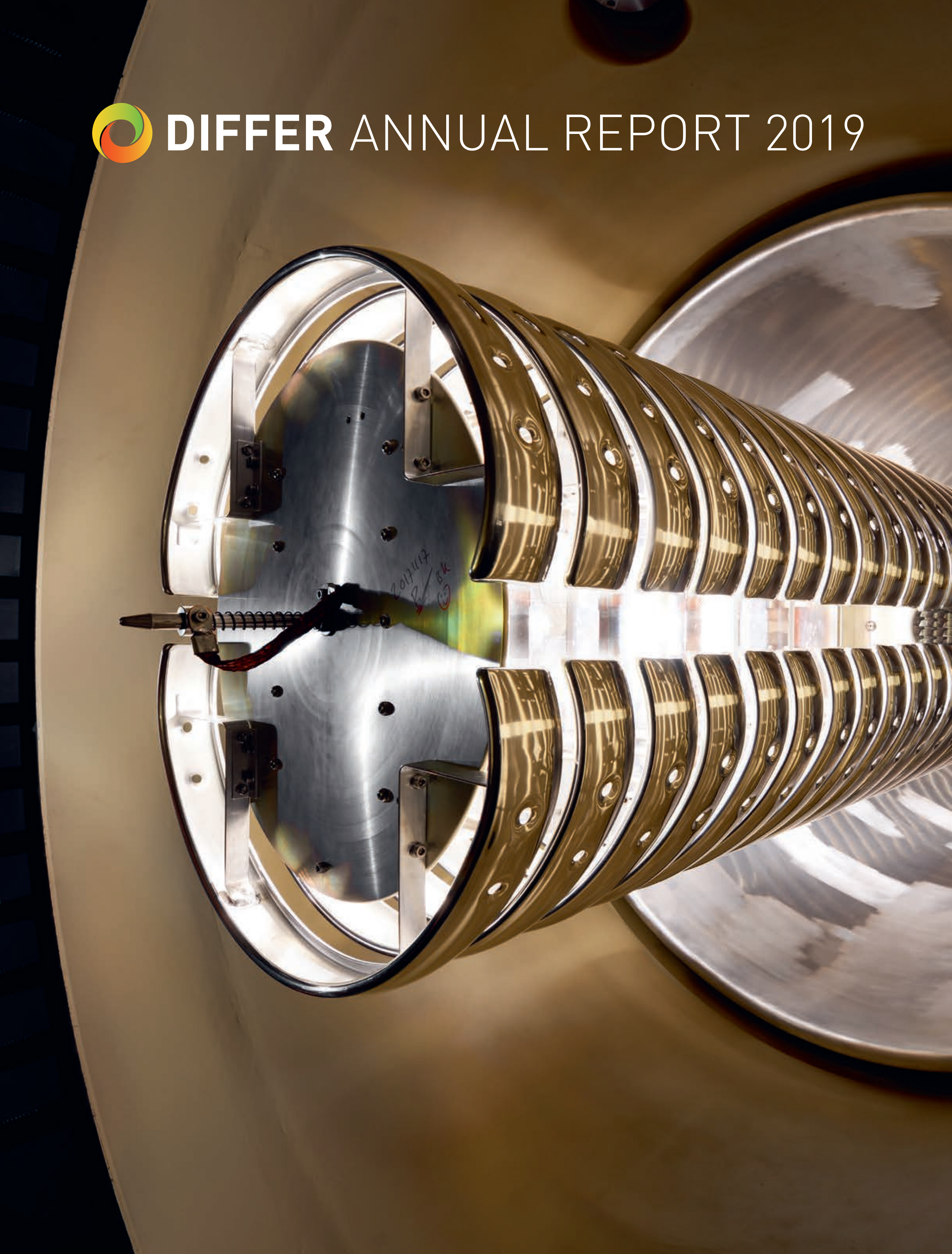
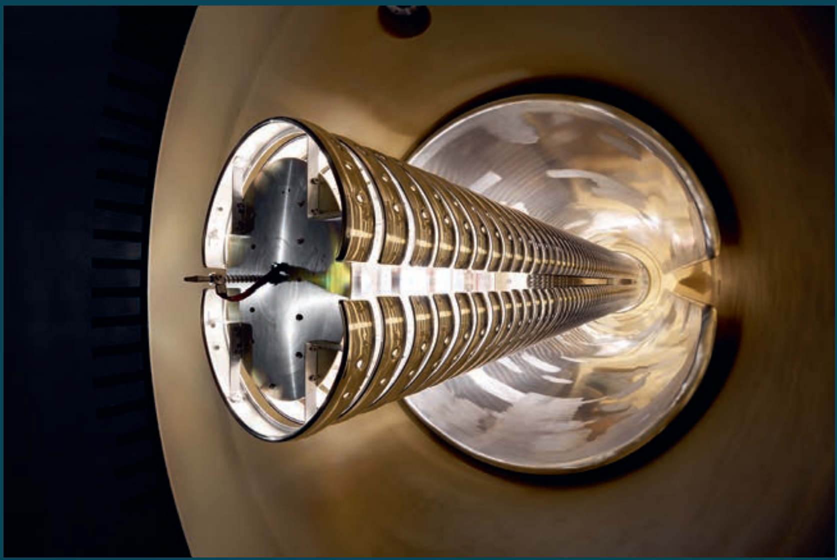
DIFFER ANNUAL REPORT 2019





