, an important extension of the HZDR was recently completed: the new building for the helium liquefier which is scheduled to become fully operational by March 2014. The research community is currently bracing itself for a devastating price increase or, possibly, even a serious bottleneck for liquid helium. Thomas Herrmannsdörfer, division head at the Dresden High Magnetic Field Laboratory (HLD), sheds light on the situation.

SCARCE, SCARCER, HELIUM

_Interview . Sara Schmiedel

Mr. Herrmannsdörfer, why is it so important for the HLD to run its own helium liquefier?

Here's the issue: The global demand for helium has been increasing steadily over the last few years, for example through the economic and scientific catch-up of up-and-coming nations like China. In response, the global helium supply either stagnates or drops. There is also the very real possibility that the US National Helium Reserve will be shut down. Within a few years, two-thirds of the helium supply that had been built up over several decades were being sold out. This is now recognized everywhere and it could easily lead to a crisis. There is a real fear on the part of our US colleagues, e.g. at the National High Magnetic Field Laboratory in Tallahassee that they will no longer receive enough helium from the reserve.

Are there no helium deposits outside the US?

Here on Earth, helium is a natural gas by-product. Unfortunately, only a handful of large natural gas sources have been tapped that contain sufficient quantities of helium: outside the United States, the only other sources are in

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THE HELIUM LIQUEFIER'S CENTERPIECE:
Thomas Herrmannsdörfer at the coldbox, inside of which gaseous helium is purified and liquefied.
Photo: Oliver Killig

Algeria, Qatar, and Russia. The one that's closest to us is Wrocław, but that one is small by comparison. Europe's helium supply is highly dependent on the refineries at these larger sources as well as on overseas transports. In case there is a problem, this is instantly reflected by supply bottlenecks.

What does the HZDR need the helium for and what are the associated costs?

This year, we ordered 100,000 liters at the HZDR, and some 70 percent of that amount we need at the HLD. We use the helium for low temperature experiments. We also use it as a coolant for our superconducting magnets. True, we collect the helium and sell it back to our supplier, but unfortunately we only ever recoup a small part of the original cost. Each year, the whole affair is costing us several hundreds of thousands of Euros.

Are there alternatives to helium cooling?

No, not really. True, there are such things as closed cryosystems, but their main advantage – no helium losses – goes hand in hand with a high electric energy consumption and, unfortunately, with vibrations as well which have a negative impact on a number of precision-measurement techniques. Furthermore, it would be a huge effort to retrofit all of the measuring setups.

Did you already begin to feel the bottleneck?

Definitely! Especially in October and December of last year we were sitting and waiting in vain for weeks for the helium we had ordered. Thankfully, we were able to serve those users that had traveled far to do research at the HZDR, but our own research took a real hit due to the helium scarcity and sadly this bottleneck is back again just now.

Will the HZDR become fully self-sufficient once the liquefier becomes operational?

Not completely. There are process and operations based losses of experimental setups, collecting systems, and high pressure storage tanks. We expect that we will incur losses of around ten percent, which is the best of what's been possible in facilities of comparative size. Our plan is to buy slightly impure helium gas – which is much cheaper than buying pure liquid helium; purification and liquefaction we can do here at our own facility.

The extension building was finished in a matter of months, was that just in time?

Yes, I think so. All suppliers are predicting that a crisis is impending. When exactly it will arrive in its full scope, nobody knows. We're happy that our approach to using helium as a resource is future-oriented and that we noticed the first signs of the crisis. The fact that the HZDR's board of directors acted so supportive in acquiring the helium liquefaction facility and that Mr. Reichelt's team [Editor's note: Central Department Technical Services] was able to make the add-on happen in record time was essential. This way, we will be able to ensure future research activities of our own staff as well as external user groups.

GREATER CAPACITY: To meet the increased demand for measurement time in highest magnetic fields, an extension to the Dresden High Magnetic Field Laboratory will open its doors for external users as of 2014.

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// The search for mineral resources in the Ore Mountains (Erzgebirge) of Saxony, Germany, is being conducted both by helicopter and on the ground. The first flight took place in October. The goal: to test low-impact sensing methods.

MEASURING FLIGHT: This helicopter is capable of detecting raw materials that are hidden up to 500 meters below the surface.
Photo: Detlev Müller

ORE MOUNTAINS

_Text . Anja Weigl

A pithead building, a glory hole, the Brotherhood of Miners – one notices that mining was carried on here in Geyer at one time. And the era of mining may not be past yet – at least mineral exploration is being carried on once again in the vicinity of Geyer. A subsidiary of Deutsche Rohstoff AG drilled for tin south of the town and estimated the deposit to contain 44,000 tons of tin accompanied by significant amounts of indium and zinc. The Helmholtz Institute Freiberg for Resource Technology (HIF), part of HZDR, is interested in the resource potential of an area west of Geyer – from a scientific point of →

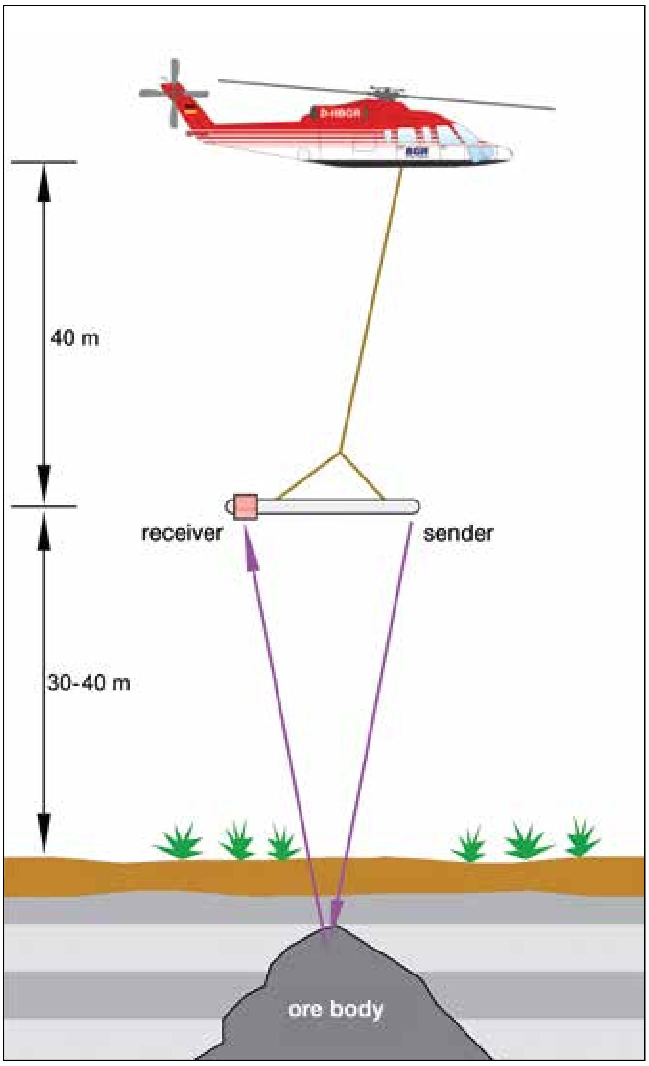
GENTLE EXPLORATION OF RAW MATERIALS:
Several institutes are all pooling their know-how (from left to right): Olaf Hellwig (TU Bergakademie Freiberg), Jens Gutzmer (Helmholtz Institute Freiberg/ HIF), Saskia Stein (HIF), Mathias Scheunert (TU Freiberg) and Bernhard Siemon (Federal Institute for Geosciences and Raw Materials). Photo: Detlev Müller

view, however. The researchers want to jointly develop non-invasive mineral exploration methods to detect so-called blind ore deposits, i.e. deposits not exposed at surface.

The area is about 110 square kilometers in size and comprises the municipalities of Ehrenfriedersdorf, Gelenau/Erzgebirge, Lauter-Bernsbach, Grünhain-Beierfeld, Lößnitz, Elterlein, Raschau-Markersbach, Thum, Zwönitz, Auerbach, Drebach, and Geyer, as well as Schwarzenberg/Erzgebirge. "It is well-documented that mineral deposits of tin and zinc as well as tungsten and indium occur in this region," according to HIF Director Jens Gutzmer. His staff had learned this from researching the archives of the Saxony State Office of Environment, Agriculture, and Geology. From the point of view of mining, the region all around Geyer has been well explored – at least as far as one can judge from the individual bore holes drilled during the period of the German Democratic Republic. What the HIF scientists are now working on is a comprehensive investigation of Geyer Forest, which encompasses every inch of the ground between the earlier bore holes.

Electromagnetic signals from the air

The researchers are collaborating with the German Federal Institute for Geosciences and Natural Resources (BGR) in Hanover, which is employing its helicopter for the project. It represents a re-entry for the authorities into mineral exploration; the helicopter is used much more commonly in foreign locations for detecting water reservoirs. It's irrelevant though, whether water or minerals are involved – the method is the same. A ten-meter-long airborne sensor is flown on a 45 meters cable behind the helicopter. It contains the measurement instrumentation and transceiver for the electromagnetic signals. "It provides information about the electrical conductivity of the subsurface, which can be an indicator of the presence of ore," says Bernhard Siemon, head of Airborne Geophysics and Flight Operations at BGR. →



ELECTROMAGNETICS IN THE AIR:
Diagram depicting a helicopter and flight probe

The Sikorsky helicopter took off on its first data acquisition flight over the Ore Mountains of Germany (Erzgebirge) on 22 October, 2013. In the meantime, it has now covered the core area of Geyer Forest. It is expected to be there again during the next two years, but with new measurement techniques on board that the experts of BGR want to test. These techniques should enable mineral resources to be found at depths of up to 500 meters; during the first flight, the measurements were only able to penetrate to a depth of 150 meters. Even though the airborne probe is flown about 30 to 40 meters above the ground, you cannot see the distinctive helicopter from the ground very often. It flies over the area keeping distances of 300 to 500 meters, following pre-determined flight lines.

The BGR experts record countless data points. Nevertheless, they cannot draw definite conclusions about specific ore bodies. "You would have to go back and drill the identified target areas. Only these drill cores give exact insight as to which minerals in what quantities are present," according to Gutzmer. A further challenge: the researchers want to know exactly where the valuable resources are located in the subsurface. The airborne data by themselves are insufficient for this. Only the extent of the ore body can be determined from them. Additional measurement techniques are therefore needed.

