RUHR-UNIVERSITÄT BOCHUM

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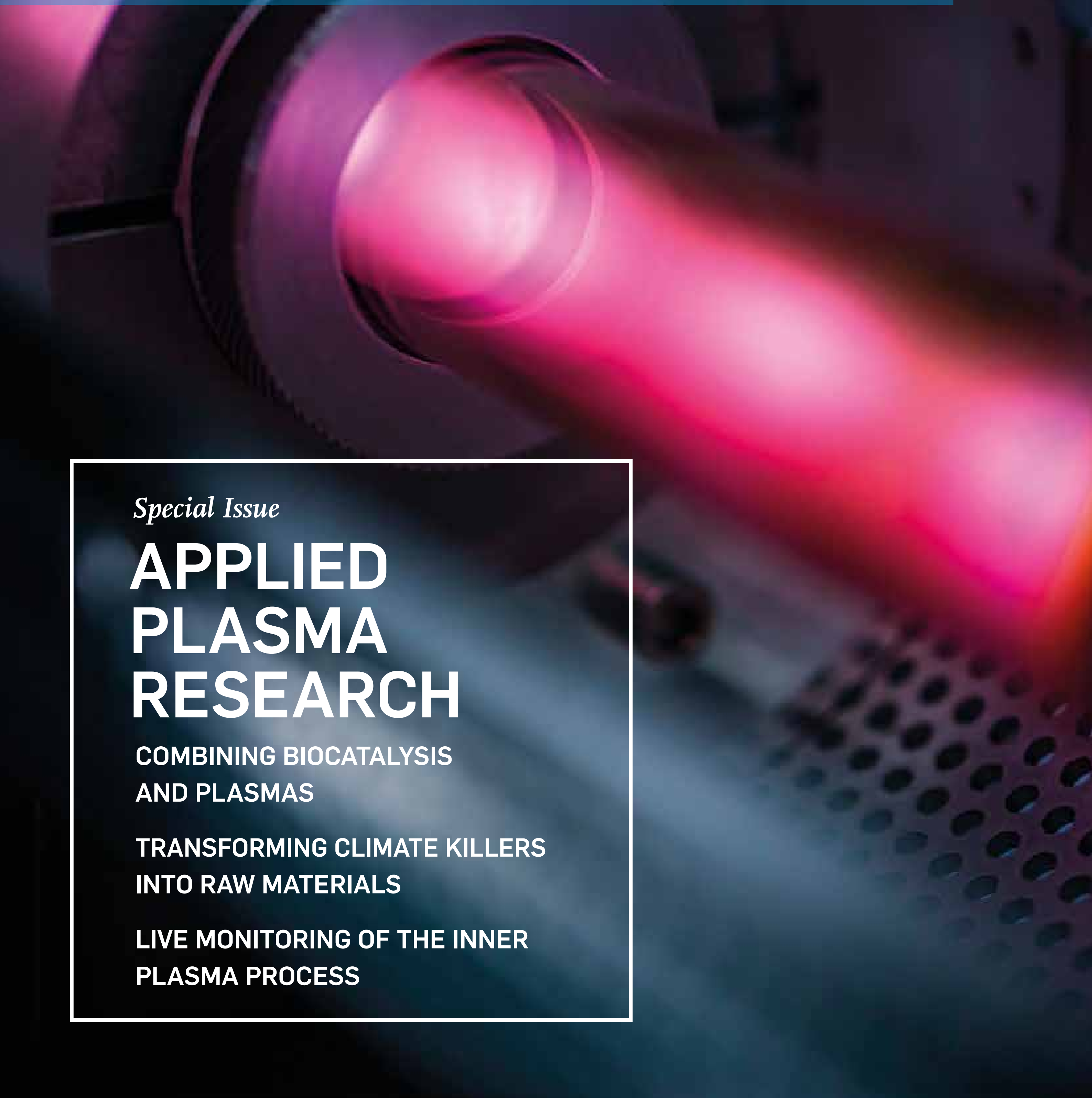
SCIENCEMAGAZINE

SPECIAL ISSUE



Special Issue

APPLIED PLASMA RESEARCH

COMBINING BIOCATALYSIS AND PLASMAS

TRANSFORMING CLIMATE KILLERS INTO RAW MATERIALS

LIVE MONITORING OF THE INNER PLASMA PROCESS

Plasma diagnostics

A SPHERE THAT MAKES ELECTRONS OSCILLATE

A spherical probe allows the electron density in plasmas to be continuously monitored and, consequently, kept constant.