COVER: A 3.5 megavolt singletron power supply of the Ion Beam Facility (IBF). The heart of the facility is an ion accelerator, in which lightweight gas ions are extracted from plasma and accelerated over (at most) 3.5 megavolt. The beam of ions formed this way, is steered to an experimental setup of choice, where it allows for non-destructive investigation of materials for fusion and for solar fuels. See page 17 for an interview with Beata Tyburska-Pueschel, project leader of the IBF.
Picture Bart van Overbeeke

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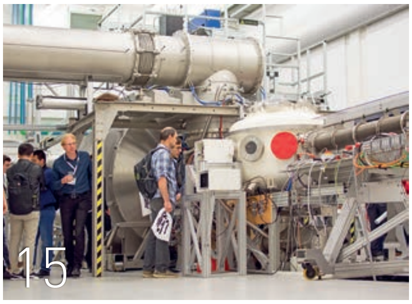
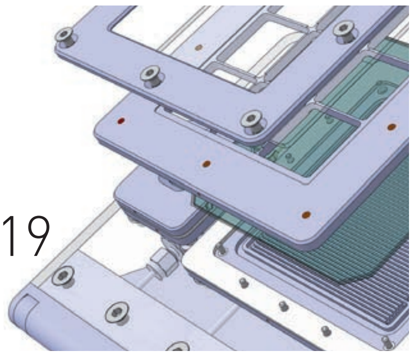




Looking back, you realise how much progress has been made. And above all else, that it is a human effort: a special synergy between our scientific and technical staff, guests and students, and the support staff. In 2019, DIFFER celebrated its sixtieth anniversary, which we marked with a symposium, a party and a permanent photo wall full of memories. Memories of the scaling up of the nuclear fusion plasma within the theme Fusion Energy since 1959. Or of the spin-out of research groups to universities following our change of mission in 2011. And of the developments in the new research line Solar Fuels since 2013. Sixty years: congratulations to everybody who has contributed to the institute!

Although the progress is gradual, we can see that many small steps together have a large impact. This annual report shows what we achieved in 2019. I proudly look at the progress achieved at the Upgraded Pilot-PSI facility, which produced its first plasma and was connected with the ion accelerator for operando studies. And at the research that uses solar energy to directly convert water vapour from the air into hydrogen, which captures the imagination and received a lot of media attention. It demonstrates that the societal impact of DIFFER's research is more clearly coming under the spotlight.

I want to briefly reflect on the chemical incident at DIFFER in December, in which unfortunately a colleague was wounded. I am pleased that a recovery is in sight. It does, however, clearly remind us that research remains a human effort and an accident can unexpectedly happen. Even though no direct cause of the accident was found, as DIFFER we have drawn our lessons from this incident and we are taking steps to improve our safety structure.

In October, I announced my departure as director, something which will take place in the middle of 2020. By that time, I will have been the director of DIFFER for 9.5 years, almost two full terms. With pride, I look back at the work achieved in and by the entire institute. The role of fundamental energy research has become more prominent in the energy transition: a process of long-term goals in which innovation is vital. Based on the positive outcomes from the institute portfolio analysis, the time seems to be ripe to more prominently put DIFFER on the map through a strategic repositioning around large infrastructure for energy research.

For now, I hope you will enjoy reading this annual report, which is once again brimming with the latest developments and surprising research.

April 2020,
Richard van de Sanden
DIFFER Director

ABOUT DIFFER

DIFFER is the Dutch Institute for Fundamental Energy Research. Its mission is to perform leading fundamental research on materials, processes, and systems for a global sustainable energy infrastructure, in close partnership with (inter)national academia and industry. DIFFER plays a key role in the Dutch research landscape as the foremost strategic instrument of the Dutch Research Council (NWO) in fundamental energy research.

Energy is vital. Sustainable solutions are the future. Ensuring plentiful energy supplies is a societal challenge for this century. Energy sources, infrastructure, and usage must become sustainable. And all of this needs to happen while the demand for energy increases due to the rising standard of living in much of the world. Scientific research plays a crucial role in developing sustainable solutions. DIFFER contributes to two building blocks for a sustainable society: clean, safe, and inexhaustible energy from nuclear fusion, and conversion and storage of energy in fuels and chemicals.

In 2019, DIFFER stimulated collaborative research between its groups and themes to gain more benefit from in-house expertise and skills. Two postdoc positions were granted to bridge the expertise of groups on in situ operando studies and cavity-enhanced chemistry. DIFFER will continue this type of strategic seed funding in 2020.

DIFFER also started a new research group, Energy systems and control. This group will contribute the latest insights and developments from control engineering to further advance DIFFER's research into fusion energy and solar fuels.

Director Richard van de Sanden chairs the advisory committee of the platform Electrochemical Conversion and Materials (ECCM), on behalf of three Dutch Top Sectors. In 2019, NWO launched an ECCM tenure-track programme, and a top-down call within the Dutch Research Agenda (NWA) programme. Both of these are in line with the advisory committee's report published in 2017. Furthermore, DIFFER contributed to the Dutch climate agreement and its Integral Knowledge and Innovation Agenda (IKIA) through its leading role in the NERA alliance for energy research in the Netherlands.

