HELMHOLTZ-ZENTRUM GEESTHACHT

People with Ideas

In2science #2

Team Magazine

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

How do we shape our future? *Research for city and country.*

That was the slogan of the 2015 Annual Meeting. Scientists presented some solutions to this issue during the meeting. In2science asked employees: What should we research in the future? What can we change? Read some answers here:

Felix Beck: "We really should expand research in the areas of sustainability and on the topic of climate change. These are topics that concern us all. These are global undertakings that we can only solve together."

Gisela Bengtson: "I wish that people would feel more of a responsibility toward the Earth and the environment. So we could then rely only on voluntary behaviour rather than on taxes and penalties, and people's sense of personal responsibility would be addressed. Think of your children or even your neighbour's children. They're the ones who will want to ultimately live on this planet."

Holger Brix: "I think research in the direction of sustainability needs to become more interdisciplinary, spanning various fields. And we need to try to establish a connection between what we know as the natural sciences and the cultural and social sciences. I think there needs to be a focus on trying to cooperate better and more closely with the different disciplines."

Holger Buhr: "An important topic for me is mobility: we want to go to work by the most efficient possible means and use as few resources as possible. We should therefore advance research in the field of hydrogen technology. We could then count on a hydrogen car. Because the vehicle would need to be economically feasible for people, I hope this would mean politics would assist in lowering taxes. I would switch to a hydrogen car if it meant the cost would be the same or only a little higher."

We are HZG

Hajo Dieringa: "An important topic for me is creating lighter airplanes, cars and other vehicles because vehicles in motion require energy. The lighter they are, the less energy is required to run them."

Katharina Jantzen: "Sustainable resource protection would be an important topic for the future. Implementing sustainable fishery management and then studying the issue so that we have sufficient long-term fish populations. We're simply overfishing the sea. That would perhaps be a future topic for our coastal researchers."

Nina Diercks: "I think we really need to keep climate change in mind, most of all, climate change in coastal regions. This concerns water levels and perhaps dike expansion; flood protection measures must be expanded to adapt to climate change."

Dear Colleagues,

Selecting material for the second issue of our staff magazine was difficult. The centre generates a great deal of good stories. Because we couldn't include all of those, here's a tip: check out our other stories on our homepage at www.hzg.de. You'll find a lot of exciting news that we unfortunately couldn't fit in this issue.

Our materials scientists at the Deutsches Elektronen Synchrotron (DESY) beamlines use X-ray to look deep inside materials. What exactly happens when materials, for example, are fused? Specifically developed instruments shed light on the behaviour of materials during processing. Find out more about this detective work in our photo feature.

What does a cruise have to do with science and why do we cooperate with the tour operator TUI? These questions are covered in an interview with Dr. Wilhelm Peterson.

Dr. Regine Willumeit-Römer has been institute director in Geesthacht since the start of the year. Read more about her institute's research in the interview.

We hope you enjoy reading this issue and we look forward to receiving your feedback. Feel free to get in touch!
Your Editorial Team / In2science@hzg.de

Photo Story

The Experiment

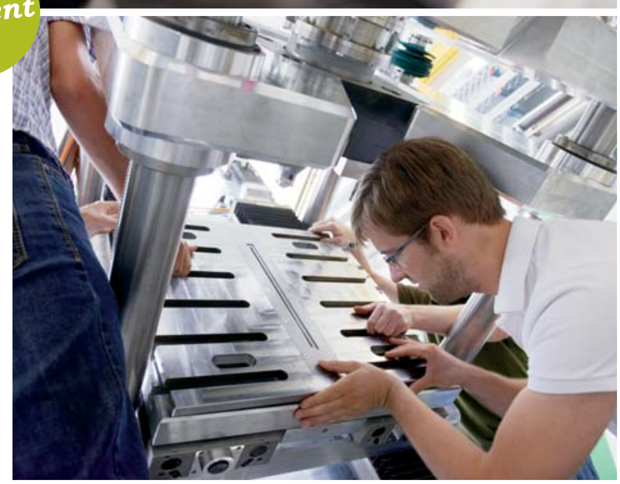
Detective Work with X-rays

They are a speciality of the material researchers in Geesthacht: measurement devices with which materials can be processed and characterised live within the synchrotron beam. Scientists at the X-ray source PETRA III at DESY in Hamburg watch, for example, the stir welding process. Their aim: they're on the hunt for the optimal joining seam. That can better be discovered if they understand the processes during welding. To achieve their goal, they're using the modular welding machine "Flexi-Stir". This machine was conceived, partially designed and manufactured at the HZG. From left to right: Jakob Hilgert, Luciano Bergmann, Torben Fischer and Malte Blankenburg.

The Moment

Before the measurement

In situ instruments like the Flexi-Stir here must be adjusted with extreme precision before starting the measurements. During these adjustments, the accelerator ring doesn't yet supply a beam for HZG's own High Energy Material Beamline (HEMS) at PETRA III.



Synchrotron radiation

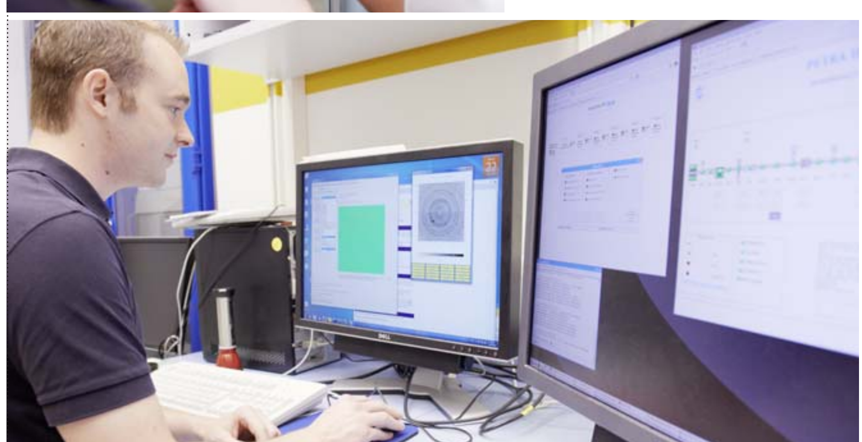
It arises when charged particles rotate in an accelerator: when, by employing magnets, electrons move at nearly the speed of light around a curve, they lose part of their energy by emitting a high intensity light beam. In the X-ray range, the light is up to one million times brighter than an X-ray tube utilised in the medical field. It's ideal for penetrating deep into materials.

Metal welding

The researchers look for internal stresses in the sample introduced during the production process. Cracks could develop at these locations.

At the Beamline

As soon as the beam arrives in the HEMS Beamline measurement shed, the experiments can be only observed from the adjacent rooms. Now the researchers wait and hope that the sensitive FlexiStir instrument has been precisely positioned.



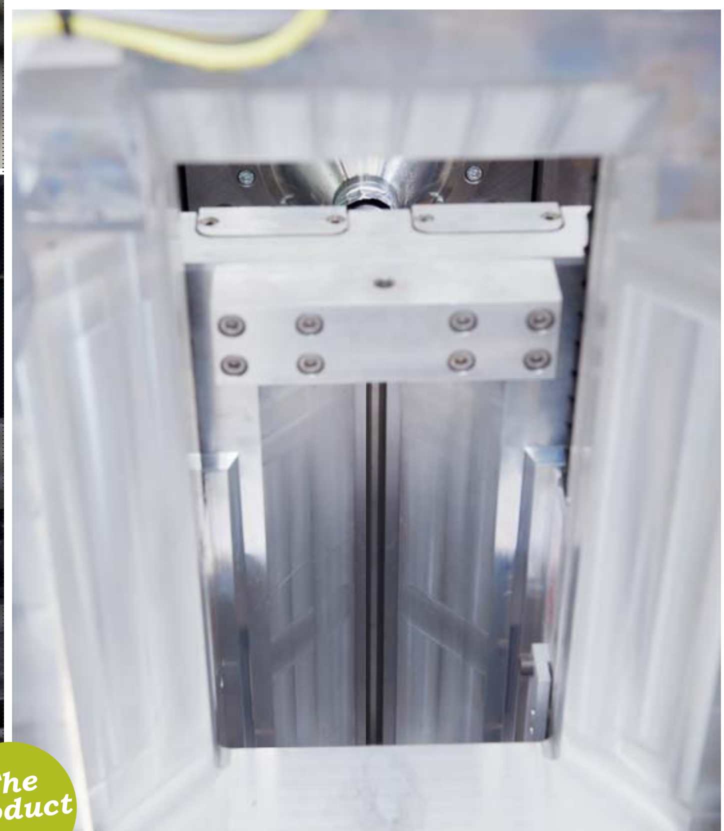
In situ

The refrigerator-sized FlexiStir instrument is set up in advance at the HEMS Beamline. The metal sample that is to be joined is clamped and the position of the welding head is tested.

The Idea

Finding the correct position

The tool, glowing orange, sits perfectly in the instrument. The experiment can now begin.



The Product

Deep Insights – in Real-Time

What is particularly interesting during the live joining process is how the thermomechanically influenced zone of the welded seam behaves. Thanks to Flexi-Stir, this can be observed at any time during joining with the help of the beamline X-ray.

The End

Dismantling

Another part of the researchers' everyday routine carried out at the HEMS Beamline: scientists help with FlexiStir so they can transport it back to Geesthacht. Also pictured: DESY colleague René Kirchhof.

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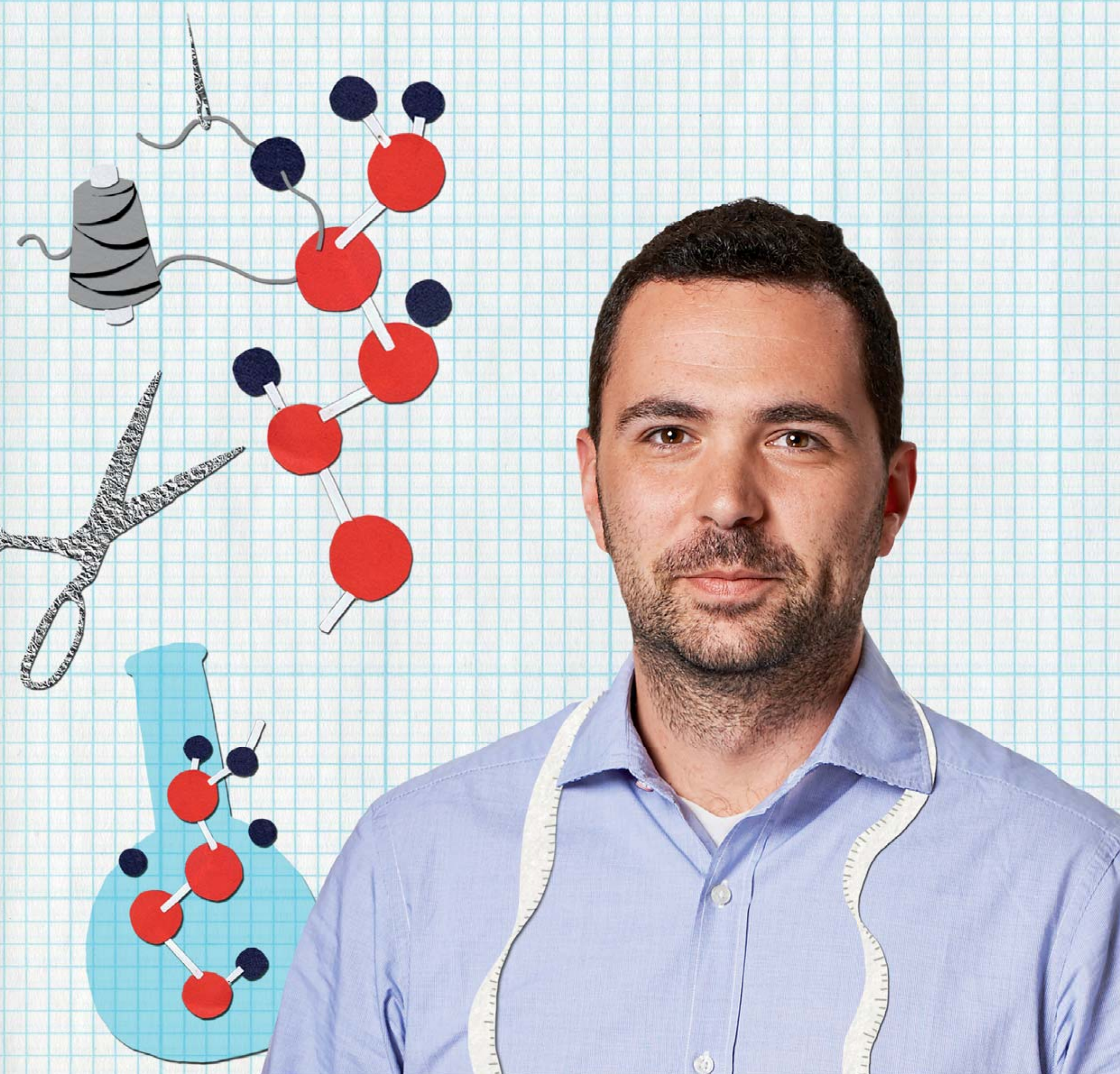
The HZG Molecule Tailor:
"Even small changes can be effective"