Seismic waves in the ground

These techniques come from the Institute for Geophysics and Geoinformatics of the TU Bergakademie Freiberg. The researchers drop small weights on the ground there and set off small explosions similar to fireworks in order to create seismic waves in the ground. These are recorded by highly sensitive geophones. Since the individual strata in the subsurface reflect the seismic waves differently, the scientists can draw inferences about the subterranean formations this way. "The waves we create have a much lower signal level than signals created when the wind blows through the trees," says research associate Olaf Hellwig. The investigations therefore have as little impact on the environment as measurements by helicopter.

In addition, the plan is that researchers from the University will take over another important task in the project: all of the information collected is to be incorporated into a high-resolution spatial model of the Geyer Forest subsurface. The scientists already have experience with this type of mathematical modeling for areas in northern Germany, but the Ore Mountains are considerably more complex in architecture according to Hellwig's colleague, Mathias Scheunert. The experts of the Helmholtz Institute in Freiberg, the BGR, as well as those from the University all hope to present their findings publicly three years from now. It is conceivable that industry will be interested also. "First we have to await the investigations, especially those of the helicopter," says Gutzmer from HIF. "Then we can provide an informed assessment of the resource potential of the area. But the interaction of our proven low-impact methodology is just as important; it could be employed elsewhere for detection of mineral resources."

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// Sören Kliem is head of the Reactor Safety group at HZDR. He explains in a conversation with "discovered" why certain aspects of reactor safety research continue to be important, despite the energy turnaround with its nuclear phase-out decision in Germany.


Photo: Areva

"IT IS ABOUT ACTIVELY MAINTAINING OUR EXPERTISE"

_Interview . Simon Schmitt

Dr. Kliem, you were just at the 23rd Symposium of the Atomic Energy Research (AER) organization in Štrbské Pleso, Slovakia. Was there a special topic this year?

The conference normally has no special topic as a primary focus. It is much more an on-going exchange of information related to developments in safety research being conducted on what are known as water-water energy reactors, or WWERs.

What is involved with this?

This is a Russian type pressurized water reactor design. The term water-water stands for water-moderated and water-cooled, which means the water serves to both moderate the neutrons and remove the heat produced as well. This is exactly the same as in corresponding reactors designed in the West. The most important differences between these reactors lie primarily in the arrangement of the fuel rods in the reactor core and the orientation of the steam generators.

Do you see any trend at present for this type of reactor?

There actually is increased export activity of technology in this area by the Russians at the moment. Suitable preparations are being made, and WWERs are being built in India, China, Vietnam, Bangladesh, and Turkey at present. In addition, reactors of this type are on the list of reactors being offered under current tenders for new reactor construction in the Czech Republic and Finland. →

In contrast, Germany is exiting the field?

Yes, as we all know, Germany has decided on a complete phase out from electric power generation through nuclear energy and commenced an energy turnaround. We now face the consequences that result from this. Nevertheless, we continue to need active research in reactor safety.

Why is that?

Well, on the one hand, the last German power plant will only go off-line in 2022. The German federal Atomic Energy Act prescribes that reactors shall be operated in accordance with the current state-of-the-art in engineering and science. This applies through the last day of operation and beyond. The keyword here for this is "post-operation phase". We can only accomplish this if we continue to actively pursue research. But it remains important even afterwards that we maintain our expertise. It is only through our own active research that we can influence international development and safety standards. Germany is one of the leaders in the field of reactor safety. It is politically desirable that we continue to support improving the safety of nuclear reactors. Moreover, we need an independent investigative and assessment authority for our government in the future as well. It is well known, of course, that neighboring countries are planning new construction of nuclear power plants, some with new types of reactors even. France is planning the construction of a liquid metal cooled reactor, for example. This is a completely different technology that we naturally can only really comprehend if we actively involve ourselves with it. And this expertise will become especially important if we want to influence the licensing procedures – which the EU permits neighboring countries to do.

How could HZDR contribute here?

We still maintain some of the traditions of the former Rossendorf nuclear research center, which is also why we have become members of the Atomic Energy Research organization as experts on WWERs. We were able to develop a high profile based upon this expertise in the area of reactor safety research. Our reactor dynamics program, DYN3D, was designed especially for WWER accident analysis, for instance. We extended the code in the 1990s to handle light water reactors built in the West. We've established DYN3D as an independent and complementary tool for both application areas. It is being used by research institutions, the nuclear industry, and by licensing authorities as well. Now we want to adapt the computer program to cover new types of designs, such as liquid metal cooled reactors.

What is involved in that?

We need to adapt the software to the specifics of these reactors and incorporate models for effects that do not occur in the reactors we've considered so far.

Is it actually feasible in the long term to help determine international safety standards without operating one's own nuclear reactors?

But of course! There is already an example of this – following reunification, Germany abandoned WWER technology and shut down all of these reactors. But because we continued to conduct active research in this field, and by that I mean the reactor safety research conducted at HZDR, and produced pertinent results, we are still an important, recognized, and influential member within AER, even 20 years later. Following our exit from nuclear energy, this needs to be our goal for the future, and we have already demonstrated that this is feasible.

Are you concerned that you soon may not have the new generation of scientists for such projects on account of the German energy turnaround?

We're not able to judge this accurately yet, the timeframe for that is still too short. The universities have thus far shown no sign of any serious drop in the fundamental areas. We need to check in two to three years whether the universities do show a drop, and if so, what special field of study this year's first-year students have chosen. Perhaps we will also get an increase in junior scientists from other countries again – a trend we saw during the Social-Democrat/Green Party coalition government during the exit from nuclear energy agreed with industry in 2002.

REACTOR SAFETY EXPERT: Sören Kliem

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// At the HZDR Research Site Leipzig, a device that is the first commercial one of its kind in Germany unites two different imaging processes: positron emission and magnetic resonance tomography (PET/MRI) for small animals.

HOW MUCH IS TOO MUCH: Ph.D. student Mathias Kranz examines the degree of radiation exposure of individual organs during use of a radiotracer. Photo: André Künzelmann

OF MICE AND MEN: LEIPZIG RESEARCHERS INVESTIGATE RADIATION EXPOSURE IN DIAGNOSTICS

_Text . Sara Schmiedel

Six white CD-1 mice are scurrying through the litter in their cage, climbing the metal bars, nibbling away at the pellets they are being fed, and snuggling with each other. What they don't yet know is they're about to participate in a pivotal study. One that will save lives - those of mice and, one day, of men. As part of his dissertation, Mathias Kranz, Ph.D. student at the HZDR Research Site Leipzig, is currently investigating the degree of radioactivity that builds up within the bodies of mice whenever radioactive probes - called radiotracers - are used, and identifying in which organs specifically it accumulates. Eventually, these data will be extrapolated to the human magnitude. Radiotracers are chemical compounds that include a radioactive element of some sort, which can help scientists observe metabolic processes in living organisms. →

Specifically, in the case of the Leipzig project, we're talking about the two radiotracers [^{18}F]fluspidine and [^{18}F]flubatine - both of them molecules containing the radionuclide ^{18}F (fluorine). They're supposed to ultimately find their way into the diagnostics of cancers and neurodegenerative diseases like Alzheimer's. Key is their ability to imitate properties of various endogenous structures.

Once injected into the human body, they bind with high affinity to certain targets - in the case of the "PET sugar" [^{18}F]FDG, which is also used at the Leipzig site, highly metabolically active tissues like tumors. The emitted radiation from the radioactive molecules can be captured and subsequently analyzed using positron emission tomography (PET). However, before a radioactive tracer can be introduced into the hospital setting, its efficacy and safety to the living organism must first be confirmed. This is a prerequisite imposed by the German Federal Office for Radiation Protection (BfS) and the Federal Institute for Drugs and Medical Devices (BfArM). This multistep procedure starts with work on mice and occasionally pigs and ultimately leads to research conducted on healthy human subjects. Here, the HZDR scientists are receiving support from their colleagues at the Clinic for Nuclear Medicine at Leipzig University Hospital.

> Before a radioactive probe is ready for use in the hospital setting, its efficacy and safety must first be documented in living organisms.

Leipzig as reference site

As of spring 2013, when operations by experienced colleagues at the HZDR main site Dresden first commenced, Germany's first-ever commercial full-body PET/MRI for small animals opened in Leipzig - one of only a few worldwide. The HZDR is the reference site for Hungarian manufacturer Mediso (Budapest) - which brings with it a number of obvious benefits: "There are still a handful of delayed-onset childhood illnesses but whenever we do report any problem, help typically arrives within a matter of hours," Mathias Kranz explains. The 27-year-old fellow, who holds a master's in engineering, studied biomedical technology at Ilmenau University of Technology, and has been working at the HZDR Institute of Radiopharmaceutical Cancer Research for about a year now. He is thrilled with the new device: "Not only does it allow us to obtain information about metabolic processes that are happening inside the body, it also yields high-resolution three-dimensional images that document the exact location and distribution of soft tissues." Especially when it comes to brain imaging, MR devices yield far better results than conventional PET and computer tomography (CT) combinations.

The mice remain safe

"Without these methods, we would need to dissect the animal subjects, remove individual organs, and then measure them in order to determine the degree of radioactivity that has accumulated in the body following injection of the radiotracer. What's interesting is not only the current dose rate but also how it changes over the course of minutes and hours, which helps determine the organ dose. Thanks to PET/MRI, we're able to conduct even long-term studies using the same exact mouse," Mathias Kranz explains. In the case of other methods, one laboratory animal has to be sacrificed each time a single measurement is obtained.

During examination, the mice are lying on a heated animal bed, their breathing monitored with the help of a pressure sensor. The radioactively labeled substance is injected into the tail vein. The mice are fully anesthetized and won't remember anything afterwards. On a screen, Mathias Kranz is now examining a black and grey image showing the inside of the mouse's body. Red, yellow, and blue spots are lighting up in certain body regions. "Red means these are sites where there is a high degree of radioactivity, in other words that a lot of our substance was deposited in these places," the young scientist explains. At first glance, the liver, kidneys, and bladder are easily recognized - organs, which are actively involved in the substance's elimination from the body.