Plasmas play a vital role in many industrial applications. The energetically excited gases can be used, for example, to deposit coatings on surfaces, such as scratch-resistant protective layers on plastic spectacle lenses, or high-precision optical filters on quartz glass. In the process, the plasma is used to bombard the coatings that grow on the substrate by vapour deposition with ions, thus effectively hammering them into place.

But such processes must meet many requirements. For example, they must take place at low temperatures to prevent damage to the coated surfaces. "In modern production processes, more and more emphasis is also being placed on precision," stresses Professor Ralf Peter Brinkmann, who holds the Chair for Theoretical Electrical Engineering at RUB. All resulting products must be exactly the same, and the coating must be defect-free. To achieve this level of precision, it is necessary to constantly monitor the plasma. The electron density is particularly important in coating processes. If it were to fluctuate too much, this would negatively affect the quality of the finished coating. "Ideally, the electron density should be constantly measured and automatically readjusted if necessary, so that no human has to interfere in the process," explains Brinkmann.

A measuring instrument that can do all this has to meet a variety of requirements: it should be as small as possible, reliable, maintenance-free, and it must neither interfere with the coating process nor be damaged in the plasma. Experts refer to this as "process-compatible plasma diagnostics".

Researchers have been pursuing one idea for a long time: The electrons, which move freely in the plasma, can be made to oscillate by applying a small external voltage. If the right frequency is hit, a detectable resonance occurs. Since the resonance frequency depends on the electron density, this can then be theoretically calculated.

However, earlier attempts to put this idea into practice encountered some difficulties. A Japanese research group, for example, proposed a very simple construction: The team used a coaxial cable, similar to an analogue antenna cable, allowed the inner conductor to protrude a little, and inserted the end of the cable into the plasma. If a voltage was applied, resonances of the plasma could be measured. However, resonances of equal value occurred at several different frequencies – a veritable zoo. "The problem was: which one should be used for diagnostics," explains Ralf Peter Brinkmann.

Analyses by the Bochum-based researchers provided an answer to the question of where the different resonances came from: as simple as the design of the measuring equipment was, different oscillations with different resonance frequencies arose at different sections of the apparatus. "Picture this like driving an old car," as Ralf Peter Brinkmann illustrates the principle. "At a certain speed, the exhaust rattles, at another, it's the wing mirror."

To remedy the situation, the team devised a concept that aimed for the simplest possible oscillations. Their aim was: the more symmetrical, the better. "The spherical shape is the simplest configuration imaginable," says Brinkmann. "A floating marble would've been our first choice." However, it was not quite that simple, of course. Electricity always needs a forward and a return conductor. Accordingly, two metallic hemispheres were chosen. The construction is rotationally and mirror-symmetrical, both electrodes are the same size. "Here, too, we measure resonances at different frequencies," explains Ralf Peter Brinkmann. "But they can be clearly sorted. The strongest resonance is the dipole resonance; the other, weaker ones, represent the overtones to this keynote, so to speak." The name "multipole resonance probe" (MRP) was derived from the mathematical method of "multipole analysis" used for this purpose.