Alberto Tena –

Alberto Tena's working realm is at the molecular level.
The young chemist feels good here.

Alberto Tena's working realm is at the molecular level. The young chemist feels good here and it is here that he has been making important contributions to the Helmholtz-Zentrum Geesthacht (HZG) since 2014. These contributions lie in the production of tailor-made polymers for complex synthetic membranes. It is Tena's objective to separate undesirable materials. His area of expertise concerns polymers for gas separation.

Alberto Tena might be in the mood for a party right now. Together with a group of colleagues, the 32-year-old submitted his first patent a few weeks ago. Isn't it a reason to be proud? "Oh, not really worth talking about," he says, fending off the question with a wave of his hand. "It's basically not much different than a scientific publication." There's a brief pause, then he adds, "I'm very self-critical. I still need a bit of time to really feel proud of myself."

Regular publications, a long list of scientific lectures given at national and international conferences as well as research visits financed through grants all adorn his professional record. Tena has worked at the 'European Synchrotron Radiation Facility', a multi-national large-scale research establishment located in Grenoble, France. His passion for science also led him temporarily to Texas, Bologna and Alicante.

His current stop: Geesthacht. Here the young scientist works in the Department of Polymer Synthesis at the Institute of Polymer Research. "I also had the chance to go to the United States or to England," he says. "I decided in favour of the HZG because it is internationally distinguished in membrane research. I also find it exciting that the Institute of Polymer Research covers the entire production chain – from the basic research to the creation of prototypes." Tena had discovered the Geesthacht research centre through scientific HZG publications. "The research community involved with membrane production is manageable," he says. "Here," he adds, "everyone knows what the other scientists are working on."

The HZG also knew about Alberto Tena and his scientific background. "The HZG wanted me because my work involves polyimides," he explains. Polyimides are specific polymers, which are particularly suitable for gas separation processes. These properties were also instrumental for Alberto Tena in his patent submission. For that work, the young chemist resorted to a special form of polyimides that are able to transform into a completely new compound, polybenzoxazole, when utilising an additional temperature treatment. It is ideal for separating a variety of gases. "One disadvantage is that the membrane becomes brittle and breaks easily. Apart from that, very high temperatures are necessary," Tena explains.

The aim of the HZG scientists was therefore to reduce these temperatures while also maintaining or improving the excellent separation properties. Tena and his colleagues rose to the challenge: they altered the chemical structure, experimented with various temperatures and adjusted the production parameters. The outcome was astounding. Tena says, "The results were really good in just the second test." Tena is a realist and knows it will be some time before there's a breakthrough. He adds, "Now it's all about understanding the processes and continuing to improve them."

He is content with his life in Geesthacht. His colleagues are friendly and he's learning a lot. The Germans warmly welcomed him. "As a Spaniard," he says, "I always have a sense that they associate me a bit with their vacations, sunshine and fun. I've found a really nice group of young people here." They all come from different countries and are employed at the HZG as doctoral candidates or post-doctorates. They meet during the weekends for various activities. They go out to eat, make daytrips, absorb the Hamburg nightlife, watch movies, explore cities—the list is long. "I'm not bored," Tena declares.

But there is a downside to his life: his wife is a post-doctorate in Madrid. If time permits, the 32-year-old hops on a plane and flies to Spain every two months or so. "We also talk via internet a lot," Tena says. They met during their school days and they were in the same class, but it took a while until they clicked. "I can make good decisions very quickly in the professional realm, but I sometimes need more time in private matters," he explains, thoughtfully stroking his designer stubble, "I'm really rather more of an analytical person."

"Of course," he says, "it would be great if my partner and I could live in the same city." The young Spaniard dreams of a family and a small house in the long-term, adding, "Houses in Spain are unaffordable." In the professional realm, he is striving for more responsibility as he looks to the future, perhaps in the form of his own research group. "To prove myself in such a capacity, yeah, I think I'd be proud of that," Tena says. By that time he will have tailored one or two garments of molecules.

Editor: Vanessa Barth / Illustration: Luca Candotti

Caribbean Cruise

with Scientific Instruments

Research and a cruise ship. What's the connection? Scientists at the Helmholtz-Zentrum Geesthacht are plumbing the depths of this relationship in cooperation with TUI Cruises by installing an array of scientific measurement instruments on MeinSchiff 3. The measurement instruments function independently so that constant observation isn't a requirement. Both partners are covering new ground together.

Read the interview with Project Leads Dr. Wilhelm Peterson, HZG Department Head of In Situ Measurement Systems, and Lucienne Damm, Environmental Manager at TUI Cruises.

ABOUT
Lucienne Damm
Lucienne Damm has worked as environmental manager at TUI Cruises since 2011. She further develops environmental strategies and compiles environmental and sustainability concepts. After studying political science, she had been active as a consultant in the Nature and Biodiversity Conservation Union Germany before joining TUI.

ABOUT
Dr. Wilhelm Petersen
Dr. Wilhelm Peterson is the head of the Department of In Situ Measurement Systems at the Institute of Coastal Research. Peterson and his team develop automated measurement systems used on ships. His focus lies in biogeochemical processes in the environment and in the North Sea.

The Experiment

Wilhelm Petersen

All on-board data is transmitted via satellite in real-time to a database at our institute and is then immediately made available over the Internet to researchers worldwide.

Cooperation between a research institute and a cruise ship company sounds unusual. How did that come about?

Lucienne Damm: It began as an educational option on board for children and youth in our Kids Club. This led to scientists asking how we could also facilitate research on the ships. As environmental manager and due to my scientific background, the idea immediately appealed to me. Everything was a bit provisional at first. But the construction of Mein Schiff 3 gave us quite a bit of wiggling room to accommodate scientific instruments.

How does the cooperation work?

Wilhelm Petersen: This cooperation creates the opportunity for carrying out research on a cruise ship. We have installed what is known as a FerryBox on Mein Schiff 3. Using the FerryBox, we can analyse the water quality of seawater during the cruise. In addition, a mercury analyser as well as a sulphur dioxide and a carbon monoxide measurement instrument are installed on board for measuring pollutants. All on-board data is transmitted via satellite in real-time to a database at our institute and is then immediately made available over the Internet to researchers worldwide. We also offer regular lectures on the ship in which we present our research, the measurements and the marine ecosystem.

Lucienne Damm: What is also exciting from the point of view of our guests is that we operate the "Meer leben" ("Sea Life") – a maritime museum on the sea. We present the research activities here interactively as well as making cruise guests aware of marine ecosystem protection. When the passenger is relaxed and well-informed after the journey, then we consider that a terrific success.

What are your objectives in this cooperation?

Wilhelm Petersen: We already operate FerryBoxes on different ferries and cargo ships, which travel fixed routes. The cruise ship, on the other hand, heads to different destinations. The advantage here is that we cover a larger surface area and, at times, regions where standard commercial vessels don't travel. The cooperation is just as new for us as it is for TUI Cruises and we still need to see how the scientific benefits compare to the effort required. Even if the units are fully automated, we are still dependent on support on board the ship. An environmental officer, for example, needs to check the device and change the filters as needed. We could, On-board research activities are represented in the exhibition: „Sea Life“ - a maritime museum at sea.

however, very nicely observe the formation of the first algal blooms in the Mediterranean during spring of this year.

Lucienne Damm: We are gladly supporting the project even though it doesn’t pursue any primary commercial goal. I simply find it exciting to facilitate on-board research. And of course our guests can also benefit because it is part of our marine life exhibition. Our central activities in environmental management are entirely different however. They are mainly concerned with constructing our ships in an environmentally friendlier manner and with lowering emissions. We also work toward avoiding the production of garbage, reducing wastewater and creating a more sustainable supply chain.

Wilhelm Petersen: One aim of the HZG is to make stronger public connections. We don’t simply sit behind closed doors with our research, but also make our data publicly accessible. On a cruise ship like the Mein Schiff 3, there are approximately two thousand people on board, with passengers changing weekly, so we can reach a lot of individuals.

The environmental officer on board ensures that the scientific equipment operates properly and replaces the filter if necessary.

Wilhelm Petersen

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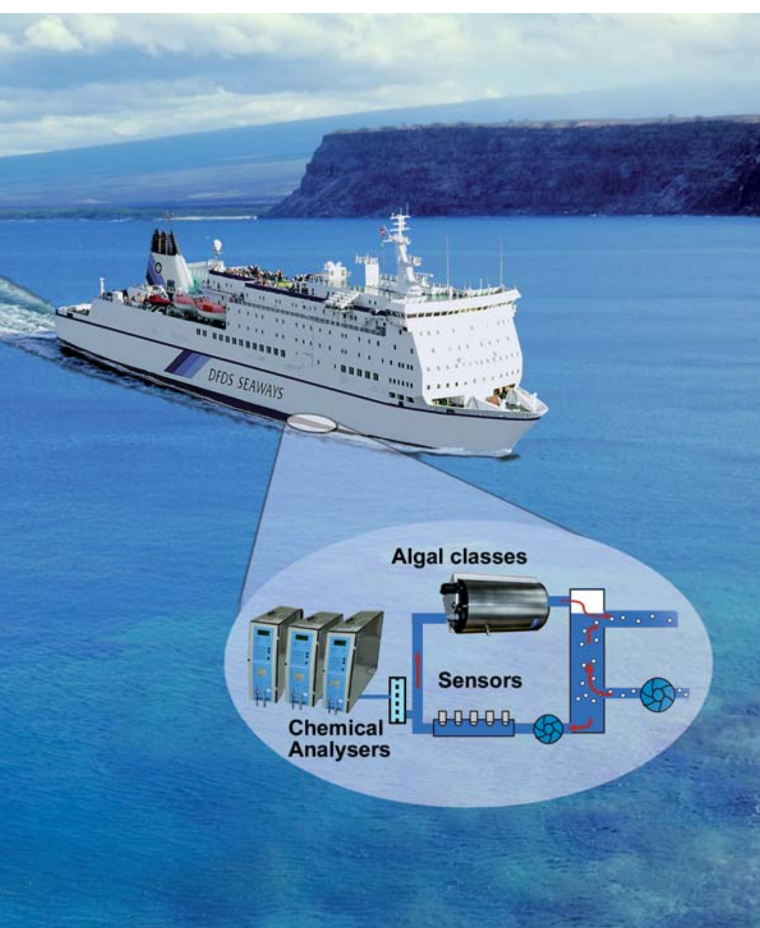
What exactly do you want to study?