After the experiments are done, Mathias Kranz calculates the expected effective human dose. This serves as a risk-assessment at the time of introducing the probes into the clinical setting. Based on their results, the researchers have filed for approval of a study with the BfS for use of their newly developed radiotracers (+)-[^{18}F]flubatine and (S)-(-)-[^{18}F]fluspidine in humans. The scientists are working closely with their colleagues at Leipzig University Hospital, Department of Nuclear Medicine, on these projects. The projected start date is early 2014.

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// Experiments at the High-Intensity Gamma-Ray Source HIGS at Durham in the USA have produced detailed values for the magnetic dipole resonance for the first time – thereby revealing details about the structure of atomic nuclei.

SOURCE OF RADIATION: Gamma rays used in the study of atomic nuclei are produced when fast-moving electrons from the ELBE accelerator hit a special target. This strongly decelerates the electrons, which is why physicists speak of "bremsstrahlung."
Photo: Frank Bierstedt

MAGNETIC RESONANCE OF ATOMIC NUCLEI

_TEXT . Uta Bilow

"It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you." New Zealand physicist Ernest Rutherford described the result of his experiments in these words, after having directed positively charged helium nuclei (alpha particles) at a piece of delicate gold foil. To his great surprise, not all of the particles flew unhindered through the metal foil. Instead, a certain percentage altered their direction of travel or were even reflected. The scattering experiment by Ernest Rutherford roughly 100 years ago marked a turning point in our understanding of atomic structure. His results led to the conception that every atom possesses a very small, positively charged nucleus which is surrounded by negatively charged electrons.

As miniscule as an atomic nucleus is, important phenomena are bound up with the processes in the atomic nucleus, like radioactivity and nuclear fission, as well as formation of chemical elements in the stars. For this reason, scientists attempt to find out as many of the details about the structure and reactions of atomic nuclei as possible. Researchers at HZDR are also participating in this effort. Ronald Schwengner and his colleagues are especially interested in what are called dipole resonances in atomic nuclei and their influence on the course of nuclear reactions. Joint research by scientists at the Triangle Universities Nuclear Laboratory (TUNL) in Durham, North Carolina, USA and at HZDR has recently been successful in measuring the magnetic dipole resonance of an atomic nucleus with great accuracy. The new data can be incorporated in calculations pertinent to nuclear astrophysics and nuclear engineering, among other fields.

However, just how does one investigate atomic nuclei, those tiny structures of neutrons and protons? "You first have to raise the nuclei into energetically excited states," explains physicist Ronald Schwengner. This takes place by bombarding them with ions, neutrons, or with highly energetic photons (gamma quanta). When the atomic nuclei then fall back to →

their energetic ground state, they in turn emit particles or characteristic gamma rays. In photon-nucleus reactions, you can observe two phenomena. If the incident gamma quantum has a sufficiently high energy, a neutron may be ejected from the atomic nucleus, for example. This process, known as photo dissociation, is bound up with what is referred to as the giant electric dipole resonance (GDR). If the incident photons instead have a lower energy, scattering results that excites the atomic nucleus. "Whereas the giant electric dipole resonances for numerous nuclides had already been measured years ago, there is comparatively little knowledge about electromagnetic dipole excitations of the atomic nucleus in the case of lower energies lying below the threshold of photo dissociation," says Schwengner.

Sensitive measuring instruments and techniques needed

Experiments on photon scattering have been carried on for several years at the ELBE electron accelerator of HZDR. If the highly energetic electron beam from the ELBE electron source is fired at a metal foil, the beam will be slowed down. The high-energy bremsstrahlung radiation resulting from this is utilized to systematically investigate atomic nuclei in various regions of mass. But there are still unanswered questions about the distribution of energies and nature of the magnetic dipole excitations. This is because the electric radiation thoroughly obscures the magnetic radiation in the measured spectra, as Ronald Schwengner explains: "The magnetic dipole excitations have far lower intensities than the electric dipole excitations. You therefore need highly sensitive instruments and techniques to detect and unambiguously differentiate between magnetic and electric radiation."

An experiment carried out at the High-Intensity Gamma-Ray Source HIGS in Durham has now made the breakthrough. While the gamma radiation from this source is very intense, more importantly it is polarized and almost monoenergetic. This polarization permits very precise differentiation between electric and magnetic dipole radiation. Data previously acquired at ELBE from bremsstrahlung experiments was used for calibrating the spectra measured at HIGS. Schwengner: "The combination of ELBE and HIGS proved to be ideal. The two institutions cover various aspects of the experimental techniques and the results can be combined very well." The outcome: an excitation spectrum of nuclide Zr-90 revealing an increased concentration of magnetic dipole excitations in a particular energy region. The intensity and location of the magnetic dipole energy uncover the fine structure of the magnetic dipole resonance and permit conclusions to be drawn about the properties of the atomic nucleus.

On the one hand, the experiments at HZDR and in Durham produced an important increase in knowledge about the strength and structure of magnetic dipole excitations in atomic nuclei. On the other, they can also be incorporated into future calculations and simulations of nuclear reactions, because the probability that an atomic nucleus absorbs or emits a gamma quantum can be inferred from the distributions of the excitation strengths. The exact knowledge of the probability is important, for example, in describing neutron capture reactions. These reactions play a decisive role in nuclear astrophysics – where we are investigating the origin of heavy elements in stellar explosions – as well as in nuclear engineering, for instance in the transmutation of radionuclides with long half-lives. Ernest Rutherford would probably be excited about the breadth of detail that has been discovered about the atomic nucleus over the past century.

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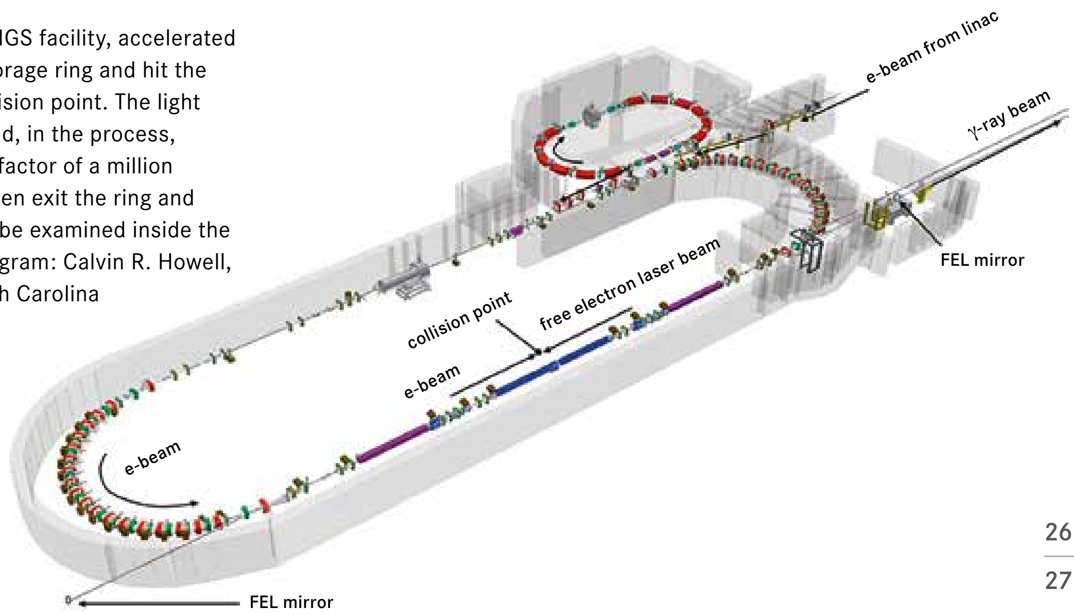
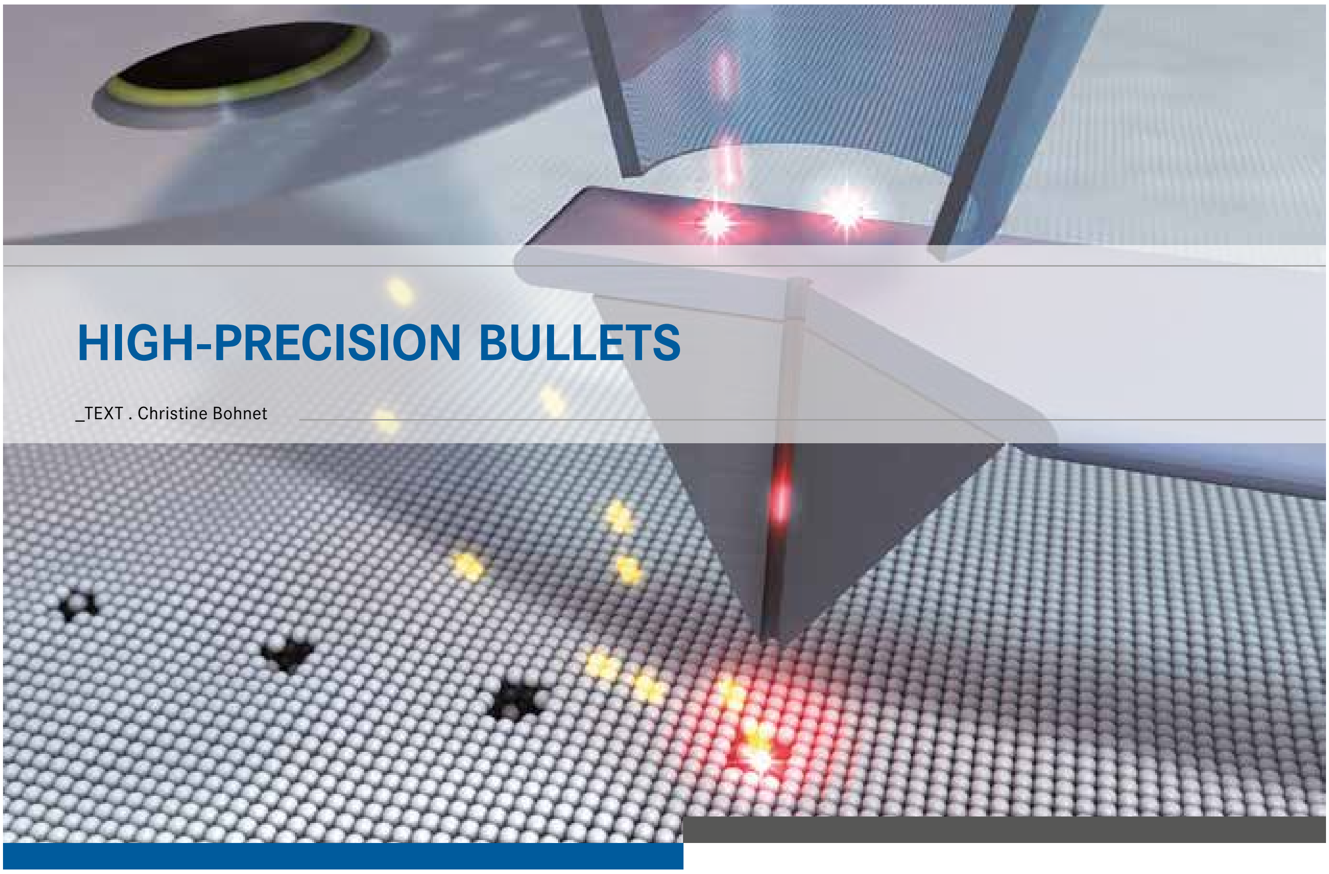