Symposium DIFFER 60: Energizing the future

DIFFER celebrated its 60th anniversary with the symposium Energizing the Future, and a big party for DIFFER staff in the former Paterschurch in Eindhoven.

Right from the start, DIFFER has contributed to the development of nuclear fusion as a clean energy source for mankind. In 1959, the FOM Institute for Plasma Physics Rijnhuizen opened, which became the Dutch home base for research into fusion energy. In those days, the slogan 'Let us make a sun on earth' accurately described the institute's mission. Nowadays, DIFFER's mission is broader, but just as appealing: Science for future energy.

Solar Fuels and Fusion Energy

In the late 1980s, the institute broadened its research. In 2012, it became DIFFER, the Dutch Institute for Fundamental Energy Research, with a focus on Fusion Energy and the new research theme Solar Fuels: the storage and conversion of sustainable energy via chemical bonds. The institute relocated to a brand new building on the campus of Eindhoven University of Technology in 2015, where it has built strong ties with the university's research and the high-tech Brainport environment.

Talks and labtour

The 60th-anniversary symposium Energizing the Future was organized in December 2019 and was attended by 200 people. The day's themes were the future directions of energy research on solar fuels and fusion energy. Four excellent speakers gave their views and opinions on the matter: Tony Donné (EUROfusion), Jonathan Citrin (DIFFER), Peter Styring (The Univeristy of Sheffield) and Anja Bieberle (DIFFER, picture below). The DIFFER facilities and labs were also opened, which gave insight into the research focus of the various groups and the in-house expertise and skills.

Timeline

DIFFER director Richard van de Sanden officially opened the DIFFER Timeline on the walls of the main entrance to the institute. A 40-meter long photo wall beautifully illustrates the history of DIFFER and two architectural models were unveiled: the renowned Rijnhuizen estate in Nieuwegein (picture above) and the ultra-modern DIFFER building in Eindhoven.


INTERVIEW

Living and breathing energy research

"The time has come for new people to rethink DIFFER's mission and future direction." In 2020, Richard van de Sanden will step down as director of DIFFER. "For the energy transition, science should focus on the things that are not that easy to decarbonize."

Richard van de Sanden captures the soul of DIFFER in seven words: "We all live and breathe energy research." Interest in the fundamentals, paired with intrinsic motivation to contribute to the energy problem is what makes DIFFER people different, he says. The director started his job in 2011. Then DIFFER was still the FOM Institute for Plasma Physics Rijnhuizen; big changes were ahead. Over the next few years, the institute would move from Nieuwegein to Eindhoven, and be turned into an institute for fundamental energy research. A good move, the director says: "We are more connected to the outside world. The societal relevance of our work is more apparent."

Traditionally, fusion research was DIFFER's raison d'être. Now DIFFER's focus is on materials, control, and real-time modelling. "The PSI-facilities and crown jewel Magnum-PSI are unique, especially once the coupling with the ion beam facility has been made."

"The societal relevance of our work is more apparent."

The road to take

Solar fuels is the new kid on the block. This research line has run for five years now. Van de Sanden: "We are gradually making an impact. The research on using plasmas for gas conversion is a clear niche area. We have also made clear choices in our electrochemical research, like membrane reactors and modelling the electrolyte-electrode interfaces. However, we have yet to reach the top. A new director needs to develop a vision on which route we should take to achieve that."

DIFFER was originally tasked to play a coordinating role in fundamental energy research in the Netherlands. "For fusion, this came naturally, since we are the liaison point between the Dutch parties and the international fusion facilities. For other topics, it was harder. Universities saw us as a competitor." Therefore, Van de Sanden decided to adopt a more facilitating role instead. "We breathed new life into the Electrochemical Conversion & Materials community, now a flourishing theme again in our country. We noticed there was no mention of energy research in the Dutch Research Agenda (NWA), and so together with NERA we initiated what became the NWA route Energy Transition." And for the field, we initiated several NWO programs, such as CO_2-neutral fuels and Solar-to-Products.

Van de Sanden also participated in national debates on climate change. He was not amused when academia was left out of establishing the Dutch Climate Agreement. In the Dutch national newspaper *Trouw*, he spoke of a missed opportunity. "Now climate policy is almost all about the built environment. To make an actual impact, you have to focus on industry and increasing the availability of sustainable energy. Also, the timelines are wrong. If we can produce sustainable, synthetic gas in a couple of years, all the energy that went into transforming the energy infrastructure will have been wasted."

The role of DIFFER is to look beyond 2030, Van de Sanden says. "Science should focus on the things that are not that easy to decarbonize."

TWEETS

NWO Domain Science @NWO_Science ***11 Feb 2019***
#physics | Celebrating Shuxia Tao, assistant professor @TUeindhoven @DIFFERenergy for receiving an NWO START-UP grant for her research on the role of small ions in perovskite solar cells #CSER #WomenInScience #WomenInScienceDay

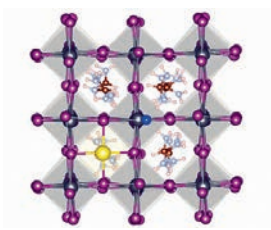
DIFFER @DIFFERenergy
4 Mar 2019
Artificial leaf researchers Anja Bieberle and Mihalis Tsampas now have a tenured position as group leader at DIFFER - congratulations!