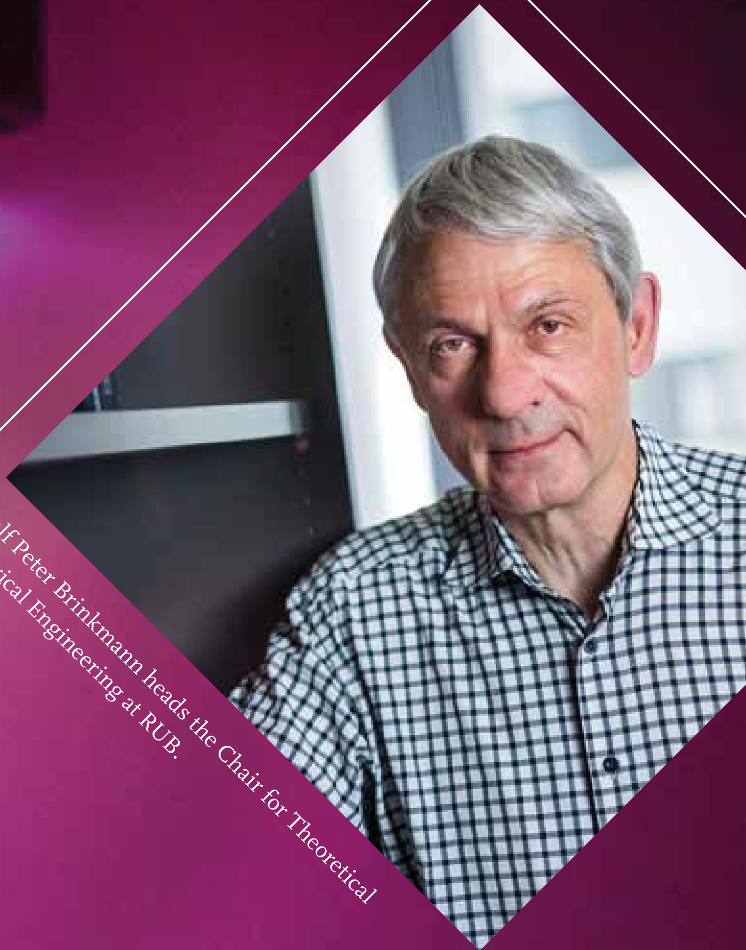
The advantage of the formula

The reason why researchers opt for the MRP is that the relationship between plasma density and resonance frequency is given by a simple mathematical formula. The plasma density is the only unknown in this equation. Once the equation is solved, it can be calculated from the measured values. "This means that it is not necessary to calibrate the measuring probe before use, i.e. to compare it with other measured values," elaborates Ralf Peter Brinkmann.

So much for the underlying theory. For practical implementation, the researchers teamed up with three other chairs at the faculty. Professor Ilona Rolfes' High Frequency Engineering Institute carried out a high-frequency optimisation of the entire system consisting of probe head and holder. For example, it was possible to make the holder practically invisible to the plasma. Professor Thomas Musch's Institute of Electronic Circuits designed control electronics based on radar technology. And finally, Professor Peter Awakowicz' Institute for Electrical Engineering and Plasma Technology tested the finished probe in a number of plasma processes.

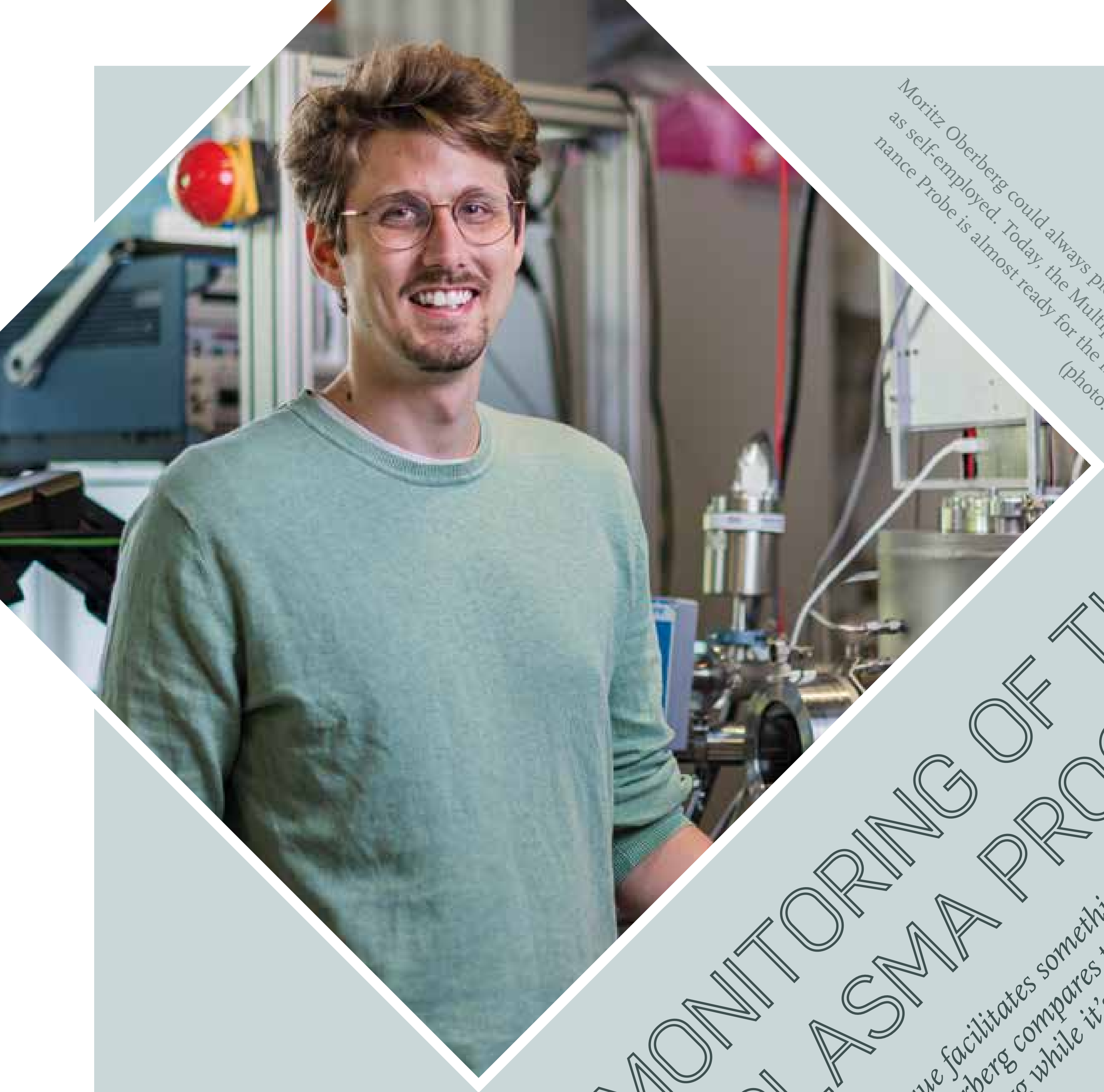
The Federal Ministry of Education and Research funded the joint projects Pluto and Pluto plus to develop the MRP to the point where it could be used in practice. This also provided the opportunity to test the probe with industrial partners. And it turned out that if the electron density in the plasma was kept consistent through constant monitoring by means of MRP and automatic adjustment of the control, the fluctuations in the process results were significantly reduced.