INCREASED ENERGY: At the HIGS facility, accelerated electrons circulate inside a storage ring and hit the incoming FEL beam at the collision point. The light particles are backscattered and, in the process, their energy is increased by a factor of a million into the gamma range. They then exit the ring and irradiate the sample that is to be examined inside the experimentation chamber. Diagram: Calvin R. Howell, Duke University Durham, North Carolina

// S.N.I.P.E.R. is the name given to a one-by-one-and-a-half-meter small facility at the HZDR's ion beam center. It is the setup that René Heller intends to use for depositing individual ions onto surfaces in a controlled manner.



HIGH-PRECISION BULLETS

_TEXT . Christine Bohnet

ONE ATOM AT A TIME: With the help of a glass capillary and a tip, similar to the kind used in atomic force microscopes, accelerated particles are being sorted out of their packet.
Diagram: Sander Münster

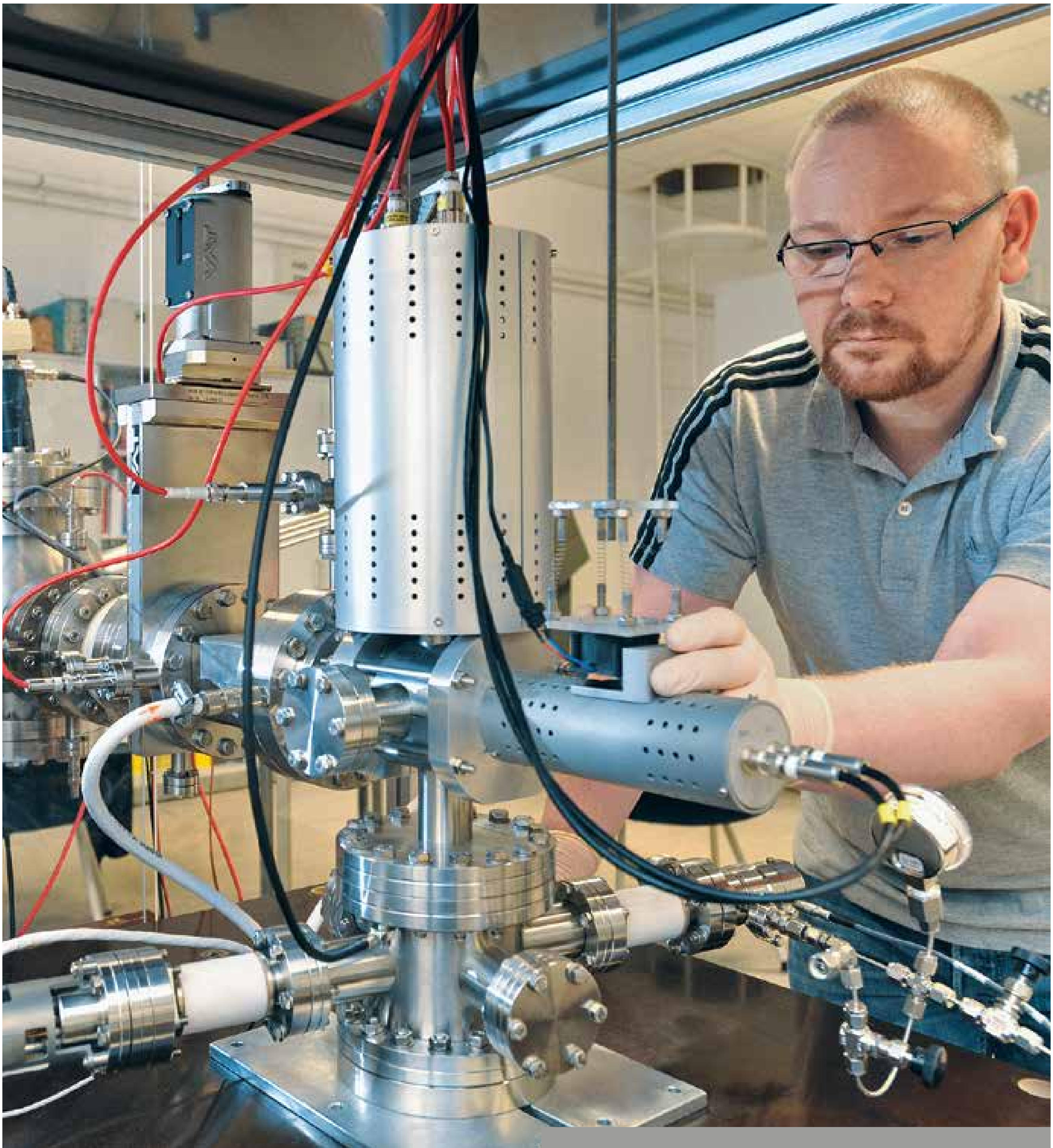
Whereas at the ion beam center charged particles are typically accelerated to high energies and impact on materials in order to change their properties, physicist René Heller has taken on the challenge of decelerating a handful of particles, in particular those that are highly charged, and using the benefits of their unique properties. These particles can potentially induce damage to the material surface that is spatially limited on a nanometer scale. In this way, nanostructures can be produced on the surface without inflicting radiation-induced damage to the material's bulk.

In terms of their electric charge, atoms are neutral. When stripping an atom of its negatively charged electrons, you end up with a positively charged ion. The more electrons an atom is stripped of, the more energy is required for the ionizing to take place. The total amount of energy remains stored inside the ion in the form of potential energy. S.N.I.P.E.R. is capable of stripping xenon atoms of up to 44 electrons. The resulting highly charged ions thus become carriers of a huge amount of energy, which is released on a femtosecond time scale, or a millionth of a billionth of a second, during collision with a solid surface. Furthermore, the area of interaction with the surface is limited to a mere few square nanometers so that the ions give off an enormous amount of energy on a very small time and size scale.

The result: tiny morphologic structures at the surface such as hillocks or holes in the nanometer range. Since the ions are comparatively slow, they do not penetrate the material very deeply and produce nanostructures only right where they are supposed to, that is, at the surfaces. Working with the TU Vienna, René Heller and his colleagues were able to answer the physically challenging question of which conditions tend to promote nanocrater or nanohillock formation.

Filtering single particles

Like many physicists from around the World, René Heller's vision is to selectively "engrave" individual ions onto a surface, each of them spaced but a few nanometers apart. Given this rather ambitious goal, his facility's unique name, →



SHOOTING: The S.N.I.P.E.R. facility allows René Heller to implant individual ions onto a surface to produce nanostructures. Photo: Frank Bierstedt

S.N.I.P.E.R. - the acronym stands for "Surface Nanostructures by Ions Potential Energy Release" - actually holds a double meaning: For one, it's referring to the projectiles' sharp local energy release; for another, it's pointing out the high degree of precision that is required to deposit the ions onto the surface.

The projected bombardment of surfaces with highly charged ions holds tremendous potential for coming up with answers to new scientific questions in both basic and applied research. Therefore, the most prominent example is most likely the realization of quantum computers as the placement of individual ions in a well-defined manner is key to their production. In addition, the selective bombardment of existing nanostructures is charting new experimental territory for observing and modifying their physical properties. Everything from biomolecules to magnetic nanostructures could be modified in a controlled manner using highly charged ions. Although, admittedly, one still has a long way to go.

In its present state, S.N.I.P.E.R. produces ions in the form of a particle beam approximately one millimeter in diameter. Also, the necessary deceleration of the projectiles to energies as low as a few tens of eV per charge has been achieved already. The next step, which is no doubt the most challenging one, will be the reduction of the beam to single particles and their controlled placement onto the surface. "This can be achieved by combining an ultrathin glass capillary with the modified tip of an atomic force microscope," explains Heller.

"What keeps us even more preoccupied is the fact that we have to know when an individual particle makes its way to the surface. In other words, what we need is a reliable individual ion detector. However, before such a detector can be realized, we have yet to overcome several major obstacles."

