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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

THE FUTURE OF PLASMA RESEARCH

Industrial chemistry

PLASMA GENERATORS CONTROL CATALYTIC PROCESSES

In ten years, researchers will have understood the interactions between catalysts, which determine the speed of chemical reactions, and plasmas. This will facilitate the excitation of the plasma at atmospheric pressure in such a way that its properties accelerate the reactions on the catalyst surface in a controlled manner. As a result, chemical engineers will not only increase the turnover of the starting materials, but also the percentage of these materials that will be converted into the required product.

Therefore, the vision is that plasma generators will control catalytic processes. New compact plasma catalyst modules will be created, through which large gas flows can pass with little pressure drop. This will enable exhaust gas streams to be purified and other important industrial reactions to be carried out. In order for the modules to work in a resource-saving way, researchers still have to boost their energy efficiency. In future, catalysis, plasma and reaction engineering experts will work hand in hand to develop plasma catalyst modules. Computer-aided plasma, velocity and flow simulations will help to optimise them.

Prof. Dr. Martin Muhler

photos: dg

Applied microbiology

PLASMAS AID IN WOUND HEALING, CANCER THERAPY AND POLLUTANT DEGRADATION

Reactive oxygen and nitrogen species (RONS) have different functions in biological contexts: At low concentrations they act as signalling substances, for example in wound healing. At high concentrations they destroy biomolecules, an effect immune cells use to kill pathogens. Non-equilibrium plasmas, in which the electrons have high temperatures but the gas temperature remains low, can produce such RONS without heating the treated samples. These non-thermal plasmas are already being used for sterilisation purposes. Their therapeutic use in wound treatment and cancer therapy is currently being explored.

In ten years, we will understand in more detail the mechanisms underlying the generation of the different reactive particles in plasma as well as their biological effects. Based on this knowledge, plasma reactors can then be designed that provide RONS at concentrations and with mixing ratios required for specific applications – such as reactions catalysed by enzymes that utilise plasma-generated species or the degradation of pollutants through the joint action of plasmas and microbes.

Prof. Dr. Julia Bandow

Electrodynamics and plasma technology

PLASMA SIMULATION AIDS THE DEVELOPMENT OF FASTER PROCESSORS

Plasma simulations will play an increasingly important role in the development of plasma processes – especially for the production of nanoelectronic circuits. Without a fundamental understanding of the unique properties of low-temperature plasmas, it will hardly be possible to produce smaller and faster processors and storage devices. The necessary knowledge is increasingly derived from plasma simulations and complementary experiments.

In order to develop strategies for controlling the processes in particular, we will have to be aided by customised mathematical models. Modern machine learning methods will also be utilised for this purpose. However, even in ten years we won't be able to simulate a plasma completely – not even with all the supercomputers in the world. A laboratory plasma consists of an unimaginable 10 to the power of 18 particles. To store just a single state, one million one-terabyte hard drives have to be used. The only thing that can help here is mathematical models that, on the one hand, reduce the complexity to a minimum, but on the other hand, take into account all crucial aspects. There's still a lot to be done.

Prof. Dr. Thomas Mussenbrock

THE FUTURE OF PLASMA RESEARCH

Plasma medicine

ACHIEVING SUCCESS TOGETHER

One of the most interesting and important features of plasma medicine as a topic is its interdisciplinary nature, bringing together natural scientists, engineers and clinicians. The number of different scientific areas represented within the field has been continuously growing in the past ten years. This interdisciplinary environment has been a driving force behind clinical studies in a number of cases, wound treatment being a prominent example.

Over the next ten years, as plasma medicine continues to grow and attract new researchers, I expect this trend to accelerate and for the field to become even more interdisciplinary than it is today. This will bring new perspectives on existing questions, new therapeutic concepts, and novel research methods. I believe that these factors will be crucial for new scientific discoveries and the translation of emerging approaches such as plasma-based cancer therapy, into clinical practice.

Prof. Dr. Andrew Gibson

photos: dg

Plasma physics

WHERE BASIC SCIENCE MEETS TECHNOLOGY

Plasma physics is the study of the behaviour of ionised gases. Statistical physics, fluid dynamics, electrodynamics as well as atomic and molecular physics come together to form a discrete discipline. Plasmas determine both stellar evolution on astronomical scales and etching of nanostructures in the semiconductor industry. Plasma-based engines are already powering satellites in space, and very hot magnetised plasmas may provide clean energy through controlled nuclear fusion in the future. Tiny cold plasmas at atmospheric pressure offer a wide range of applications, from CO_2 conversion to medicine and biology. Major advances in measuring the internal parameters of plasmas and in their simulation have recently contributed to a much better understanding of these complex systems. Wherever the journey into the future takes us, it will not be without plasmas.

Prof. Dr. Uwe Czarnetzki

Microsystem technology

PLASMAS FACILITATE THE PRODUCTION OF SMALL STRUCTURES

Plasmas are the tool of choice for microsystem technology. As electronic chips are getting smaller and smaller, structures can only be realized with dry, plasma-assisted processes. Wet chemical processes no longer work in these dimensions. During drying, small, movable structures are glued together by surface tension, just as two sheets of glass with a very thin film of water between them can hardly be separated. New materials such as glasses or 2D semiconductors require new processes for deposition and structuring.

The key is specially adapted plasmas. In addition, we need to significantly advance the methods for measuring the internal parameters of a plasma and the relevant process control in real time. This is the only way we can also achieve reproducible results in batch production. In addition, plasma processes offer resource-saving, environmentally friendly manufacturing methods with minimal material input – even when coating with new types of materials. This future begins now, with the construction of research facilities at the boundary between basic and applied research and cross-disciplinary cooperation to enable the use of innovative materials.

Prof. Dr. Martin Hoffmann

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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