text: md, photos: dg



Ralf Peter Brinkmann heads the Chair for Theoretical Electrical Engineering at RUB.

The probe monitors the interior of a plasma by measuring its vibrations.

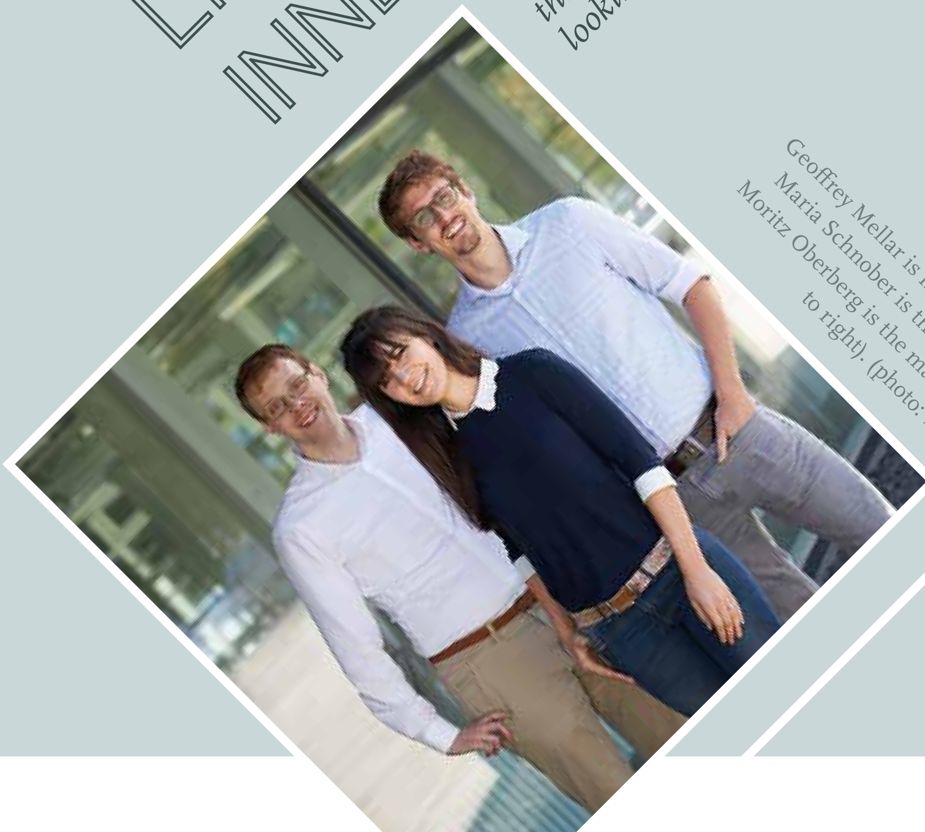


Moritz Oberberg could always picture himself as self-employed. Today, the Multipole Resonance Probe is almost ready for the market. (photo: dg)

Interview

LIVE MONITORING OF THE INNER PLASMA PROCESS

A new technique facilitates something that Moritz Oberberg compares to looking inside an egg while it's cooking.