PUBLICATIONS:

R. Heller et al.: "Defect mediated desorption of the KBr(001) surface induced by single highly charged ion impact", in Physical Review Letters, Vol. 101/9 (2008; DOI: 10.1103/PhysRevLett.101.096102)

A.S. El-Said et al.: "Phase diagram for nanostructuring CaF2 surfaces by slow highly charged ions", in Physical Review Letters, Vol. 109 (2012; DOI: 10.1103/PhysRevLett.109.117602)

R. Ritter et al.: "Fabrication of nanopores in 1 nm thick carbon nanomembranes with slow highly charged ions", in Applied Physics Letters, Vol. 102 (2013; DOI: 10.1063/1.4792511)

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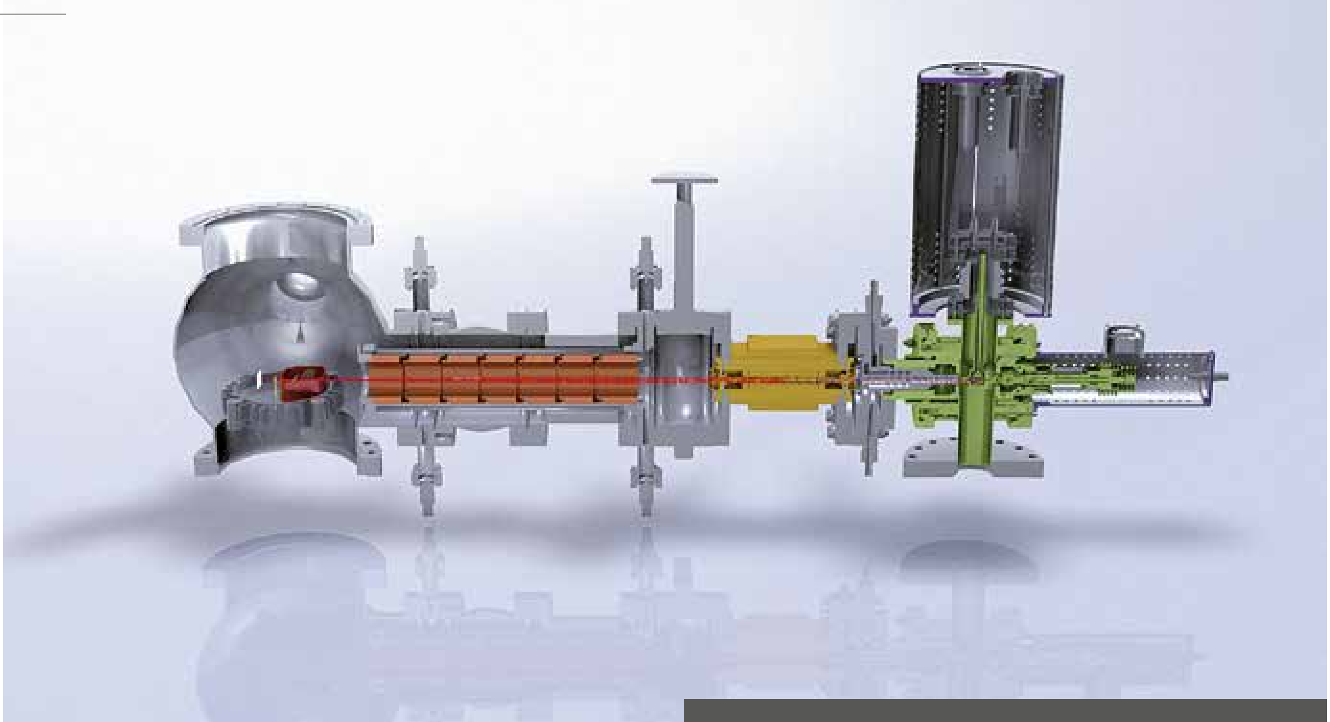
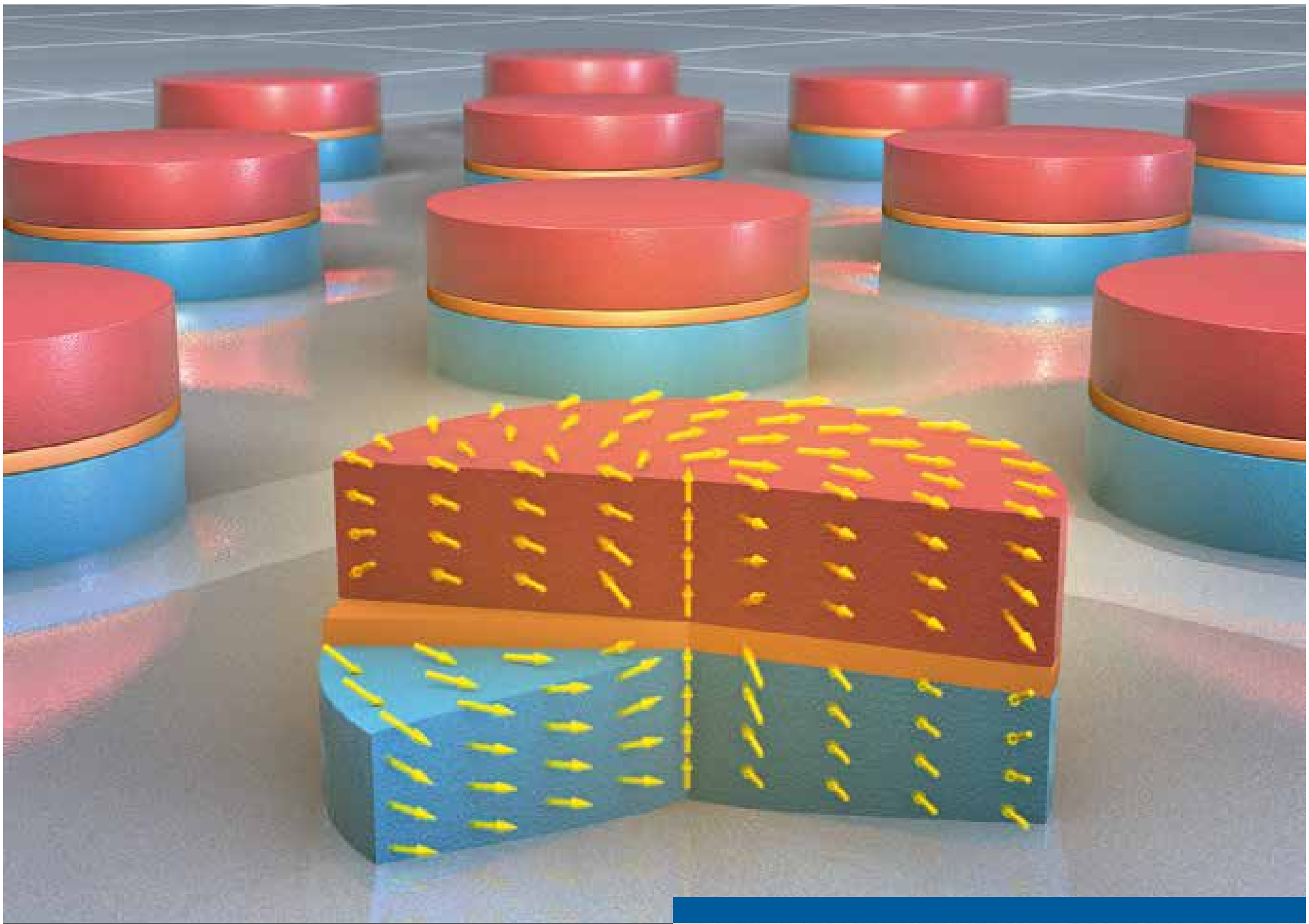
CROSS-SECTIONAL VIEW: The S.N.I.P.E.R. facility.
Diagram: Sander Münster



// 3D magnetic vortices can be important for high-performance radio antennas and data storage media.



STABILITY THROUGH A VORTEX: Within the space between two magnetic layers, static three-dimensional magnetic vortices form around a non-magnetic intermediate layer. They act to stabilize the direction of magnetization in the vortex' central core – a prerequisite for the kind of stable vortex antennae applicable in wireless data transfer. Diagram: Sander Münster

MAGNETIC VORTICES IN 3D

_Text . Anja Weigl

Like many other young scientists, HZDR physicist Sebastian Wintz, too, is currently working on his dissertation. And even if the goal of all doctoral candidates is to enrich science with new knowledge and insight, they do not always discover a hither-to unknown phenomenon necessarily. Wintz can make that claim for himself – together with colleagues from HZDR and the Paul Scherrer Institute (PSI) in Switzerland.

Sebastian Wintz is involved with extremely small structures of magnetic films only a few nanometers thick, with a diameter of a few thousandths of a millimeter. It is at these tiny dimensions, and particularly at the even smaller level of atoms, that the magnetic properties exhibited by a material originate. For in magnetic materials, electrons of the atoms behave like small magnets that interact with one another. If you influence magnetic thin-film structures the way that Wintz has, unusual things can appear. →

What was initially known about magnetic discs at the nanometer-scale was that magnets can form two-dimensional vortices. In doing so, they arrange themselves in circles around a vortex core. These kinds of static magnetic vortices – whereby all of the individual magnets remain in place – are not just a matter of interest to basic science, they could have technological applications as well. If a current is applied to the system, for example, the magnets in the disc change their direction, so the magnetic vortex core looks like it is oscillating around in circles. This results in electromagnetic waves being radiated. "That is of interest for ultra-high-speed wireless transmission of information," says Wintz.

Stacked layers replace single layers

"These magnetic antennas have so far not operated very stably at high power, though. If the rotational speed of the magnetic vortex becomes too high, the orientation of the vortex core switches and the radio wave is interrupted," he explains further. Wintz then experimented not with individual magnetic discs, but instead he stacked two or three magnetic layers on top of one another, each only about ten nanometers thick. He insulated these using non-magnetic metallic layers of various thicknesses. Then he drove to PSI in Switzerland to investigate the fabricated system of layers. The scanning →

WRITING WITH ELECTRONS: Physicist Sebastian Wintz at the electron-beam writer, a device used to incorporate ultra-small structures into wafer coats. Photo: Oliver Killig

transmission electron microscope operated there has the capability of differentiating between magnetic directions at a resolution of 20 nanometers, just right for his structures.

Sebastian Wintz observed the familiar magnetic vortices in the individual magnetic layers. What was new, however, were vortices he discovered between two magnetic layers – circulating around the intermediate layer. "These are therefore not just two-dimensional, but instead three-dimensional magnetic vortices," explains Wintz the new phenomenon. However, they only occur in certain cases, e.g. when the magnets in the stacked single layers have opposite directions of rotation and are also slightly off-axis. This condition is favored in turn by the very thin intermediate layers, which you can selectively influence. To do this, they are bombarded with high-speed charged particles in the HZDR ion beam center. This results in disordering of the atoms and blurring of the boundaries between the magnetic layers and the non-magnetic intermediate layer. Depending on how strongly the materials are bombarded, the magnets "couple" in the individual layers in a certain way with each other and orient themselves in the desired direction.