Wilhelm Petersen: Using the FerryBox, we can measure basic oceanographic parameters such as temperature, salinity and water turbidity, which are supplemented with further information. We determine, for example, algal blooms through the chlorophyll content as well as measure the oxygen content and the pH value.

The mercury collector's data is explained to Lucienne Damm.



What information can you obtain from this?

Wilhelm Petersen: Scientists have determined, for example, that ocean acidification in the polar regions is progressing faster than in other regions. This is partly related to the water temperature or the fact that biodegradation processes are slower there. It is these processes that we wish to study and understand. The same applies to carbon dioxide in the water, something that is of particular interest in connection with climate research. It is estimated that approximately thirty percent of anthropogenic CO2 emissions is absorbed by the sea and is thus extracted from the atmosphere, slowing the greenhouse effect of the CO2. These are, however, rough estimates and we are missing precise numbers, such as on regional variations. It is also unclear whether the coastal regions are a source or sink for carbon dioxide. We haven't yet measured carbon dioxide on Mein Schiff 3, but it's something I can certainly imagine undertaking soon. We also would like to determine how algal blooms arise, what triggers them, when they disappear and what effects they have. We are still missing comprehensive measurements covering a large area. We hope we can provide such measurements using the FerryBox systems.

There are three additional instruments on board. What is their purpose?

Wilhelm Petersen: With the mercury analyser we want to determine the mercury pollution in the atmosphere during the journey. We obtain supplemental information using the carbon monoxide and sulphur monoxide measurement instruments, which provide information on anthropogenic sources, allowing us to analyse and classify the data. Is this plume, for example, from a coal-fired power plant or is it caused by a wildfire? This can only be determined if we measure the other two gases in addition to mercury.

The FerryBox automatically measures, for example, turbidity and water temperature.

Does this also apply to exhaust plumes from ships?

Wilhelm Petersen: If it concerns mercury exposure, the contribution from ships is negligible. The exhaust from ships is of course measured, but the focus lies in global mercury measurement projects like GMOS (Global Mercury Observation System). The goal is to set up a worldwide measurement network and, in doing so, to determine the global mercury distribution. Mercury reaches the atmosphere mainly due to fossil combustion processes and, in the end, even finds it way to the polar bears at the North pole. Mercury primarily accumulates in the fatty tissues and enters the food chain, eventually reaching humans.

Why does it actually make sense to equip a cruise ship with scientific instruments instead of collecting specific data via research expeditions?

Wilhelm Petersen: We benefit from a high data density and can conduct research very economically in comparison. Imagine a scenario of the following magnitude: in order to operate a small research ship, costs run approximately ten thousand Euros per day. If we use the Polarstern, Germany's largest research vessel, the price quickly goes up to 100,000 Euros. This was also the basic philosophy behind the FerryBox: we have access to ships that are traveling anyway. Of course we cannot determine the route, something we'd of course like to do, but in exchange we get continuous measurement series along one route. In collecting this data, we can measure long-term changes and short-term processes such as algal blooms, which we might otherwise miss during a very temporally limited research expedition because they might have occurred right before or after the cruise.

> Lucienne Damm:
> The new systems, which we utilise globally, have helped us reduce sulphur emissions by ninety-nine percent. We are thus virtually at the same level as marine diesel, in which sulphur makes up 0.1 percent of the fuel. That is considerably more than is required by law. With the aid of catalytic converters, we reduce the nitrogen oxide output in the exhaust by approximately seventy-five percent and the amount of soot particles is decreased by sixty percent.

Ms. Damm, from a distance, cooperation with the HZG could be construed by malicious critics as a kind of "greenwashing."

Lucienne Damm: I would have to ask myself why here. What we're doing is making a platform available for research. We neither advertise this to customers nor do we represent ourselves as a top eco-company.

What environmental measures does TUI Cruises currently adhere to?

Lucienne Damm: Important measures concern the construction of our new vessels. Mein Schiff 3 and 4 as well as our planned ships Mein Schiff 5 and 6 possess a combined exhaust after-treatment system. We have also installed very innovative wastewater treatment units on board the new ships.

Willi Petersen will determine the mercury levels in the atmosphere.

Lucienne Damm and the captain of the Mein Schiff 3 are happy about the research on board.

Where do you stand in comparison with other European cruise ship operators?

Lucienne Damm: I can be relatively confident at the moment in saying that in Europe as well as globally there are currently no other cruise ship companies that have installed such a comprehensive exhaust after-treatment system as TUI Cruises has. At least none that I'm aware of.

But you're still using heavy oil.

Lucienne Damm: What is crucial for us as a globally active cruise ship company is that we can refuel anywhere in the world, so we are therefore dependent on what is regionally available. This winter we're in Asia, the following year in Central America, then we're headed to the Orient and the Caribbean. There's no demand in those areas for low-sulphur fuels so they aren't available there at all. We therefore decided as a company that we would use exhaust after-treatment as a bridging technology and utilise it worldwide. We and other cruise ship operators do consider liquefied natural gas as an environmentally friendly alternative in the future. We must first, however, solve many technical and infrastructural problems.

Could you tell us a bit about your role as environmental manager at TUI Cruises?

Lucienne Damm: I joined TUI Cruises because I wanted to do more than just point fingers at others. My new position as environmental manager allows me to shape and take on challenges to improve matters. I was, for example, heavily involved with the basic planning of Mein Schiff 3 and 4 and could therefore define some central environmental standards. That was very exciting for me. In the end, we are of course a commercial enterprise, but I can influence our future course in my role.

What further opportunities do you see for cooperation?

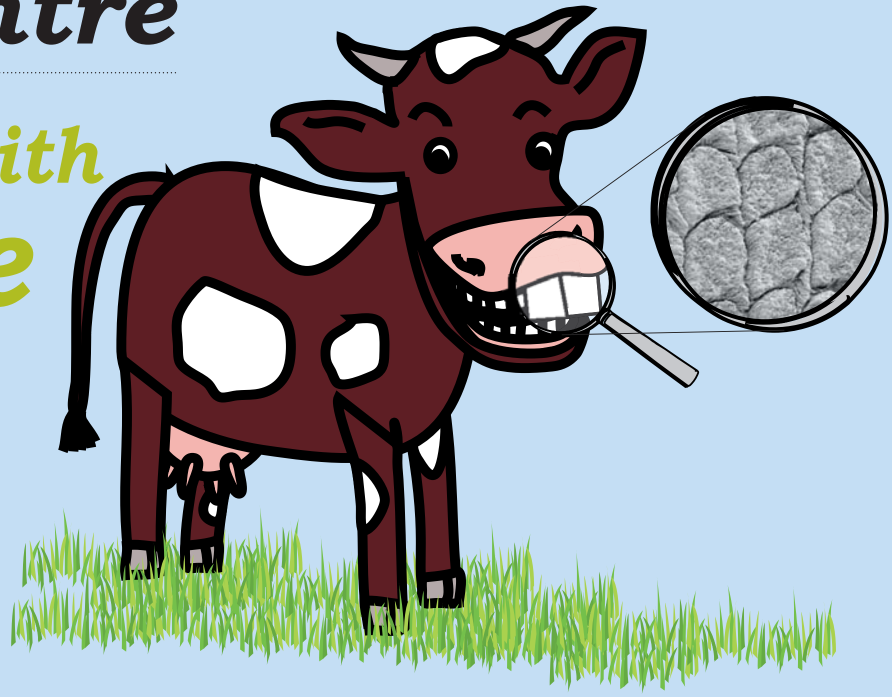
Lucienne Damm: We are open to everything. We could, for example, expand the instruments on Mein Schiff 3 in the future or equip other ships with suitable instruments to cover additional regions. I say that everything is possible.

Wilhelm Petersen: Expanding the spectrum of measurement parameters would be relatively simple. A dream would of course be to have a laboratory on board in the future. Frau Damm's suggestion for equipping additional cruise ships with scientific technology seems attractive to me too. Mein Schiff 4, for example, will mainly be traveling the northern regions and would therefore ideally expand our measurements on fixed routes in the North Sea.

Interview: Vanessa.Barth@hzg.de

At the Centre

Researcher with a Bite



Working with light metals such as aluminium and magnesium are part of Dr. Ingo Scheider's everyday routine. But recently the materials researcher stumbled upon the tooth. Specifically on cow teeth. He is researching bovine teeth within the Special Research Area 986, "Custom Multi-Scale Materials Systems", led by the Technical University Hamburg-Harburg (TUHH).

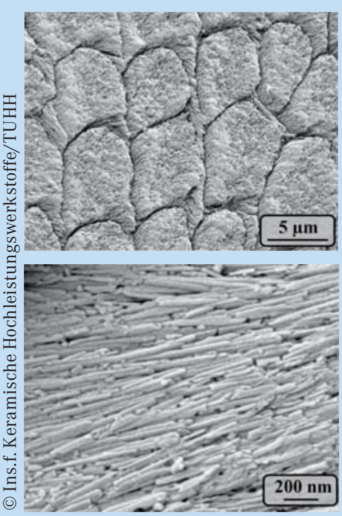
The focus lies on the highly-stressed outer layer of the teeth, the enamel. "It's only a few millimetres thin but we tend to keep it throughout our lives despite the incredible stress of daily chewing. Nature has really taken a lot into consideration," says Schneider, putting his excitement for the natural high-performance material into words.

The experimental characterisation of the tooth's material by Prof. Gerold Schneider (TUHH) served as the starting point. In order to support the work through simulations, this explorative project was established within the HZG's ACE research platform.

It is the researcher's aim to characterise enamel as a model for synthetic, hierarchical materials systems, which possess similarly positive mechanical properties: high hardness with high fracture toughness.

A prerequisite for characterisation meant that the scientists needed to first understand what lends enamel its hardness. The researchers therefore cut out thin rods from the cow teeth and placed them under increasing pressure—until the material yielded.

The important point here for the researchers was less the "when", but rather the "how". The astounding result was that in order to destroy the sample, the scientists needed to use much more energy than had been assumed from looking at the components. This increased their curiosity. How can such a thin layer be so durable? Under the electron microscope, scientists led by Prof. Gerold Schneider recognised that the structure was ultimately crucial. They glimpsed numerous thin fibres that were just over fifty millionths of a millimetre thick. This is about one thousandth the thickness of a strand of hair. "The combination of hard and soft components is crucial in terms of the unusual properties. The fibres are closely interwoven and are always changing direction, whereby they can better avert severe damage," Schneider says, summarising their findings.



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These findings are integrated into a mathematical model with which the team can predict the fracture behaviour of enamel very precisely, as can be seen when compared to control experiments on bovine teeth. "New to our model is that we can map the hierarchical structure of the tooth enamel for all layers," says the HZG scientist. The procedure is crucial for the next step: to manufacture the materials in-house. The simulation helps the researchers to make important predictions on how artificial fibres must be constituted so that, in the end, they possess the unique properties of enamel.

The HZG researchers, Ingo Scheider and Swantje Bargmann, have published their first papers. "I hope that we can completely describe tooth enamel within about a year," says Scheider about the research progress. In order to do so, simulations and tests will be carried out at Erica Lilleodden's nanolab at the HZG and a second doctoral thesis on this project is underway at the TUHH. All results will be encompassed in the SFB's second funding period.