Marion Hinderdael @mhinderdael ***11 Apr 2019***
During climate round table Industry, Prof. Van der Sanden @DIFFERenergy emphasizes the opportunities of energy transition. The combination of knowledge and expertise in the chemical industry combined with technical manufacturing industry gives NL a unique position.

EUROfusion @FusionInCloseUp
30 Apr 2019
#Fusion @DIFFERenergy #spinoff @chromoBV explores applications of real-time #imaging in #cancer diagnosis & treatment, industrial quality & process control. The #startup has bagged @ATTRACTEU grant &signed Coo-op Agreement with @iterorg. Read all about it!

DIFFER @DIFFERenergy
28 Mar 2019
DIFFER spin-off @chromoBV is on the short-list to win the Golden Lightbulb start-up award. Will this novel imaging system designed by @WouterVijvers take the prize? Stay tuned for the award ceremony on April 3rd!

DIFFER @DIFFERenergy
14 May 2019
How a fluoride layer protects not just teeth, but also cheap and efficient perovskite solar cells. Beautiful work in *Nature Energy* by Shuxia Tao and Chidozie Onwudinante of our joint energy research group with @TUeindhoven



Joe Allcock @JSAllcock
28 May 2019
This month, several @FusionCDT students are working on the Magnum PSI experiment at @DIFFERenergy, NL. We are testing novel techniques for measuring fusion plasma, in preparation for the MAST-U tokamak at @UKAEAofficial, due to switch on later this year. It's all very exciting!

TU/e ST @TUe_ST
5 Jul 2019
An international research team led by Prof. René Janssen @TUeindhoven developed a method to create two subtypes of one polymer, with different semiconductor characteristics. Read more on their @NatureComms publication here: http://ow.ly/IkXD50uU4XZ

Tarek Alskaif @Tarek_Skaif
30 Oct. 2019
Interesting keynote speech by Prof. Wim Zeiler at @TUeindhoven on small and big data in the built environment at Applied Computational Science Symposium #ACOS2019 at @DIFFERenergy

Marieke Moorman @mariekemoorman
7 nov. 2019
Full house at Energiefestival in Evoluon. The need for the energy transition in Brabant is widely felt. And also the recognition that there is still a lot of work to be done.#EFBrabant

DIFFER @DIFFERenergy
7 nov. 2019
@DIFFERenergy at Energiefestival Brabant: #solarfules in action #EFBrabant @Evoluon

Mark Boneschanscher @MBoneschanscher
25 Nov 2019
Delegation of @MinOCW takes a look behind the scenes at @DIFFERenergy.

DIFFER @DIFFERenergy
29 Nov. 2019
Modelling the conversion of molecules into valuable chemicals like fertilizers by means of plasmas. @DIFFERenergy scientist Paola Diomede receives a @NWO_Science KLEIN grant.

Goodbye song at the farewell reception of Wim Koppers

New institute manager: Senf succeeds Koppers

DIFFER welcomed its new institute manager Freya Senf in August 2019. Senf succeeds Wim Koppers, who left DIFFER in February 2019 to become director of operations and finance at NWO.
Koppers had a long history at DIFFER, where he started as a project manager in 2004 and later became the institute manager. He was also a member of the governing board of Fusion for Energy, from 2014 till 2019.
He was highly appreciated for his structured and careful managing that lead to a robust and financially healthy institute. Koppers played a considerable role in guiding the process of relocating the institute from Nieuwegein to the new building in Eindhoven.
New institute manager Senf (interview page 29) oversees the institute's support facilities and is part of the management team together with director and theme leader Solar Fuels Richard van de Sanden and theme leader Fusion Energy Marco de Baar. She already has extensive experience in managing a scientific institute. Senf was previously managing director of Radboud University's Institute for Molecules and Materials.

Wim Koppers

DIFFER of added value for Dutch research field

DIFFER has a clear added value for the Dutch knowledge landscape and fulfils an important coordinating role in the research field of nuclear fusion. That is the outcome from the Portfolio evaluation of the landscape of Dutch research institutes.
NWO and KNAW commissioned an independent committee to evaluate the role of the KNAW and NWO institutes. The committee considered what added value the institutes have for the Dutch research landscape. The report was submitted to the Dutch House of Representatives in February 2019.

Driving role

The portfolio committee reports that DIFFER clearly fulfils a national role with added value for the Dutch research field. DIFFER director Van de Sanden is proud of the positive evaluation: "It is good to see that the internationally prestigious nature of our nuclear fusion program is appreciated. The committee underlines DIFFER's driving, connecting, and coordinating role within nuclear fusion research." The committee advises DIFFER to further strengthen the young research line Solar fuels so that the Institute can acquire a leading role in this field too. "We gratefully take this advice on board", says Van de Sanden.

FUSION ENERGY

Fusion Energy has the potential to provide concentrated, safe, and clean energy from the process which powers the sun and stars. A nuclear fusion reactor can deliver large-scale dispatchable and non-intermittent power, a key component in a robust and secure future energy system. The global endeavor focuses on constructing the experimental reactor ITER, the first fusion reactor capable of controlling a 'burning' fusion plasma to generate net power.