Stable instead of unstable

The magnetic layer system produced by Wintz can also be made into transmitters for electromagnetic waves by applying current. And yet the new three-dimensional magnetic vortices could help antennas remain stable, even at high power: "The magnetization in the core no longer switches back and forth as easily with the new magnetic vortices. The system of layers is therefore probably more suitable for vortex antennas than comparable single layers. Even at high vortex rotational speeds, the magnetic orientation of the vortex core remains unchanged," says Wintz. Transmission frequencies of more than a gigahertz – that corresponds to one billion vortex rotations per second – simultaneously with a high signal quality would be conceivable. Today's WiFi and cellular networks operate in this frequency region, for example.

Until now, the junior scientist's work has only been basic research. He is continuing at the moment to concentrate on influencing magnetic systems of layers using current or magnetic fields – at higher frequencies than before. He can only hint at more interesting observations thus far. However, this much could be said: these involve not just possible applications for radio antennas, but instead the potential of magnets to process information in very small spatial dimensions, with the help of what are known as "spin" waves. One can count on further exciting and useful phenomena from the world of magnetism.

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// Dresden is enjoying a most excellent reputation as a cancer research hub. A number of awards garnered by scientists from Helmholtz-Zentrum Dresden-Rossendorf and the OncoRay center testify to this.

HONOREE: Michael Baumann at the OncoRay Center Dresden's gantry. Right at the heart of this huge bending magnet, the first cancer patients will be treated with protons beginning in the fall of 2014. Photo: UKD/Christoph Reichelt

FROM EARLY DETECTION TO THE FIGHT AGAINST DISEASED CELLS

_TEXT . Simon Schmitt

Every year, some 450,000 Germans develop cancer. For progress in the fight against the disease, it is essential for researchers from the most varied of disciplines – biology, chemistry, physics, medicine – to all work together. Here, the smooth transfer of insights gleaned in basic research into the clinical setting where it can ultimately benefit patients (as well as from the clinical setting into the research lab) is key. This is precisely the reason why as recently as September 2013, ECCO, the European CanCer Organisation, presented its Clinical Research Award to Michael Baumann, Director of the HZDR's Institute of Radiooncology.

With this award, the multidisciplinary governing body, which is comprised of oncological societies, cancer researchers, and patient organizations, recognizes Baumann's outstanding contributions in the area of integrating scientific findings into the clinical setting. "In my work, translational thinking has always been integral, in other words, the idea of taking insights that hold potential for cancer therapy from the lab through the clinical trial stage and into the clinical setting where they can benefit patients," stresses Baumann, who is also the Director of OncoRay, Dresden's National Center for Radiation Research in Oncology, which is run jointly by HZDR, the University Hospital Carl Gustav Carus, and the TU Dresden. →

The radiation oncologist's special focus has been on merging biological research findings with technological advances made in radiation therapy. As such, one of the things Baumann is looking at are candidate biomarkers that are good predictors of tumor radiosensitivity. In one clinical trial, he and his team were able to show that tumors of the head and neck that are deprived of oxygen are extremely resistant to radiation therapy. "Chances of healing largely depend upon individual biological factors," explains Baumann. "These have to be studied to allow us to customize the radiation dose for each individual tumor."

Precise measurements of the radiation dose

To improve the precision of radiotherapy – such is also Christian Richter's goal. Richter, who is head of a research group at OncoRay, has devised a reliable technology for obtaining precise real-time measurements of the radiation dose of laser-accelerated, ultrashort pulsed particle beams. This is yet another step in the direction of progress along the way to future cancer treatment options using laser-accelerated proton beams. Because similarly to the big conventional accelerator facilities, laser light is capable of powering protons in such an intense way that they may be used in the fight against tumors in future. Until now, however, the biological effect of laser-accelerated particle beams has largely been unknown.

Thanks to Richter's study, this issue could at long last be addressed by applying his precise dose-measurement methodology in radiobiological experiments. This has allowed the researchers to obtain reliable initial experimental data on these rays' biological efficacy – a necessary prerequisite for using laser-accelerated protons and electrons in cancer therapy. Thanks to this achievement, Christian Richter was able to come in second for the Behnken Berger Award, which earned him 10,000 Euro. This recognition is given by the endowment of the same name to junior scientists who are working on an application of radiation in medicine or on radiation protection.

Fight from inside and out

Whereas radiation therapy, which is already used to treat some 50 percent of all cancer patients, targets diseased cells and destroys them using radiation that is introduced into the body from outside, other research conducted at the HZDR actually starts from inside the body. What is known as endoradionuclide therapy will ultimately target tumors and damage them by delivering radioactive substances directly to the cancer cell. The path is laid out for them by specialized antibodies, for instance, which travel to the site of the tumor as transport molecules via the bloodstream, and dock to the tumor.

These antibodies can either be directly radioactively labeled or, alternatively, they may initially label the tumor cell, which, in a second step, is followed by injection of the radiation source. Think of it as a key fitting in a lock – because the scientists are using two artificial complementary single strands of DNA, one of which attaches to the antibody, the other to the radioactive substance. When they contact each other, the two substances rapidly form a highly stable compound. For this, modified DNA is used, which the organism no longer recognizes as DNA but which maintains its binding property by virtue of this "lock-and-key" principle.

Christian Förster has gone ahead and modified one of the single DNA strands in such a way as to be able to attach the therapeutic radionuclide to it. Once inside the organism, this radioactively labeled single strand exhibits near perfect properties: For one, it circulates long enough for it to locate the complementary DNA strand with its attached antibody; for another, only little accumulates in those organs that are especially radiosensitive. Also, the single DNA strand is not degraded in the bloodstream. In the end, there is but one choice for binding site left inside the organism, that is to those antibodies carrying the complementary DNA strand and which mostly accumulated in the tumor tissue. The radioactive substance thus unfolds its destructive potential for the most part right at the diseased cells while the rest of the organism is safe from radiation exposure. In recognition of this research, the German Chemical Society's Subdivision of Nuclear Chemistry presented Förster with its Ph.D. Award.

Yet it isn't only cancer treatment but also precise diagnostics and tumor characterization that are integral to the successful fight against the disease, all of which are important research emphases at the HZDR. As such, Reik Löser's junior research group recently developed a new peptide-based radiotracer. The tracer, which is labeled with the radionuclide fluoride-18, is used to visualize activity of the enzyme lysyl oxidase, which plays an important role in cancer. "We used PET imaging to prove the uptake of the tracer by the neoplastic tissues of three different types of breast cancer tumors," explains Manuela Kuchar, who is part of the junior research group. For her presentation of these research findings, the Ph.D. student recently received the Best Presentation Award at the Radiochemistry/Radiopharmacy Work Group's Annual Conference.

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// Physicists of HZDR have been able to simulate the motion of billions of electrons within astrophysical plasma jets and calculate the light they emit with the help of a high-performance computer. They have been nominated for the Gordon Bell Prize as a result of their work.

A REVOLUTION FOR PLASMA SIMULATIONS

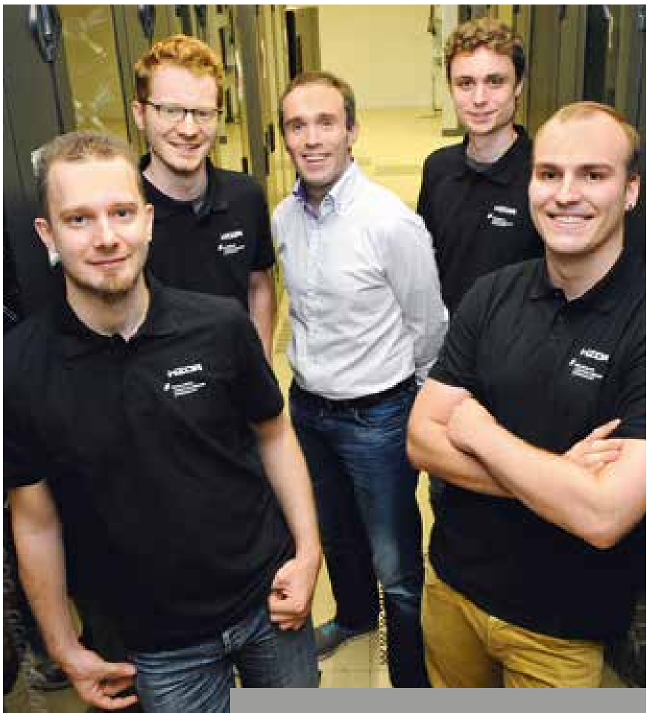
_Text . Simon Schmitt

"When the wind blows over the ocean, waves form," Michael Bussmann, head of a HZDR junior research group, starts to explain. "At high wind speeds, water and wind swirl about one another, which is how spray and froth arise. Spray is thus a turbulent mixture of water and air. A similar thing occurs in space when a star ejects hot gas. The jet created by the hot plasma mixes with other gas that surrounds the star. Turbulent flows arise at the boundary region between the two gases." The staff members of the "Computational Radiation Physics" group recently studied the formation of these turbulent phenomena, known as Kelvin-Helmholtz instabilities, with the help of simulations.

"We hope to understand Kelvin-Helmholtz instabilities in detail. To do so, we have tried something that almost no one else has up to now," explains Bussmann. "We have simulated a plasma jet at such high resolution that we could follow the electrons in the jet. That by itself requires enormous computing power, as we had to simulate almost a hundred billion particles." It is impossible even with the most modern telescopes to see individual particles in a stellar jet, however. Scientists were therefore faced with the problem of how to compare their theoretical results to observations. They solved it by making use of the fact that electrons emit light over a broad spectrum of wavelengths when they change their direction of motion or speed. They adapted their simulation program PIConGPU to allow light emitted in all directions to be calculated from the motion of the electrons.

"With luck, we are able to see the light emitted with telescopes from Earth," explains the physicist. "We can therefore simulate something that can be measured on earth. However, the computer power necessary for this is enormous." The light emitted had to be calculated individually for the billions of electrons in the simulation – and in hundreds of different directions. For this reason, the HZDR team used what was then the most powerful supercomputer in the world for their calculations in June 2013: TITAN at Oak Ridge National Laboratory. PIConGPU spent over 16 hours calculating the solution to this problem using 18,000 graphics cards. Few simulation programs can make use of such powerful compute capability. Simulations that operate the most efficiently are honored each year with the Gordon Bell Prize for outstanding achievement in the field of high-performance computing, for which the HZDR scientists have now been nominated.