At the Centre

Role Models sought

to Help Youth Make University and Career Choices

A „Speed Dating Day“ will take place at the Helmholtz-Zentrum Geesthacht in January for female scientists and female students in eleventh grade. We're therefore searching for female scientists at various stages of their careers.

Background: Half of students entering universities today are women. Women, however, are still clearly underrepresented in the areas of technical and natural sciences. Particularly low numbers of women enter the engineering sciences (thirteen percent) and the fields of mathematics and natural sciences (twenty-one percent). We would therefore like to encourage girls to opt for a degree in the natural sciences.

"Speed dating" means that doctoral candidates, post-docs or women researchers in management positions will introduce their area of expertise in a round of dialogue with ten to fifteen secondary school students and will answer the girls' questions on their choice of profession. After a short round, the students switch to the next discussion circle. This method allows the students to learn, in one morning, about different career paths and research areas.

The Speed Dating event is organised by Heidrun Hillen (HZG Public Relations), Sabine Mendach (Quantum Leap School Laboratory) and our Equal Opportunities Representative Elina Valli. Kindly contact Heidrun Hillen (Tel: 04152 87 1648) if you are a female scientist willing to meet with the pupils. We're aiming for January 13th or 14th, 2016, to host the event.

Research for Smooth Operation

Nothing is as good for reducing friction: the best lubricants in the world are the fluids found in joint cartilage. A group led by Regine Willumeit-Römer from the Institute of Materials Research at the Helmholtz-Zentrum Geesthacht wants to understand how this special property materialises. She is researching the structural reasons for such exceptional functionality of the joint fluids in the project JOINT, supported by the Federal Ministry of Education and Research.

She therefore developed two sample environments with which she could study the components of joint fluid under realistic working conditions. "One of the two experimental setups is a microfluidic chip, which constricts from one hundred to ten micrometres, whereby different shearing stresses affect the components," explains Florian Wieland, who is participating in the project. With the aid of focused X-ray, the scientists can, for example, study the behaviour of protein clusters contained in the joint fluid. "We discovered that the protein clusters can be destabilised or destroyed by shearing," says Wieland.

To measure the deformation and flow properties of the joint fluid components under pressure and under shearing, Wieland and his colleagues converted a rheometer as a second sample environment so that it was compatible with the measurement stations of the X-ray sources.

While the researchers are initially concentrating on the individual components of the natural lubricant, they want to ultimately understand their mutual interactions: this knowledge could, for example, play a role in therapeutic approaches for injured joints.

Editor: Franziska Konitzer

Capturing Neutrons with Ceramics

Material researchers use neutron scattering for characterising materials. Recent prototypes of novel detectors were successfully developed at the Institute of Materials Research.

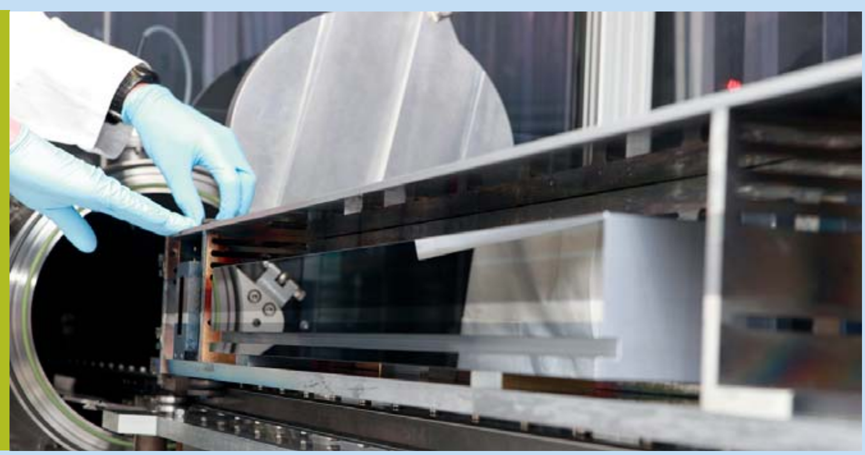
Special detectors are required for spotting neutrons because detecting neutrons is a difficult task. Whoever undertakes a search for neutrons must quickly understand that they're difficult to grasp. Neutrons are, as their name already indicates, neutral – that is, uncharged. The method for detecting neutrons is therefore indirect, in which, for example, the nucleus of the very rare helium3 (^{3}He) gas is split from the neutrons and thereby two charged ions and a photon are released. Ions are easily detected because the moving charge represents a small electrical current. The problem is that there are no natural sources on the planet of the extremely rare ^{3}He gas. It is extremely expensive due to its rarity. An urgent search for an alternative material has been on-going globally.

Dr. Gregor Nowak, physicist in the Department of Structural Research on New Materials says, "The Idea was to incorporate neutron sensitive coatings into a conventional gas detector. A solid coating is therefore used instead of the expensive 3He gas for neutron detection." Within three years, the scientists studied the boron carbide (10B4C) ceramic coating, which contains the neutron sensitive 10B atoms, and made it ready for a patent application. Prototypes of these detectors were built and successfully tested. Gregor Nowak explains, "The detectors can be produced economically using our technology, which meet not only the highest scientific requirements, but the spatial resolution of past detectors is also increased by a factor of ten."

How is the neutron-sensitive coating at the HZG developed?

The boron carbide ceramic is separated as a razor-thin layer on the substrate, an aluminium plate, by means of magnetron sputtering. This is possible because the HZG has a sputtering system that can apply very homogenous coatings on large surfaces. The system was conceived by Dr. Michael Störmer and Christian Horstmann from the Nanotechnology Department.

During magnetron sputtering, atoms are ejected from a solid body by bombarding it with high-energy ions, resulting in plasma. These removed atoms, as in our boron carbide target example, spread in a vacuum environment and arrange themselves as a thin layer on the aluminium plate. The atoms condense into a solid film and the coating has been created. Using this method, the required boron carbide coating of only 1.2 micrometres thick for detecting neutrons is applied.



Climate Service Center Germany – GERICS

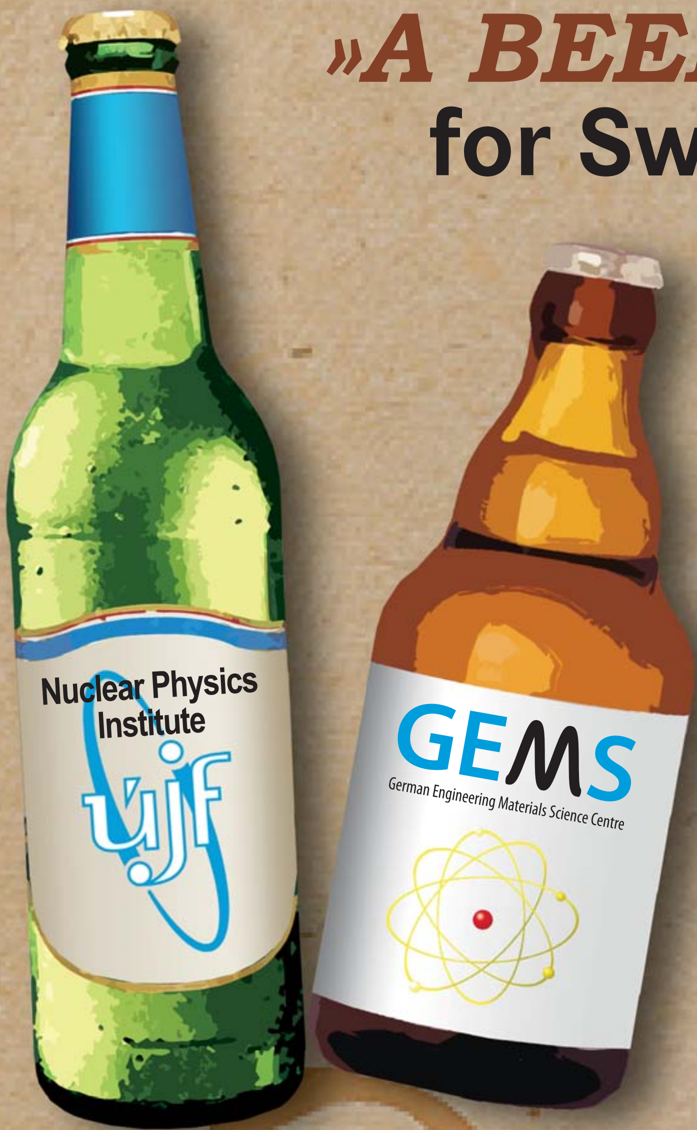
GERICS
Climate Service Center
Germany

As of July 20th, 2015, the Hamburg climate researchers are now known as "Climate Service Center Germany", abbreviated GERICS. With the reorientation of the Climate Service Center, there's been a shift in focus from a broad mandate as purely a service provider to a focussed objective as a "think tank" for prototype development in climate service. GERICS thus heavily promotes the information access they provide to political decision makers, government agencies and the economic sector by developing prototypes for consulting services.

Find out more about the new developments at the Climate Service Center in the detailed interview with Director Dr. Daniela Jaocb on www.hzg.de

At the Centre

»A BEER for Sweden«



Germany and the Czech Republic are well-known all over the world for their good beer. Beginning in 2019, BEER is expected to make a name for itself in the materials science world. The new diffractometer concept is under development for use in materials science experiments by a German-Czech team for the European Spallation Source (ESS) in Sweden.

Neutrons have been used in science at the Helmholtz-Zentrum Geesthacht for decades in order to better understand materials. The researchers operate their own in-house instruments at the FRMII in Garching bei München today. Neutrons function like a high powered magnifying lens because they can penetrate deeply into the samples: using rays, the scientists study the inner structures of materials and the particle movement within the materials. The Helmholtz-Zentrum Geesthacht consolidates the research with neutrons and photons in the platform “German Engineering Materials Science Center” (GEMS).

Experts from Geesthacht and Prague

Due to their many years of expertise, the Geesthacht scientists are participating in developing instruments for the European Spallation Source (ESS) in Lund, Sweden. For this particularly high-resolution spallation source, the German-Czech cooperation is to provide a materials science diffractometer, the Beamline for European Materials Engineering Research – BEER for short. BEER is still in its planning phase. The installation and test phases are scheduled for 2016 to 2019.

The new beamline is produced through the scientific group in Prague at the Institute for Nuclear Physics (NPI) in the Czech Republic and through GEMS, which is part of the Institute of Materials Research at the Helmholtz-Zentrum Geesthacht. Dr Jochen Fenske from the Department of Structural Research on New Materials is responsible for the HZG's portion of the project. Fenske says: "The German as well as the Czech scientists had initially developed their own concepts for the ESS diffractometer. It became quickly clear that both groups would profit from combining the concepts."

Deep New Insights Made Possible

With the help of the bright, pulsed beam at the ESS, it will be possible in the future to monitor, in millisecond intervals, the combustion processes in a running motor for example. Neutrons can also be used in other applications. Modern functional materials possess properties that are yet to be understood in detail. The new instrument will, for example, help scientists study how structures change when using new joining technologies. The BEER instrument at the ESS will enable researchers to investigate these changes in situ with neutrons during the welding process.

The Steering Committee Decides

In a rigorous selection process, the ESS steering committee (STC) decided in October 2014 which instrument proposals would be developed. A total of twenty-two instruments are installed at the ESS until 2025. BEER, as a project with two equal partners, was evaluated positively by the ESS for the first phase of instrumentation. That means that the project overcame the first hurdle in its twenty-two-million Euro development and instrumentation. The next step is to start phase one of the construction phase. Further evaluations are lined up in the future before phases two to five can begin. We can count on the first neutrons to reach the instrument in 2020 at the earliest. Then it will be the diffractometer for material science with the strongest flow in the world.