The Fusion Energy theme's goal is to enable the development and validation of science and technology for the design and operation of ITER and demonstration power plant DEMO, that EUROfusion aims to have operational around 2050 to deliver fusion power to society.
DIFFER´s fusion research focusses on one of the most critical aspects of the fusion reactor: the exhaust of heat and particles in the divertor area. The institute develops novel divertor materials solutions, model-based plasma controllers, and innovative sensors and diagnostics for the plasma periphery. This requires a fundamental physics-based analysis, developed together with control-oriented models and controllers, and new materials.

Important progress has been made in constructing the Upgraded Pilot-PSI (UPP) facility. UPP can produce fusion-relevant plasmas and now features a direct beamline from the DIFFER Ion Beam Facility, so that what happens to materials during exposure can be viewed in real-time. This provides a unique capability that exceeds the material analysis options in the lead facility Magnum-PSI, which are only possible after exposure to fusion-relevant plasmas.

Plasma detachment is needed during the operation of fusion reactors to protect the wall against damaging extreme heat and particles fluxes. DIFFER achieved full detachment control in both L- and H-mode at the TCV reactor by using the C-III plasma emission line as a proxy for the detachment. The key factor is the optimization of the entire control system, including the sensor, the real-time analysis, and the dynamic modelling of the plasma response to the inputs from the actuators. This result is generic for implementation at other reactors.

Controlling the heat

How to best control a fusion reactor? Combine state-of-the-art plasma diagnostics with advanced feedback control design and then systematically optimize everything. That approach enabled two groups at DIFFER to generate a promising solution to the long-standing problem of effective detachment control.

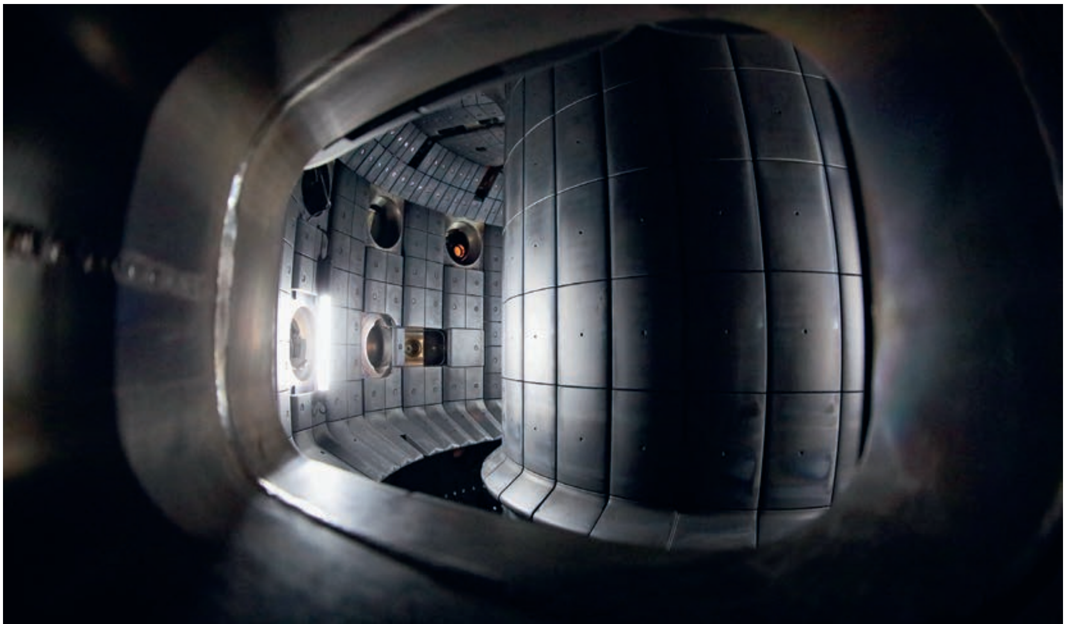
Unless unimaginably hot plasma is generated, there will be no nuclear fusion. But without effective ways of protecting the reactor wall from this devastating heat, nuclear fusion will not become a practical reality either. Controlling the heatload is therefore a crucial step towards the prolonged and safe operation of fusion reactors. Many international efforts are underway to tackle this problem. These focus on divertor detachment, as it is known in the field.

In short, the divertor is the reactor's 'exhaust' and here the reactor wall is exposed to heat and plasma leaking out of the core. To prevent damage – which is unavoidable without proper measures – gas is pumped into the divertor region, which lowers both the temperature and the particle load. However, the gas inlet must be strictly controlled to avoid too much cooling, which would interfere with the reactor's overall performance.

Proof-of-principle

Two DIFFER groups, the Energy Systems and Control group and the Plasma Edge Physics and Diagnostics group, managed to devise a new and highly promising detachment control method. A method that arose from a thorough, stepwise way of working, emphasizes Matthijs van Berkel of the Energy Systems and Control group. "Processes like this are often optimized through trial-and-error. Keep on tuning and tweaking until the overall results improve. We deliberately applied a very systematic approach: we first considered all the individual steps and then optimized each step before running the experiments." Their strategy paid off. Experiments in which the heatload was implicitly controlled at the mid-size fusion reactor TCV in Lausanne (in both L-mode and H-mode) delivered proof-of-principle of the DIFFER method.