HIGH-SPEED PROCESSOR: Members of the HZDR junior research group "Computational Radiation Physics" who were nominated for the Gordon Bell Award are posing in front of HZDR's Hypnos supercomputer: René Widera, Heiko Burau, Michael Bussmann, Richard Pausch and Axel Hübl (from left to right). Photo: Frank Bierstedt



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// Geological processes and valuable mineral resources – to locate them, Richard Gloaguen uses remote sensing methods. The scientist must also routinely get out on the land, though.

HOW MOUNTAINS FORM: Based on rock samples from Pamir, a high mountain range in Central Asia, geological processes can be characterized.

FAR-OUT EXPLORATION: Richard Gloaguen, Head of the Helmholtz Institute Freiberg for Resource Technology's Remote Sensing Group. Photo: Detlev Müller

CLUES IN STONE

_Text . Anja Weigl

Richard Gloaguen has already seen a lot of the world during his career – Siberia, Tibet, China, Ethiopia, Kenya, Ecuador, and Cuba. The list goes on. For the last few years, Tajikistan and Afghanistan have been at the top. The common border of the countries runs through the middle of one of the highest mountains in the world, the Pamir. That is right where the French-born scientist and a couple of his students are drawn to. They collect rock samples along lakes and rivers, and survey strata of the Earth's surface using GPS and laser beams.

The study trips are a small but important part of Gloaguen's work. He heads the Remote Sensing Group at the Helmholtz Institute Freiberg for Resource Technology (HIF) of HZDR and at the TU Bergakademie Freiberg. The researcher uses satellite data to describe special processes on and beneath the Earth's surface. With the Pamir Mountains, for example, this involves understanding how mountains form. The Pamir mountain range, one of the most geologically active regions of the world, is an excellent example to study such processes, Gloaguen explains. To accomplish this, he collaborates with scientists in many different disciplines from Tübingen, Potsdam, and Jena. They also investigate when earthquakes took place that were responsible for having created several of the highest naturally occurring lakes in the world, which are in the Pamir. Another project involves flood models for rivers in the Pamir mountains.

The research usually takes place on the computer in his office, but not only there. "We also need data acquired from the field to ground-truth the satellite data," says Gloaguen. He was travelling again in the Pamir with students in October. Despite its wonderful landscapes and unique regions for research, a field trip through Pamir is not for the faint-hearted. The conditions are harsh, the water quality often not good, and medical care is usually far away. Nevertheless, the risks were reasonable, according to the researcher. It was more important that all the members of the study group were in good condition and could tolerate the high altitude well. One student even started to exercise regularly to prepare herself for the trip. Gloaguen himself does not need to; he rides a mountain bike a lot to keep himself fit.

Between Tajikistan and Afghanistan in the Pamir

The recent field trip to Pamir commenced with a flight to the Tajik capital of Duschanbe. From there, the group went by car to the Pamir, then later over the border to Afghanistan. One of the most important goals was to collect rock samples for subsequent investigations. These are being studied now at the HZDR ion beam center. Gloaguen's colleagues in the Ion Beam Analysis Group operate a facility for accelerator-based mass spectrometry. This is used to measure the proportion of specific radioactive isotopes that have originated through the interaction of cosmic radiation with rocks exposed at the Earth's surface. From the ratios determined, the researchers can state precisely how long the rocks have already been exposed – an important clue for Gloaguen in describing the geological processes that have led to formation of the mountains.

The rock samples utilized to establish the age of the mountains came not only from different altitudes, but also from the shores of several of the highest naturally-occurring water reservoirs in the world, such as Lake Sares and Yashilkul for example, both in the Pamir. They are being correlated with earthquakes – the researchers want to learn in detail when these occurred and thereby specify the rough time intervals between these natural catastrophes. The rocks help with this as well.

"The processes that play a role in the formation of mountains likewise help us in detecting mineral resources," according to Gloaguen. The Helmholtz Institute in Freiberg is investigating the extent to which remote sensing methods are suited to the search for mineral resources in the Ore Mountains (Erzgebirge) of Saxony through a joint project with the German Federal Institute for Geosciences and Natural Resources (BGR) and TU Bergakademie Freiberg. In about three years, it should become clear what quantities of mineral resources like tin and tungsten still exist in the vicinity of Geyer, a town in the Ore Mountains.

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A New Institute Director at HZDR

Thorsten Stumpf has been head of the Institute of Resource Ecology at HZDR since 1 October. The radiochemist moved from the Karlsruhe Institute of Technology (KIT) to the capital of Saxony. Up to now, Stumpf has been involved in particular with the interactions between radionuclides in radioactive waste and the geological barriers in which it is stored as well as potential host rock formations. The expert group for nuclear chemistry of the Gesellschaft Deutscher Chemiker (GDCh, Society of the German Chemists) recently awarded him the Fritz Straßmann Prize for this research.

Stumpf has brought the Helmholtz junior research group "Structures and Reactivity at the Aqueous/Mineral Interface" with him from KIT. Researchers led by Moritz Schmidt are involved here with the structures, processes, and reactions at the water/mineral interface on the molecular level. Understanding these interfaces at the molecular level plays an important role in safety research on barriers for the final disposal of nuclear waste, as dependable predictions about the transport behaviour of radionuclides for hundreds of thousands of years are required.

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Photo: Oliver Killig

PANORAMA – HZDR NEWS

The search is on for junior scientists

For the past two years, the HZDR has successfully mounted its DeltaX School Lab and each year has continued to expand its offerings. Today, experimentation days on topics as diverse as magnetism, light and color, as well as radioactivity and radiation have become regular audience magnets. The German Aerospace Center DLR has a lot more experience with student labs than that, thanks to the fact that, for the last ten years, its DLR_School_Labs have made promoting junior scientists a priority. Following in the DLR's footsteps, a similar lab is currently being set up at the Dresden Technical Collections as part of a joint project by the DLR, the TU Dresden, and the city of Dresden. Starting November 13, 2013, grades 5 through 12 students are offered an up close and personal look at the world of research in the natural sciences and technology.

Photo: Christian Hüller

The DLR_School_Lab TU Dresden is starting operations.

What brings about a drop in the cost of solar cells and how can their performance be optimized? What should new kinds of materials be made of to ensure they are light-weight yet at the same time durable and versatile? At the DLR_School_Lab TU Dresden, students are able to perform experiments on these and other exciting questions. Offerings range from experiments in the areas of materials science all the way to traffic planning and energy, and are set against a real-world research background with a strong applied focus. The lab is fitted with cutting-edge equipment and has a host of different objects on display. Student-run experiments are assisted by TU Dresden students.

The staff at the DeltaX and DLR_School_Lab TU Dresden, which are both part of the Helmholtz school lab network, are striving for a close collaboration, given that they are in pursuit of a common goal. They want to give kids a real sense of the inside workings of a scientific institute in order to get them excited about the natural sciences and technology and encourage them to pursue their passion through university study or relevant job training. ⊣

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↗ dlr.de/schoollab/tu-dresden

Jana Bohovičová and Vladimir Kolesár at the ion beam center.

Bratislava → Dresden → Bratislava

The geographic distance between the Slovak University of Technology in Bratislava (STU) and Rossendorf is no less than 482 kilometers. It is also the distance travelled by Peter Joehnk, the HZDR's Administrative Director, not just once but several times a year. What started out as making available any used equipment and furniture that had served its term at the HZDR to help with the setup of new laboratories or offices at the STU, continued over a number of years with the establishment of a joint international Ph.D. seminar, development of the EASY German Federal Subsidy System, and other projects, today has evolved into a vital collaborative in both administrative/technical and scientific areas.

At the STU Faculty of Materials Technology in Trnava, 50 kilometers outside Bratislava, construction of CAMBO, the new science campus, is currently under way – one of eight science parks that have received funding totaling 280 million Euros from the Slovak government. The groundbreaking ceremony for the 42 million Euro project took place in May 2013 in the presence of the Slovak Ministers of Finance as well as University Study. Peter Joehnk was also present for the ceremony, as was Andreas Kolitsch, the current CEO of HZDR INNOVATION GmbH and the former head of the HZDR's ion beam center. In this latter capacity, Kolitsch has been tracking the fate of CAMBO for some time now as the ultimate plan is construction of an ion beam center similar to the Dresden facility. As coordinator of the scientific part of the collaborative, Kolitsch's job is to make sure the seven Slovak scientists involved with the project as well as an additional seven technicians, all of whom have traveled to Dresden, are receiving customized training. They are on a 21-months sabbatical to learn as much as they can about processes, machines, radiation schedules, and scientific experiments at Europe's largest ion beam center. Upon their return to the Slovak Republic in 2015, their job will be to ensure the start of operations and service without any complications at the ion beam center on the CAMBO campus. ⊣

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// Going forward, some 150 physicians and scientists will be working alongside each other on the future of radiation therapy in the new building of the National Center for Radiation Research in Oncology – OncoRay.

NEW ABODE FOR EXCELLENCE IN RESEARCH

_Text . Christine Bohnet & Holger Ostermeyer | Photos . OncoRay/Matthias Rietschel & André Wirsig

Smiling faces

Since the Free State of Saxony had provided funding for the building as part of an EU-backed State Excellence Initiative, Minister President Stanislaw Tillich (center) personally attended the festive inauguration ceremony on September 17, 2013. "The research center is an important poster child for Saxony as a biomedical technology hub. Many hands are pulling together in the fight against cancer to make radiation therapy ever more successful while sparing the surrounding healthy tissues," he said. Seen here in front are Federal Minister of Research Johanna Wanka (fourth from the right), Saxony's Minister President Tillich, Helmholtz Association President Jürgen Mlynek, as well as Saxony's Minister of Research Sabine von Schorlemer, OncoRay Director Michael Baumann, the Mayor of Dresden Helma Orosz, the University Hospital's Scientific Director Michael Albrecht, and the HZDR's Scientific Director Roland Sauerbrey (from right to left). As it were, many joined hands to give the starting signal for the proton accelerator at its new abode.