Until then, the developers – Jochen Fenske, Reinhard Kampann, Mustapha Rouijaa, Peter Staron, Heinz-Günther Brokmeier and Institute Director Andreas Schreyer – will have drunk some good beer with their Czech BEER colleagues.

Metallic Biomaterials: *Screws that dissolve*

Prof. Regine Willumeit-Römer has served as institute director of the Metallic Biomaterials Division at the Institute of Materials Research of the Helmholtz-Zentrum Geesthacht since January 2015. The long-time HZG department head discusses her institute's research with Erich Wittenberg.

What are the tasks and goals of this new division?

As the name indicates, we would like to develop metallic biomaterials, which are essentially implant materials for affixing and repairing bones. Our main focus lies in measurement and development of magnesium alloys for use in degradable implants. We will also, however, develop titanium alloys for permanent implants that remain in the body.

So, the main priority is to develop magnesium bone implants that no longer need to be removed from the body because they dissolve. This research has been carried out since 2011 in the EU project MagnIM.

That is correct. There are various materials available for this task. Polymers that dissolve, for example, can be used. That's actually already been done. There are some applications where small polymer screws are utilised for attaching ripped ligaments in knee and shoulder joints. We're moving in a different direction. We're using metals that dissolve. Iron, zinc and magnesium are potential candidates. We decided on magnesium because, of the three metals, it basically dissolves fastest and because it can be a very sensible supplement for the body. Magnesium is an extremely important component in the body and, in contrast to polymers, it is also a "load bearing" material – that is, it is more rigid and firm than a polymer material. We also hope to provide greater support for major bone defects with our work.

One cannot simply take a piece of magnesium and produce an implant from it, right? Where's the devil the details?

The main problem is actually the degradability of the material. If it dissolves too fast, think of it rather like a fizzy tablet: it releases a lot of gas and the material disappears quickly. Healing bones require, however, several weeks to months. That is, the material should remain in place within the body for this period of time. Also, the release of hydrogen gas is obviously not something that I would like to see happening in the bones. I therefore need to find a middle ground between a degradation rate that is fast enough, so that the material quickly disappears from the body but is slow enough so that the bones can become suitably accustomed to the implant and can heal themselves while the implant degrades. It is extremely difficult to precisely gauge. There are so many factors that must be considered. Such considerations include selecting the right alloy element, the necessary thermal and surface treatments, which, if done incorrectly, can essentially lead to the material degrading much faster than you'd like.

Which alloys do you use?

In principle, we work with rare earths as one component. But we've also been using silver as an alloy element. Silver is scientifically useful for us in adjusting certain material properties and has the added benefit of its antimicrobial effect. The idea was that, by using this implant, it would kill bacteria in the wound during the degradation process.

> One of the central questions is: how does the material actually degrade in the body and, above all, how can I measure this process?

You can, for example, also add calcium as an alloy element. We have a very large box of materials to work with. We begin with alloys, always initially mixing magnesium with an alloy element though actually more complicated mixes, using two or even three additional alloy elements, are conceivable. That is something we're working on at the moment.

What insights have your studies brought to light?

We worked for a very long time on suitable cell culture experiments. Magnesium's specific degradation behaviour requires all new experiments. Unfortunately, the standard tests cannot be used at all here, as they would lead to false results. The next problems arise with the surface characterisation and the nature of the implant surface. After we had those under control, we realised that the material was degrading too slowly, though we had discerned that the rates were suitable in cell cultures in a range of about one millimetre per year. Colleagues at the University Clinic Graz carried out animal testing on rats that were, however, substantially slower. This means that we need to retest the corrosion rates in cell cultures to ensure that the rate in the animal matches that of the corrosion rate in the cell culture.

Are your materials produced in Geesthacht?

Yes, partially. The alloys are produced with the help of our colleagues at the Magnesium Innovation Center. The final production, however, takes place elsewhere. It is something that we would like to do ourselves in the future though. We would like to undertake a number of measures for acquiring the most important instruments and machines in order to be able to create the prototypes ourselves. As it turns out, the process ranging from casting the raw material to producing the final screw requires a great many steps, all of

ABOUT

Prof. Regine Willumeit-Römer studied physics and completed qualifications for a professorship (Habilitation) twice: physics in 1996 and biochemistry in 2003. In 2014 she became W3 Professor at the University of Kiel. She has been institute director in Geesthacht since 2015.

which influence the material itself. We have therefore said that we must be in the position to optimise and scientifically measure these processes ourselves by manufacturing small batches. An implant manufacturer that produces screws, for example, supplies us in the end with hundreds of screws. If we only need ten in order to tell us that the process unfortunately didn‘t work, then that‘s a complete waste of resources. The manufacturer of course doesn’t make several runs, constantly using new process parameters; they do so using only one set. This is by far insufficient for our scientific work. This means that we would very much like to handle the entire product chain ourselves in the future, here in Geesthacht.

MagnIM was to run for a duration of four years, starting in 2011. Does it end in September of this year?

MagnIM will certainly be ending. We have already started working on acquiring follow-up projects. There are also overlaps with the virtual institute MetBioMat. This is an endeavour supported by the Helmholtz Association, in which twenty-seven partners from northern Germany cooperate in order to put magnesium implant materials more quickly into use. The main focus is the animal studies, which are carried out by this virtual institute. Participants include the University Clinic Hamburg Eppendorf, the Hannover Medical School and the University Clinic Graz. Of course, the work within the new institute division ’Metallic Biomaterials‘ is entirely in line with this research. Even if individual aspects were undertaken through external partners in MagnIM, which cannot continue as they were in the past, we still have a great deal of in-house capacity to carry out most things ourselves that we began in MagnIM.

To what extent have you reached your goals that you set out in MagnIM?

The main objective of MagnIM was the characterisation of implant materials in animals, and that is something we achieved. The materials we wanted to test were even examined once as a small screw and once as a small pin. We therefore now have a very large amount of data available that we need to evaluate. We are meanwhile in the second and, depending on the material, already in the third round of optimisation for even better adaptation of the material for use in organisms.

How long will it take before the implant materials can be used in human clinical trials?

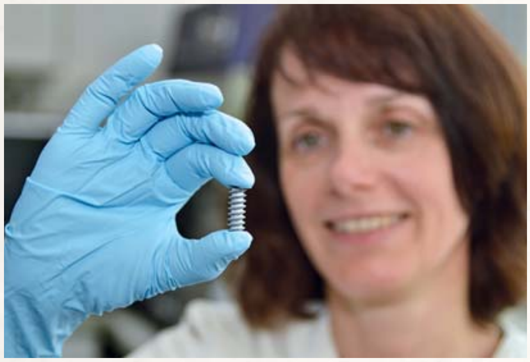
I think it will take quite a long time with the materials that we have just developed. Developing implants for children was one aspect of MagnIM. The use of silver was, for example, controversial even though it possesses antimicrobial properties. It’s a completely different situation with adults. A company will need to decide in the end because we will not carry out clinical studies, and it‘s not at all something we could afford.

What are your next objectives?

I first must see what partners I‘ll continue to cooperate with next year. One of the central questions is: how does the material actually degrade in the body and, above all, how can I measure this process? That is, how can I see what occurs during a period of one year or a year and a half in a living organism?

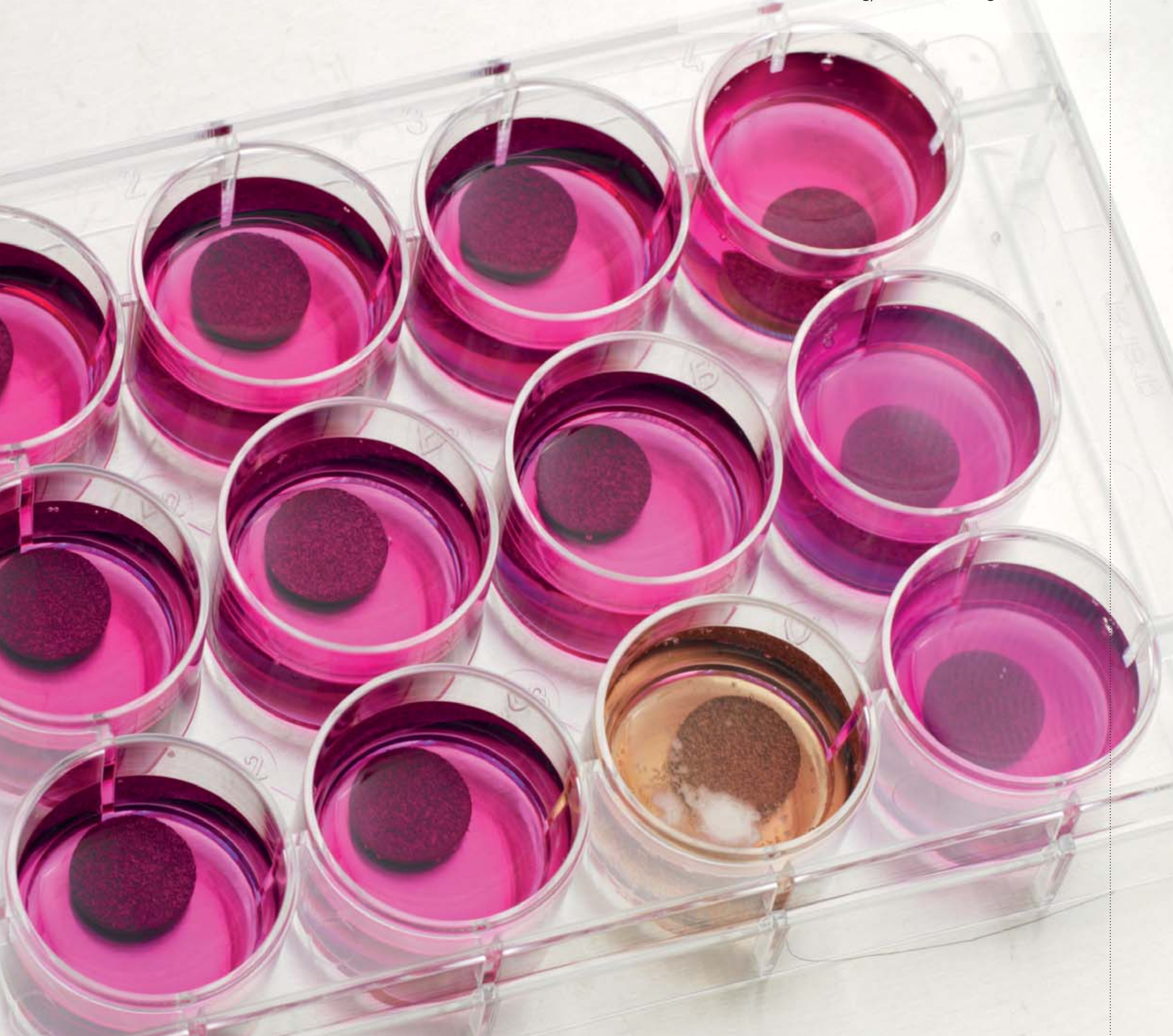
How do you want to approach this issue?

We will try to develop imaging methods through various externally funded projects. These follow-up projects will include some partners from the virtual



institute as well as from MagnIM. Because it is only when we really know what occurs in a living organism can we recreate these experiments in a laboratory and then obtain much more reliable numbers. This is how we can reduce the amount of animal testing in the future. We hope to develop sensors that tell me which proteins are formed from the body during degradation, which cells migrate to the implant site, what kind of chemistry occurs on the implant surface – that is, all these things that concern the biology in a living organism – this is the greatest challenge for me at the moment.