The various steps comprise real-time measurements using the multi-spectral imaging diagnostic MANTIS (developed at DIFFER in collaboration with EPFL and MIT), dynamic characterization of the divertor plasma using a newly developed light-tracking algorithm, and a feedback control technique based on dynamic characterization. Each of the steps requires cutting-edge technological developments. However, putting all of these pieces together in the face of severe experimental time constraints is the most innovative aspect, says Van Berkel. "Combining all of this into the fusion context is the real news."



Experiments were carried out at the TCV tokamak in Lausanne.

WPCD Code Camp at DIFFER

DIFFER hosted a code camp for fusion researchers in the EUROfusion Project on Code Development for Integrated Modelling (WPCD) in June 2019.
The participants were developing simulation codes for existing and future tokamaks, like ITER and DEMO. Codes needed to be coupled, optimized, and new physics included. The participants used the two weeks to meet in person, to work on code together and to schedule joint work. Twenty participants from around Europe came to Eindhoven. DIFFER-researcher Jonathan Citrin: "The code camp helped progress the development of a standardized, modular, user-oriented tokamak simulation suite for the EUROfusion research community and beyond."

Donné reelected EUROfusion Programme Manager

Tony Donné will serve a third term as Programme Manager (CEO) of EUROfusion. He was reelected by the General Assembly in December 2019. EUROfusion is the consortium of Europe's fusion research laboratories. In his previous term Donné updated the roadmap for the programmes of EUROfusion. Goal of this roadmap is to provide a structured way forward to commercial electricity from fusion. Donné: "The year ahead is crucial as we prepare to step into the European Research and Innovation Programme FP9, the successor of Horizon 2020." Donné was head of the Fusion Research Theme at DIFFER until he was appointed Programme Manager in 2014.

ITER wall lifetime tests

ITER materials are tested in Magnum-PSI to assess the future performance of a fusion reactor.
In 2018 a mock-up of ITER's tungsten exhaust system, or divertor, was exposed to the harsh plasma conditions as they will occur during high power fusion operations. No major damage or failure was identified after the equivalent of one year of operation in ITER. This indicates the current design is capable to fulfil the requirements.
In 2019 a new mock-up was simultaneously exposed to similar steady-state plasma but now including up to one million pulsed heat loads, with powers a 100 times as intense. These simulate the extreme conditions during transient events called ELMs, which are predicted to occur in ITER.

Only high power transient loading damaged the tungsten surface (3 x 3 mm).

Van Berkel heads new research group Energy Systems and Control

With his new research group on Energy Systems and Control, tenure tracker Matthijs van Berkel wants to bring state-of-the-art system identification and control engineering to the world of energy research. "Energy systems are becoming ever more complex", says the systems control engineer. "That's why we need a systematic approach to characterize and actively control their performance."
Van Berkel already demonstrated the value of this approach with advanced identification and efficient controller design for the bucking plasma in the fusion reactors LHD in Japan and TCV in Switzerland. At DIFFER, he will collaborate closely with leading control engineers at the TU/e to develop systems analysis and control techniques for both DIFFER's fusion and solar fuels research.

Matthijs van Berkel with a rheoscopic disc, build to visualize turbulence.

Vidi laureate Thomas Morgan

Vidi for liquid reactor walls

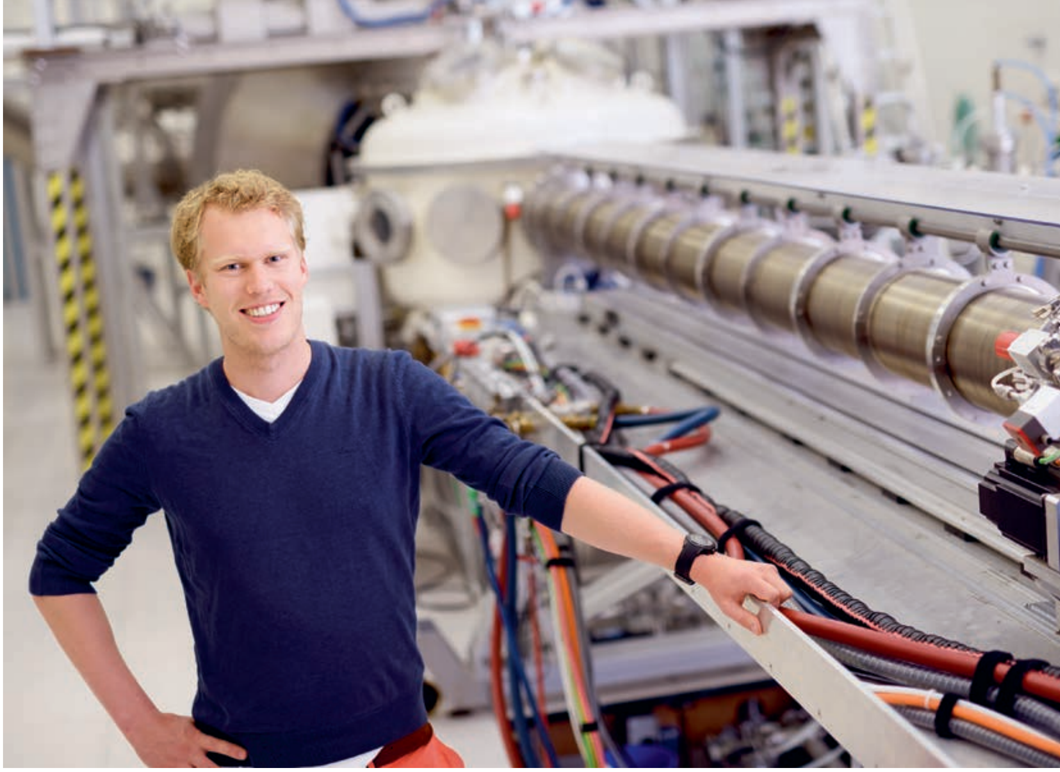
Liquid metals are exciting as a wall design for future fusion power plants, because they can repair and even shield themselves from the harsh conditions. In May group leader Thomas Morgan was granted a Vidi to further investigate the concept of liquid metal layers to protect the walls of future fusion power plants.
Developing robust reactor walls is one of the main challenges in the international quest for clean, safe and abundant fusion energy. The exhaust or divertor of the reactor will have to withstand heat loads and particle bombardments like those at the surface of the sun. "In the ITER experiment, which will begin operation in 2025, we will reach the limits of our current best materials such as solid tungsten", says Morgan. The power plants after ITER will need even sturdier designs, that can perform for months or years between maintenance.