Patient services to begin in 2014

The goal of every form of radiation therapy is to eradicate the tumor tissue or at least damage it to such an extent that it is no longer capable of proliferating uncontrollably. Until now, it was mostly ultrahard X-rays that were used for this purpose. In contrast, the main advantage of charged particles like protons is that they give off relatively little energy as they make their way to the tumor site while unfolding their full potential only once they have actually made it to the malignant tissue. Therapists are able to fashion the proton beam in such a way as to ensure the protons inflict as little damage as possible to the healthy tissues in the tumor's immediate vicinity. However, it is imperative to evaluate the medical benefits of this considerably more costly form of cancer treatment on a tumor-by-tumor basis compared with currently used forms of radiation therapy. This will soon also be the case in Dresden – as part of elaborate, strictly controlled clinical trials. As early as 2014, the first groups of patients are scheduled for treatment in the new OncoRay building.

With a firm push of the button

"I'm simply thrilled that OncoRay has become one of the World's top sites for radiation research in oncology. I'm quite certain that the new proton therapy center is going to advance radiation research here in Dresden. This way, we have taken an important step in the direction of cancer research and therapy," says Federal Minister Johanna Wanka before placing her hand on the proton accelerator's on-switch. State Minister Sabine von Schorlemer, Minister President Stanislaw Tillich, Mayor Helma Orosz, the HZDR's Scientific Director Roland Sauerbrey, OncoRay Director Michael Baumann, DKFZ Chairman of the Board Otmar Wiestler, and Helmholtz Association President Jürgen Mlynek followed suit.

Hidden inside

At its heart, the building houses a particle accelerator, which weighs a ton and which was festively inaugurated by Federal Minister of Research Wanka (left) and Minister President Tillich (fifth from the left) on September 17. Along with Minister of Research von Schorlemer, Mayor Orosz, OncoRay Director Baumann, HZDR Scientific Director Sauerbrey, DKFZ Chairman of the Board Wiestler, and the University Hospital's Administrative Director Winzer (from left to right), they took the opportunity prior to the official kick-off event to take a peek inside a hall that under normal circumstances is inaccessible to the public. Inside said hall, accelerated protons will soon be guided through a series of pipes and apertures – for their ultimate delivery to cancer patients in the hospital setting.

Photo: Frank Bierstedt

Dresden project links health care to research

One of East Germany's first-ever proton therapy facility's main advantages is that patients will benefit early on from further innovations of this form of cancer therapy, which is still fairly new, thanks to the broad spectrum of clinically oriented research projects at the OncoRay center. HZDR scientists used an accompanying exhibit to inform interested guests about laser-based proton acceleration research. The Dresden cancer researchers' consensus is that proton therapy will only be able to become the new standard if it's possible to develop compact accelerators that are practical for use in the hospital setting. Be that as it may, in the new OncoRay building, there is ample space for a first-ever and unparalleled prototype designed for purposes of comparative examination.

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Congress magnet Dresden

Accelerator experts won't want to miss an important date in Dresden in 2014, considering the city will play host to the 5th International Particle Accelerator Conference. As well, recently, the HZDR's bid for yet another important conference – the 2017 International Symposium on Radiopharmaceutical Sciences – ended up being successful.

IPAC 2014

Peter Michel, head of the HZDR's Center for High-Power Radiation Sources, expects some 1,500 participants will end up attending the IPAC 2014. Michel is the man in charge of all things having to do with locally organizing the top international accelerator conference. Three more accelerator centers, all of them part of the Helmholtz Association – the GSI Helmholtz Centre for Heavy Ion Research, the Helmholtz Center Berlin, and German Electron Synchrotron DESY – will play an active role in helping organize the event. Representatives from nearly all the top European, North American, and Asian accelerator centers are also on various organizational and programming committees. For the past four years, the global accelerator community has met up at the annual IPAC conference; before that, there were only ever continent-specific accelerator conferences. The interested public can find out about the importance of accelerators in medicine on opening day where a public lecture will focus on development of the HZDR's new compact accelerator for cancer therapy.

IPAC 2014 will take place from June 15 through 20 at the International Congress Center Dresden, right in the heart of the city's beautiful old town center. The HZDR is confident that participants are bound to enjoy their short walks around Dresden and will no doubt be impressed by the many cultural and scientific perks the city boasts.

ISRS 2017

Every two years, the Society of Radiopharmaceutical Sciences advertises for bids for venues in either North America, Asia, or Europe for their annual international symposium, the ISRS. At this year's conference in Korea, the 2017 venue was being voted on. Jörg Steinbach, director of the HZDR's Institute of Radiopharmaceutical Cancer Research, is particularly pleased that the bid ended up going to Dresden, most especially as the global competition was arguably stiff. And so, four years down the road, some 1,000 participants will now be making their way to Dresden to attend the 2017 ISRS. Nearly at the same time, Dresden's bid as venue for yet another global event, the Workshop on Targetry and Target Chemistry for cyclotron radionuclide production and processing, was successful as well. The bid also ended up going to Steinbach's Institute – and to the Nuclear Physics Institute of the ASCR in Řež, Czech Republic. The event, which is scheduled for 2014 in cooperation with their Prague colleagues, is expected to attract some 200 participants. ┤

↗ http://www.ipac14.org
↗ http://isrs2015.org/

CALENDAR OF EVENTS

December 13, 2013
Inauguration ceremony of the Dresden High Magnetic Field Laboratory extension
HZDR

February 21, 2014
Teacher training on the topic of "radioactivity in nuclear technology and medicine"
HZDR | DeltaX School Lab

Scientific events

March 11-12, 2014
HPLC Workshop (High Performance Liquid Chromatography)
HZDR | in collaboration with Knauer Berlin

April 28-30, 2014
3rd LA3NET Topical Workshop
Acceleration Techniques
HZDR

May 07-09, 2014
52. European Two-Phase Flow Group Meeting
HZDR

June 15-20, 2014
5th International Particle Accelerator Conference (IPAC)
Dresden

Radiation protection courses offered through the HZDR research site Leipzig

March 4, 2014
Update course
March 18-20, 2014
Skills course (Module GG, FA)

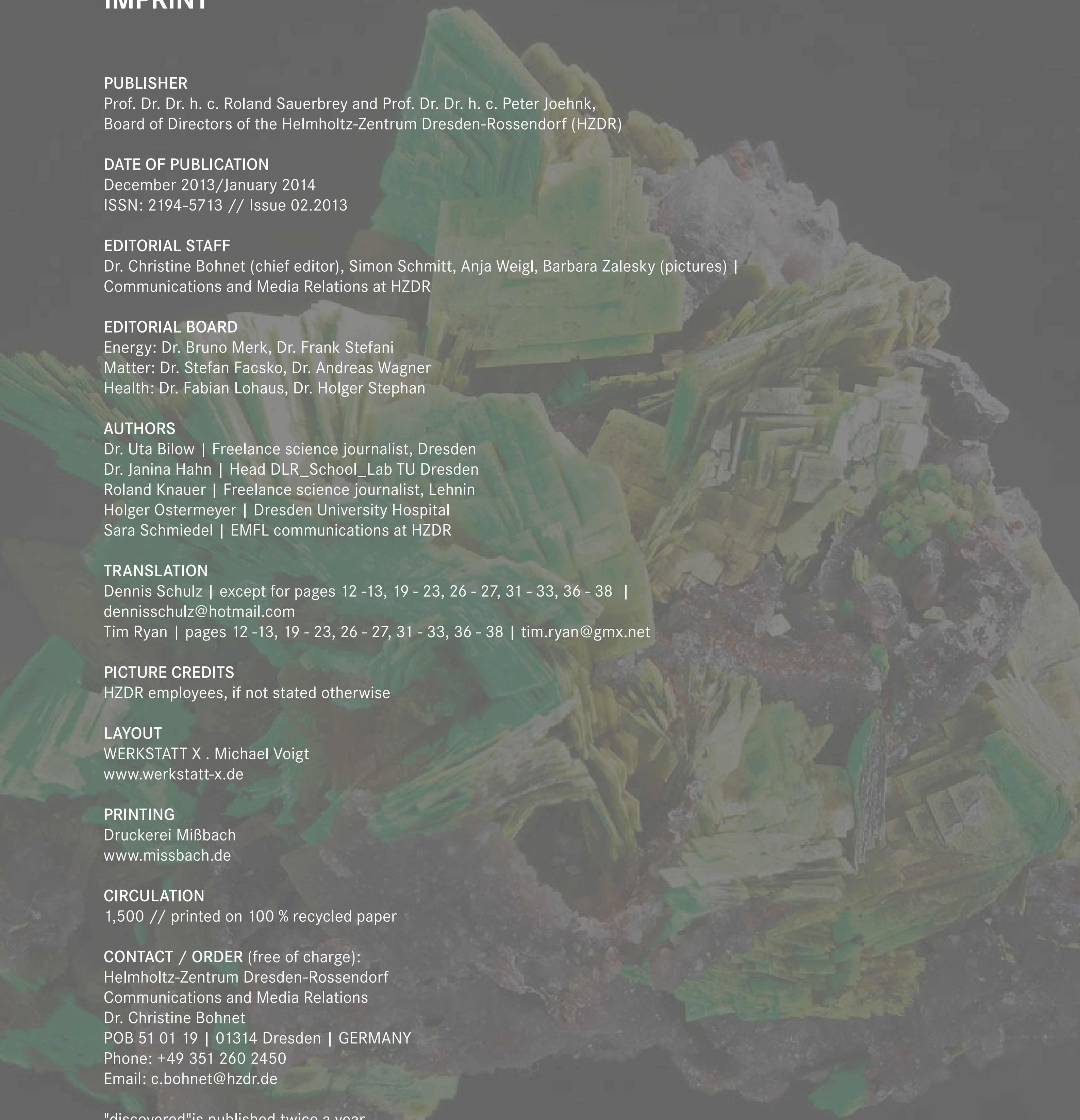
HZDR art exhibits

Vernissage begins at 5 pm

January 16, 2014
Konrad Maass

March 6, 2014
Gerd Küchler

May 8, 2014
Mandy Herrmann Amrouche



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