Editor: Erich Wittenberg, www.wittenbergmedia.de



ABOUT
Prof. Annelie Weinberg
Chief Physician at the University of Graz.

Prof. Annelie Weinberg, Chief Physician at the University of Graz works closely on two projects with Prof. Regine Willumeit-Römer. The trauma surgeon finds metallic biomaterials especially promising for paediatric surgical applications. Erich Wittenberg speaks with her about how these materials can be utilised.

Where do the differences lie in handling the material in surgical practice?

The material is more elastic down to its basic properties. At the moment it must therefore remain a bit thicker. If you take, for example, a conventional wire with a diameter of 1.6 millimetres, then you now need one of about 2.24 millimetres here. The dimensions must be greater so that you can keep the same elastic properties, which is important for healing bone fractures.

Where do you see the advantages?

If an implant dissolves and you no longer need to remove it, everyone benefits. Children in particular, whose bones heal much faster and are still growing, would benefit greatly. When dealing with adults, we try to generally avoid removing the implant because complications in doing so are relatively high. A bone, however, located where an implant takes over the strain, grows weaker over time. This can lead to problems, especially in the elderly when they already have several implants. Degradable magnesium implants would also be of benefit here.

Can magnesium implants one day completely replace the materials used today?

That depends on many factors. With adults, I see this can be more problematic because, at the end of the day, the question of method comes down to cost. We must also prove that the risk for the patients will be considerably reduced. I also believe that we'll later have access to what we would call 'design on demand'. That means that different magnesium alloys will be developed for different applications.

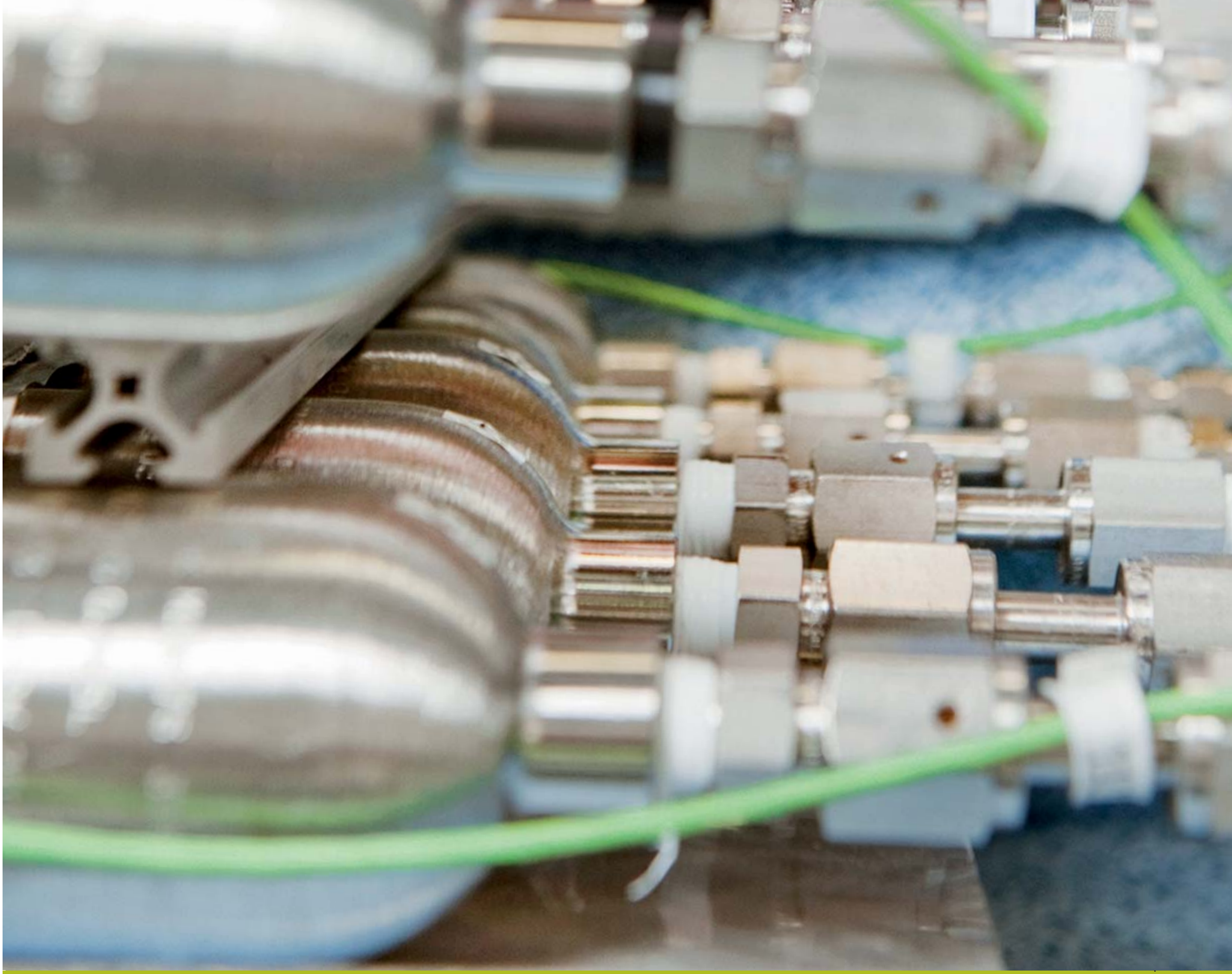
What are your objectives in the projects you're working on with Prof. Willumeit-Römer?

Our objective is to test the alloys in animals. We receive implants made of magnesium alloys from the HZG and implant them into animals. We then analyse this data. One aim is to also compare the in vitro data with the in vivo data to keep, for example, the amount of animal testing to a minimum.

What results have you attained?

We have managed to place the material in the bones and can demonstrate that this is unproblematic. The material isn't yet degrading optimally, but we're very close. We do at least have candidates that look very promising. It's important to adjust the material so that it doesn't degrade too rapidly. We also worked with a material that had dissolved very quickly and were astounded that the bones could completely heal regardless. This is good news because even if something might not work, it wouldn't have a negative impact on the bone.

> I also believe that we'll later have access to what we would call 'design on demand'.



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One Goal in Mind

What drives materials researcher Prof. Thomas Klassen?

Thomas Klassen –

Prof. Thomas Klassen heads the Materials Technology Institute at the HZG. A strange vehicle is parked in his garage ...

The two rear wheels are positioned very close together and the only door is located toward the front. You open the car as if it were a refrigerator. You can guess how Thomas Klassen (50) approaches science from this green Isetta (manufactured in 1957). It's a symbol of his academic career: a career between vision and necessity, a preference for practical application, which feeds off of theory and good networking.

"I always wanted to create something tangible that advances society," says Thomas Klassen, referring to his beginnings. After he graduated high school, he studied physics in Dortmund, where everything was theory. It was a "shock," he says today. After only seven semesters, he began his master's degree work as one of the first in his class. "I wanted to get the theoretical stuff over with as quickly as possible so that I had more time for the practical side," he says. He refers to the months in the laboratory as 'the best of his university studies'.

He was then offered a job in the commercial sector. But Thomas Klassen had other plans: "I wanted to be financially independent, but hadn't decided on my focus of content." He went to Geesthacht, to what was known as the GKSS at the time, to work on his doctorate. Three years later and a PhD to his name, he moved to the United States where he created a laboratory for high energy mills and nanocrystalline materials. He later returned to Geesthacht to lead his own department while also working toward a professorship (Habilitation) at TU Harburg. He was subsequently appointed professor at Hamburg's Helmut Schmidt University and soon thereafter became institute director in Geesthacht. 'I thought it was very important from the very beginning to find as many people as possible who were working on the same thing,' says Thomas Klassen. Networking as a principle: his doctoral students speak of the enormous freedom that also "accompanies great responsibility" for each person working for him. What is remarkable is how many projects in Klassen's institute are financed through EU cooperations. One would say about fundamental researchers that curiosity is what fuels them. For Thomas Klassen, it's the other way around: fuels are the subject of his curiosity. He dreams of a car that can drive from Geesthacht to Sicily without filling the tank once. The energy would come from the chemical element in the periodical table designated with the letter H: hydrogen.

Mobile hydrogen tanks were considered an insurmountable obstacle even in the 90s. They were either too large or too heavy or too inefficient at the time. Could the problems be resolved by binding hydrogen to a light metal hydride and releasing it as needed? First attempts at using this variant were, however, too slow: it takes several days to load such a tank. But in the early 2000s, Thomas Klassen's team made a breakthrough: loading their finely milled hydride could be done in one minute. In cooperation with European partners, they are building a light and compact hydrogen tank that can be filled in under ten minutes. Concrete application for a car would work as follows: Klassen's hydrogen tank would feed a fuel cell, which would in turn feed the battery of an electric car, thus increasing its range enormously. Refuelling would not require a power cord as it does today, but only hydrogen. Instead of sitting for eight hours connected to a socket, the car would be back on the road in a few minutes. The only emission while driving would be pure water vapour.

The Geesthacht researcher's work is also relevant in the context of energy transition. We're faced with the problem of saving electrical energy, both economically and efficiently. "Because the sun isn't always out and the wind isn't always blowing either – sometimes we need energy when none is produced. And vice versa: sometimes the sun and wind produce much more energy than we need at the time. Today hydrogen can already provide a good form of storage for energy that has been produced from regenerative sources."

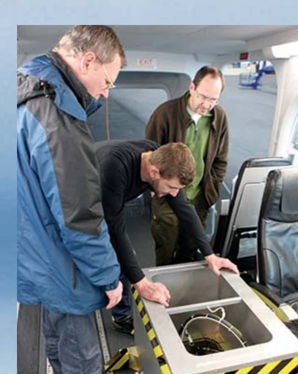
But how good is the mobile application? There is a problem in making HZG's hydrogen tank function in electric cars: the temperature. The first studies required a temperature of three hundred degrees Celsius to release the stored hydrogen. "We've managed it at 240 degrees since then," says Klassen. But it's still too much: modern fuel cells work at temperatures of 120 to 180 degrees. This means there's a gap of sixty degrees remaining. "That's exactly what we're working on at the moment," he adds.

The vision remains: perhaps our cars will actually run on hydrogen in a few years. There are a lot of political decisions, however, that also play a role according to Klassen. Getting his work to at least function technically is something he wants to demonstrate. That's precisely the reason he bought his green Isetta. "One day I'm going to convert this car to hydrogen. It's light and therefore needs little energy. And it has sufficient space for a tank and a fuel cell." When Thomas Klassen comes home from work, at first glance you'd simply see a father who is excited by technology and who loves old cars. But what really stands in his garage is the motivation and goal for a complete, fulfilled professional life.

Editor: Jochen Metzger, Journalist / Foto: Christian Schmid

The eddy hunters head for the sky

A flight with the oceanographic magnifying glass – on the lookout for ocean eddies in the airship



The Idea

Prof. Burkard Baschek is head of the division Operational Systems at the Institute of Coastal Research.

From below it seems enormous. But despite its seventy-five metre length, it's elegant. Just ten metres away from me, it lands almost silently. Like a boat, it orients itself on a mooring line with the wind. Yet another reason a zeppelin is referred to as an 'airship' and not an 'airplane'.

The personnel on the ground wave and give the command to board quickly because the next scientific flight will begin right after its short stop. Today I'm accompanying Prof. Burkard Baschek, Director at the Institute of Coastal Research of the HZG and his colleagues in the Department of Remote Sensing during the last zeppelin test flight over Lake Constance.