Vapour cloud

Morgan states: "In this project we will test the idea of a protective layer of liquid metal flowing over the divertor wall. The idea is that you can constantly replenish that layer to counter erosion. Even better, the vapour cloud that will form above it will absorb part of the incoming heat before it can reach the surface." Morgan and his team will use DIFFER's Magnum-PSI and new Upgraded Pilot-PSI facilities to test the performance of liquid lithium under conditions as expected in fusion power plants. Morgan will use the 800,000 Euro grant to appoint two PhD students and a post-doc researcher.

VSRS: diagnostic tool for ITER

DIFFER is co-developing a diagnostic instrument that can measure the impurity content of fusion plasma. The instrument will provide critical information to the control system of the nuclear fusion project ITER so that it can regulate the neutral beam heating power.
Research institutes TNO and DIFFER have teamed up with Active Space Technologies and DIFFER spin-off company Chromodynamics to develop the VSRS, Visible Spectroscopy Reference System. VSRS will 'look' into the tokamak reactor vessel to analyze the light emitted by the plasma. It provides important information on the average impurity content ('transparency') of the plasma.
The Cooperation Agreement was signed in February 2019. An early version of the VSRS will be ready for first ITER plasma in 2025, an updated version is intended by 2028. It is expected that the VSRS will be the very first instrument to observe visible light emissions from the first ITER plasmas.
Plasma impurity content is an important parameter for ITER's main source of external heating, neutral beam injection. Therefore, VSRS will monitor the absorption of the heating power by the plasma. It will provide an early warning signal if the power needs to be reduced to prevent the machine wall from overheating. In addition, it will provide a reference plasma density measurement for control purposes.



Hora est! Peter Rindt

Peter Rindt likes to think out-of-the-box. So when his Eindhoven University of Technology supervisor Niek Lopes Cardozo asked him if they could use 3D-printing to fix a long-standing problem in fusion reactors, that is what he did. Rindt designed a divertor using liquid metal contained by 3D-printed tungsten. He successfully defended his PhD thesis in July 2019. His work was a a EUROfusion project, carried out in cooperation by Eindhoven University of Technology and DIFFER.

"A major problem in a fusion reactor is the heat resistance of the divertor, where waste material from the reactor is removed. In this part, the heat flux density can be so high that the material the divertor is made from, tungsten, will crack, melt or erode away. This can be solved by using liquid metals in the divertor, as these will not crack and can be replenished. Furthermore, these liquids can take up excessive heat by vaporizing and radiating, an effect called vapor shielding. However early designs, for example using a wire mesh to soak up liquid lithium, do not yet meet the requirements of a real reactor.

"I designed a 3D-printed matrix from tungsten with capillary channels."

I designed a 3D-printed matrix from tungsten with capillary channels that contain the liquid metal. It is resistant to the various loads, such as the power and neutron fluxes, and can handle a temperature gradient very well."

DEMO divertor

"Using the linear plasma generator Magnum-PSI at DIFFER, we showed that if tin is used as the liquid metal, this divertor design can withstand almost double the required heat flux density in steady-state operation of the reactor, and even three times that for so-called slow transients. Another obstacle that remains is the resilience to very short plasma disruptions, which give much higher heat flux densities. However, the early results look promising.

As an engineer, I take up design challenges, such as the ones the European DEMO project is facing, much more than the physics challenges of ITER. I am happy that I was able to convince the team at DEMO that my divertor design is feasible and may solve many of their challenges. We are now building a prototype of this divertor using various 3D matrix materials."

Fusion materials experts meet in Eindhoven

The 17th International Conference on Plasma-Facing Materials and Components for Fusion Applications (PFMC) was held in Eindhoven. This biannual international conference is one of the most important global meetings on materials for fusion reactors.