Geoffrey Mellar is in charge of the technology, Maria Schnober is the commercial manager, Moritz Oberberg is the managing director (left to right). (photo: House of Plasma)

Together with two team colleagues, Dr. Moritz Oberberg is preparing to set up the spin-off "House of Plasma". The company is launching the Multipole Resonance Probe in various designs. It allows industrial plasmas to be monitored in real time to ensure that they help to consistently apply identical, faultless coatings to surfaces, for example.

Dr. Oberberg, if someone had told you five years ago that you would plan to start a company today, what would you have said?

The idea of setting up a spin-off with measurement technology is not that new. My predecessor, who completed his doctorate in 2015, was already talking about it, but it wasn't fully developed at the time. Personally, I could always picture myself being self-employed. The timing depends, of course, on the development and the response. Still, I've been thinking about self-employment for a while. I have a background in this field and, in addition to my education, I also have the necessary contacts.

The company has not been established yet. How do you keep busy at the moment?

Well, I'm not alone, the three of us share all tasks that come up. We are currently planning industrial tests with a company for our latest designs – we have to travel abroad for this purpose. There's a lot of red tape. It's not so easy to take measuring equipment out of the country.

Other than that, I'm busy pushing the development of our products and writing project proposals. I should mention that RUB offers invaluable support with the Worldfactory Start-up Center. It has a team of excellent people who help us with everything. At the moment, for example, we are working out how to acquire patents held by RUB. Articles of incorporation are still to be written before we can set up the company, the financial plan is being finalised, and the search for investors is also underway. Before we can sell something, we have to be able to purchase, for which we need capital; the same is true for marketing, premises, equipment and so on. In the current funding project at the university, tests continue in the laboratory and with industrial partners, under difficult conditions due to the pandemic, and the technology is constantly being optimised. This is all going on simultaneously.

What can prospective customers expect from you?

Our prospective clientele might include, for example, a company that coats spectacle lenses. We would check with them what their expectations are and whether our technology offers added value for their company. Can it be used? If yes, then our hardware in combination with the relevant software can provide insights that were not there before.

We compare it to a breakfast egg: I like it when the yolk is still soft but the egg white is hard. However, while it's cooking, I can only rely on my experience, not really measure what's going on inside the egg. At most, a peripheral measurement of the temperature on the shell would be possible, but not inside the egg. What we do now, however, is supply the data straight from the egg.

We are also happy to offer more services on request. We can develop control technology, refine the coating properties of the lens, and also support research and development projects.

Does looking into the egg set you apart from other suppliers?

Yes, it does. There are several suppliers for monitoring peripheral variables, which only allow indirect conclusions to be drawn about processes in the plasma, or for too-slow measurement technology. Whereas we offer measurement technology for internal parameters that enables live monitoring. Monitoring parameters in real time is our unique selling proposition. Until now, you could measure less important data quickly, but you could not measure the important data quickly. Now, both can be done at the same time.

Looking five years into the future, what do you wish to see?

Our company will have been founded, we will have taken on employees. In the German-speaking countries, people recognise "House of Plasma" as a provider of plasma diagnostics and consider co-operating with us. We are slowly gaining traction in the USA and South-East Asia – there are many interesting enterprises there. We want to become the ultimate provider of plasma diagnostics.

md

i FIRST PLACE AND SPECIAL PRIZE

The House of Plasma team took first place in the Senkrechtstarter competition and also won a special prize for the best university spin-off. The award ceremony took place on 17 June 2021. The competition is organised by Wirtschaftsentwicklung Bochum. The winners receive professional advice and prize money for their start-up.

EDITOR'S DEADLINE

A glowing cup – easily done thanks to plasmas. The SFB team came across this object by chance and quickly integrated it into its experiments for students. The cup's coaster contains a coil to which alternating voltage is applied. This induces an electric field that accelerates the free electrons in the gas layer between the glass walls. They collide with gas atoms, which are excited and ionised. As a result, positive and negative charges of the gas particles are separated for a short time. When the atoms de-excite a light particle is released – the cup appears to glow.

photo: dg

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EDITORIAL BOARD: Dr. Julia Weiler (jwe, editor-in-chief); Meike Drießen (md); Lisa Bischoff (lb)

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PHOTOGRAPHER: Damian Gorczany (dg), Hofsteder Str. 66, 44809 Bochum, Germany, phone:: +49 176 29706008, damiangorczany@yahoo.de, www.damiangorczany.de

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