The airship rises again briskly and the pilot steers us away from the Friedrichshafen Airport to the mouth of the Rhine River at Lake Constance. The Zeppelin has actually been used in sightseeing flights nearly every day since the nineties, so a journey for the two-person crew from the Zeppelin Luftschifftechnik GmbH is almost routine. The situation is different for the researchers of the Helmholtz-Zentrum Geesthacht.

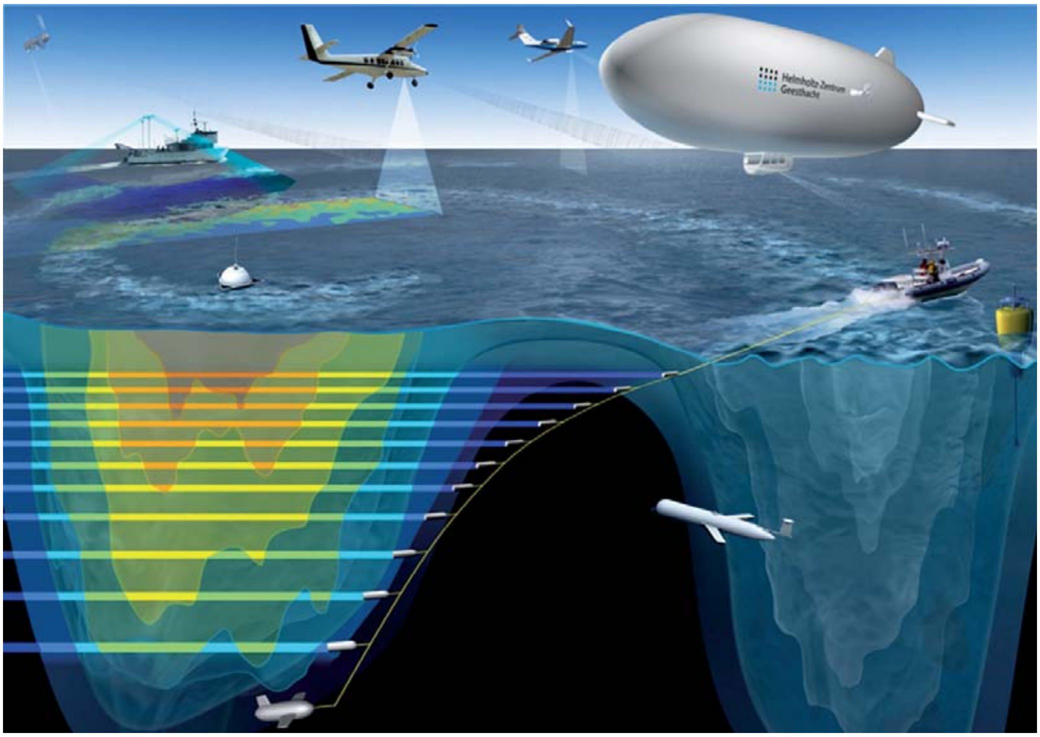
Prof. Burkard Baschek

We fly out in the mornings and don't know until we land what new scientific questions await us.

Today the Geesthacht researchers are studying small ocean eddies and are testing the zeppelin as well as their equipment for a future research expedition over the Baltic Sea.

While large ocean currents, such as the Gulf Stream, have been studied for many years, what is known about small ocean eddies, with a diameter ranging from one hundred metres to five kilometres, is still relatively little. It is an oversight in the truest sense of the word: environmental satellites with a resolution of one kilometre cannot detect each eddy, which often only exist for six to twenty four hours.

Although the small eddies, in comparison to gigantic ocean currents, seem small, they are of great importance.



The zeppelin serves as a central interface from which other measurement instruments as well as vessels are coordinated. Currents are calculated and small eddies are detected with the help of cameras.

The wind drives large global ocean currents, which are regarded as the heat pump of global climate. This energy is lost again in increasingly smaller eddies. Furthermore, scientists assume that half of the world's entire microscopically small sea algae, known as phytoplankton, rely on these eddies. This phytoplankton is at the bottom of the food chain and provides a large portion of the oxygen in the atmosphere. "We assume that the small eddies also influence fish migrations," explains Baschek. "Maybe we should park here now?"

The pilot of the zeppelin brakes and we hover at a near standstill over Lake Constance.

Flows are calculated and small eddies are tracked using the cameras.

It's a good view from the zeppelin: the water from the Rhine churns different colours and shades.

The water from the Rhine churns different colours and shades beneath us. The scientists use two special cameras for their work. A highly sensitive infrared camera provides temperature maps of the water surface, capturing one hundred images per second. The thermal imaging camera measures even small temperature differences of 0.035 degrees Celsius. The currents are calculated and small eddies are detected using these tools. "The advantage is that, as opposed to airplane expeditions or satellite measurements, the zeppelin can permanently remain above the eddy and can measure it with an accuracy of under one meter in high pixel resolution,“ explains Wolfgang Cordes, scientist at the Institute of Coastal Research, who has

The wind drives large global ocean currents, which are regarded as the heat pump of global climate. This energy is lost again in increasingly smaller eddies.

The scientists are tracking the eddies with highly sensitive cameras in this hovering laboratory.
The scientists seem content, the tension visibly decreasing. Their measurement instruments are functioning.

been studying water surfaces from the air for many years. His colleagues simultaneously observe the eddy with what is known as a hyperspectral camera. This device records up to one thousand different light spectrum bands and is thus able to determine the 'colour' of the water.

"This data helps us to differentiate, for example, green algae from red algae," explains Dr. Rüdiger Röttgers, who heads the Department of Remote Sensing at the HZG. "We hope we can come to conclusions from the air about the condition and growth of the algae in the long-run," he adds. New eddies are detected again and again, we change altitude, and the technology is put to the test. Burkard Baschek finally gives the command and the pilot begins the journey back to the airfield.

The scientists seem content, the tension visibly decreasing. Their measurement instruments are functioning.

Dr. Rüdiger Röttgers

This data helps us to differentiate, for example, green algae from red algae.

"It's obvious that we still need to adjust our cameras a bit, but we're pleased with the first tests and with using the zeppelin as a research platform," says Baschek, summing up his days in Friedrichshafen. There's still some time remaining before we land, and we enjoy the view of the Swiss mountains while the scientists discuss plans for the coming year. "We hope to use the zeppelin in summer 2016 for an eddy expedition in the Baltic Sea. It will not only be equipped with our cameras, like a sort of flying microscope, but it will also direct the ships below." To

additionally facilitate studying the interior of the eddies, colleagues on the water will steer fast boats and the HZG's research ship the Ludwig Prandtl to the eddies themselves. Measurement instruments are dragged through the water at different depths and automated gliders will be put into use. These tools supply a multitude of additional oceanographic data.

The zeppelin lands as gently as it had ascended. The airship is moored and moved to the airport's hangar. The work for the coastal researchers on the ground isn't nearly over: the data must still be evaluated in Geesthacht. The measurement instruments, however, must first be unmounted and loaded into the truck. Rüdiger Röttgers adds, "Our work doesn't just include collecting and analysing data. A coastal researcher also needs to know how to pack boxes."

Burkard Baschek

In the summer of 2016, the zeppelin will direct the ships from above.

Editor: Torsten.Fischer@hzg.de

Infographic

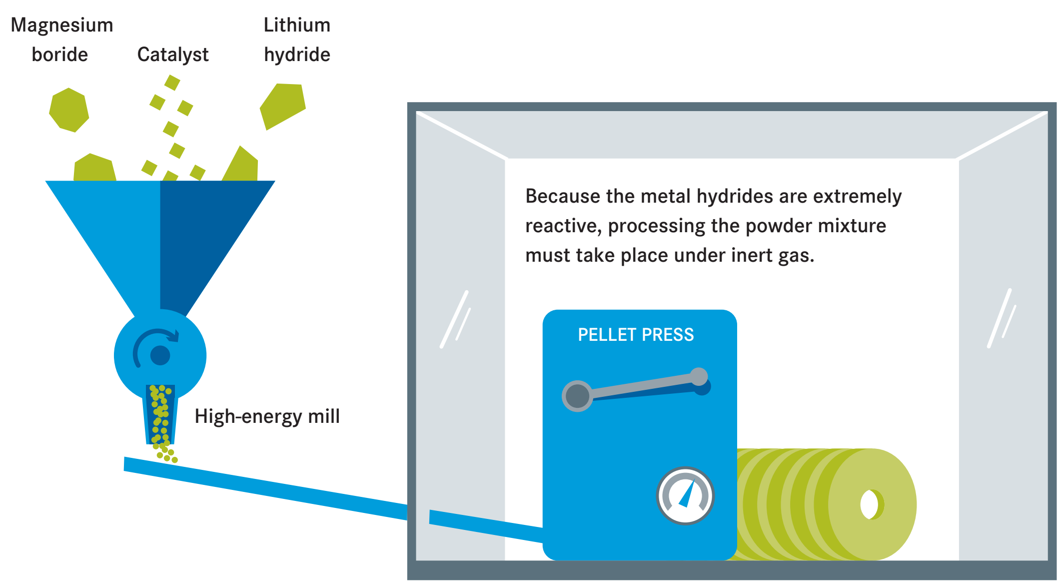
Metals Storing Hydrogen

A simpler way for storing hydrogen is needed. Great potential lies in solid storage. In Geesthacht, a solid metal alloy comes into use with which hydrogen can be stored even at moderate temperatures and low pressures.

EFFECTIVE MATERIALS

The researchers at the Helmholtz-Zentrum Geesthacht have determined that hydrogen can be stored reversibly under moderate conditions in a composite made of magnesium boride and lithium hydride at the highest weight proportion yet achieved.

Low pressure and moderate temperatures make storage in solid tanks an efficient and economical alternative.

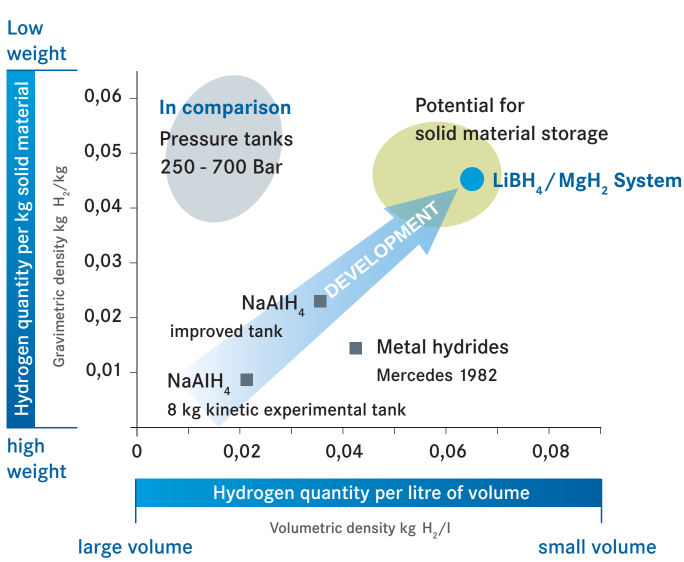


Milling

The base materials are combined on the nanoscale in a high-energy mill.

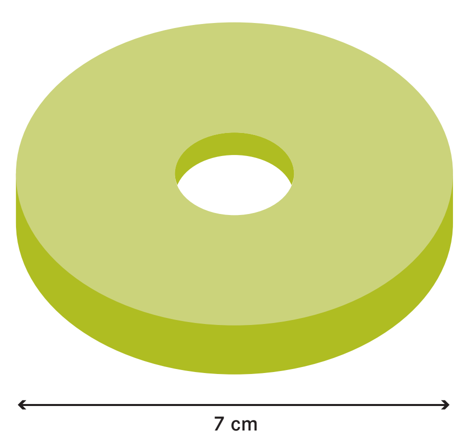
LIGHT METALS – THE HYDROGEN RESERVOIRS OF THE FUTURE

Quantity of hydrogen for selected solid storage materials that can be stored per kilogram of solid material and per litre of tank volume, in litres



METAL HYDRIDE PELLET

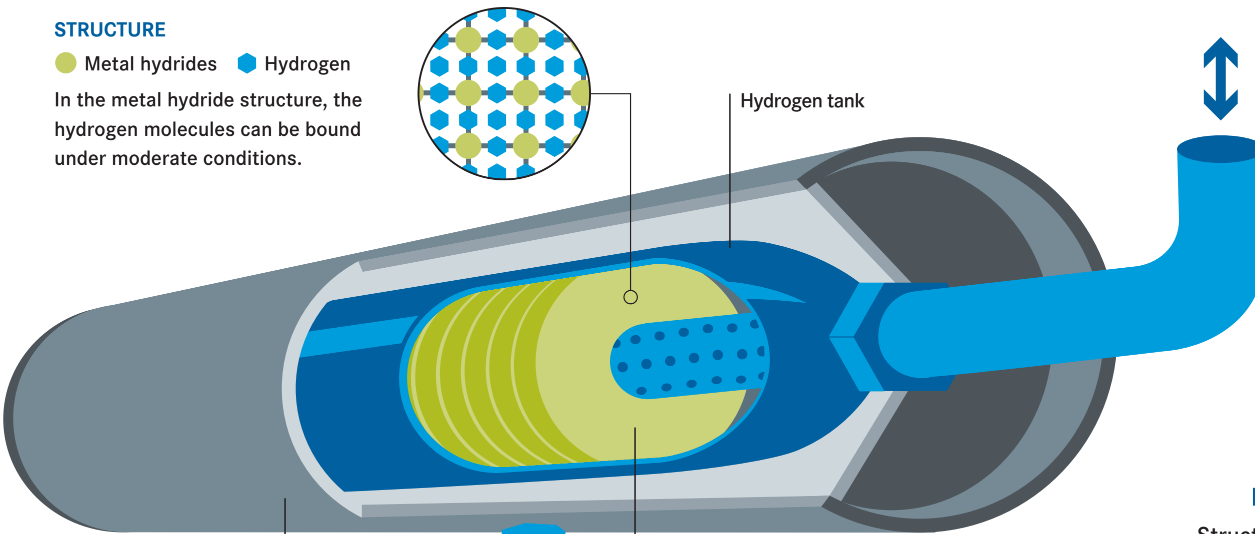
In order to ensure a uniform uptake of hydrogen, the metal hydrides are pressed into pellet form. The heat transfer is increased and the hydrogen can be stored more quickly. The pellets for one of the largest tanks made with sodium alanate as a base measure seven centimetres in diameter.



STRUCTURE

Metal hydrides   Hydrogen

In the metal hydride structure, the hydrogen molecules can be bound under moderate conditions.



HYDROGEN

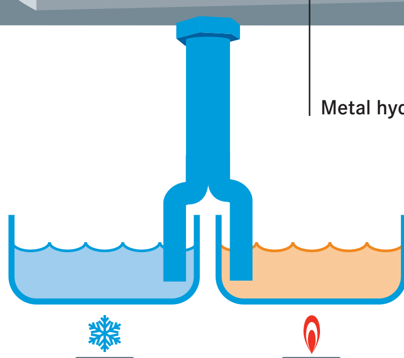
Intake and outflow

HYDROGEN TANK

Structure and function as demonstrated by Europe's largest sodium alanate-based solid storage tank for storing hydrogen.

LOADING

If hydrogen is introduced into the tank with metal hydride pellets, heat is generated. This heat is dissipated by a heat exchanger.

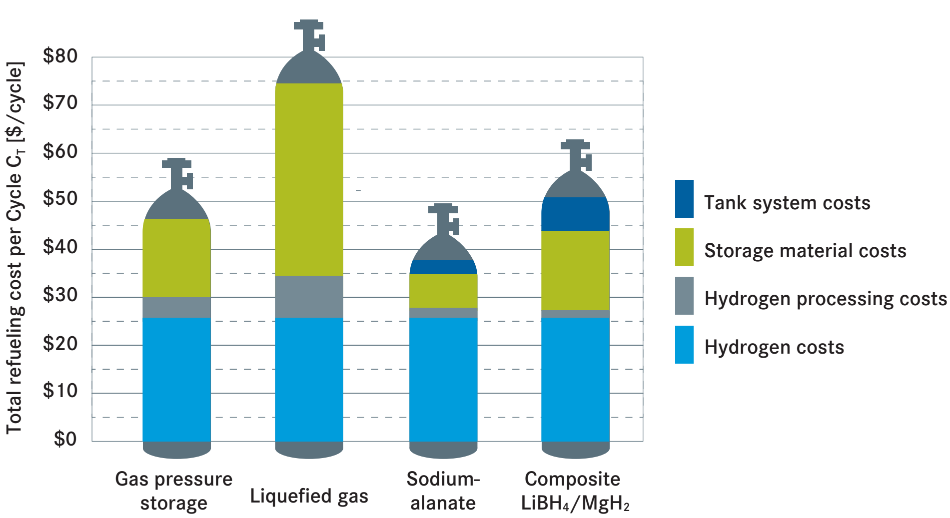


UNLOADING

Heat is required to retrieve the hydrogen from the pellets. The tank is now heated up again through the heat exchanger.

SOLID STORAGE IS ECONOMICAL

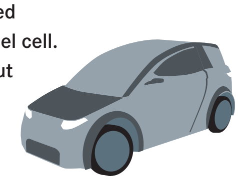
The estimated costs of loading a tank with five kilograms of hydrogen. Compared here are the various storage systems. Among them are two metal hydride systems with alanate and light metal hydrides developed by the HZG scientists.



APPLICATIONS

MOBILITY

Solid tanks in vehicles can be refuelled quickly and safely. The tanks are optimized for operation with a fuel cell. A mobile future without fossil fuels.



SUPPLY

Whether used in an emergency or as temporary storage, solid tanks are compact and reliable in the long-term and are less dangerous as they operate under low pressure.

A bit of extra information: for colleagues who would like to see their story published here, please contact the editors at In2science@hzg.de.

We also cordially welcome suggestions, praise or criticism. Please contact us any time.

We look forward to hearing what you think about this issue of In2science

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How do we shape our future?
Research for city and country.

Beréngère Luthringer: "We really should expand research in the areas of sustainability and on the topic of climate change. These are topics that concern us all. These are global undertakings that we can only solve together."

Carsten Lemmen: "I think we should concentrate more on changes than on the description of conditions. Current research is very oriented on characterising systems by studying their conditions and perhaps also on finding a climate condition that can be measured. Those are big challenges. But the conceptual challenge is not to concentrate on a state of equilibrium but on the continuous change in the context of natural and cultural interactions."

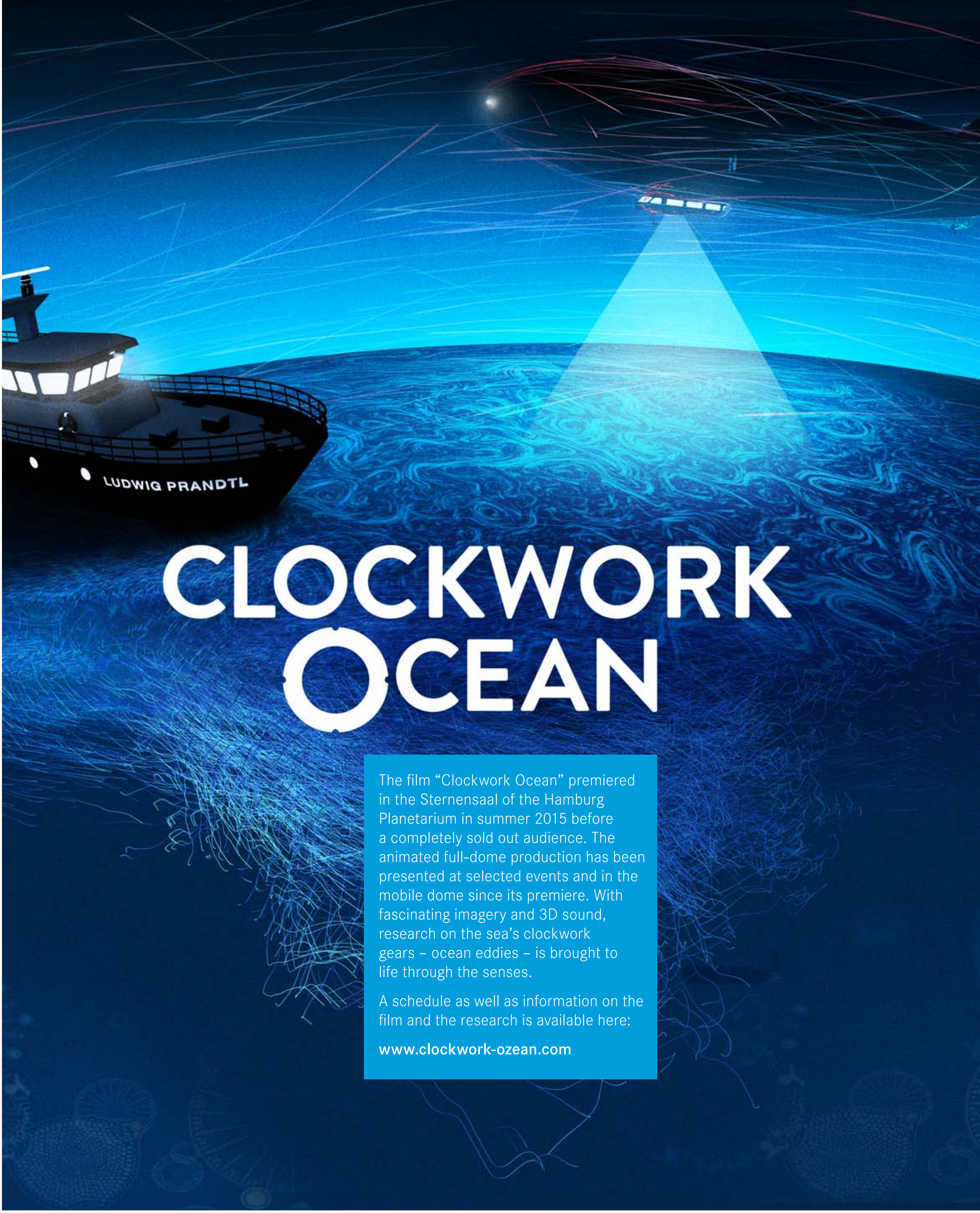
Tina Peters: "I think trash is an important topic. Where does it go? What happens to it? Is the refuse recycled? The entire world is full of garbage and no one knows where to put it. You see it in front of your door and on vacation: there's garbage everywhere, even in the global oceans. Research needs to look into how to produce less garbage, how to use degradable materials or materials that can be recycled. A good example is compostable bags."

Regina Roßmann: "On my way to work, I see that every car has only one passenger – and I'm not excluding myself. We need to switch to sustainable commuting. We need, for example, to try and build more ridesharing communities."

At the Centre

Stefan Riekehr: "My daughter thinks we should study more about climate change than about welding technology. For youth, climate change is more graspable than issues concerning mobility. Improving welding technologies, however, leads to lighter structures and therefore to a reduction in CO_2 emissions. Lighter vehicles require less energy and contribute to climate change protection."

Sigrid Wulff: "I think it's really important to continue studying climate change. It is especially important to lower emissions in the industrial sector as well as in cars. In general, more people should switch to public transportation."



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