The conference brought together around 250 international students and experts on materials capable of handling the extreme conditions in future fusion devices and power plants. The conference was jointly organized by the DIFFER and Eindhoven University of Technology (TU/e). It was held at the TU/e in May 2019. The conference is a longstanding tradition, running since 1985. This was the 17th edition, and the first hosted in the Netherlands.

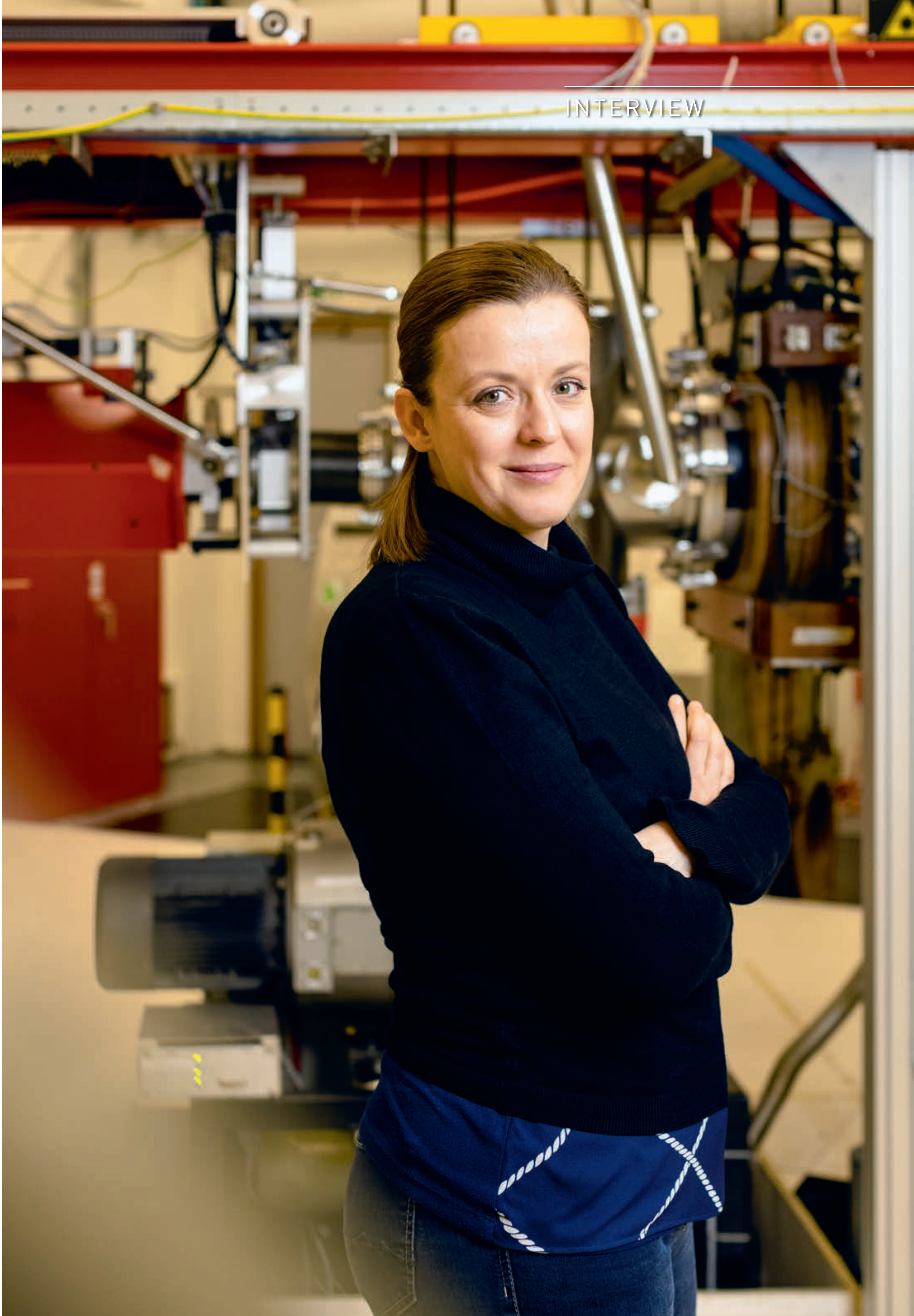
The topics of the conference ranged from advanced materials and innovative concept ideas to understanding and anticipating the performance of ITER materials. Aspects included studies on erosion, neutron irradiation, fuel retention and interplay between material and plasma. Said Local Organizing Committee Chair Thomas Morgan (DIFFER): "Organizing such a meeting is a big logistical challenge, but it was a great opportunity and honour for us to showcase the wide variety of work we do in this topic area." The next meeting will be held in Bonn in 2021.

With world experts on plasma facing materials present, DIFFER also organized a symposium on Magnum-PSI the day before PFMC started. The 160 participants learned about the capabilities and future plans for DIFFER's research facilities and visited the three Magnum-PSI, UPP and ion accelerator experiments.

Roundtable on ITER

DIFFER hosted a roundtable event on the international ITER fusion project and the business opportunities for Dutch companies and research laboratories. ITER will be the most advanced fusion reactor in the world, which brings great opportunities for science and businesses. The reactor is being built in the South of France by a global consortium. During the event at DIFFER in March 2019, Dutch researchers, companies, and director-generals and representatives from the ministries for science and economic affairs met with the heads of ITER and Fusion for Energy, the EU organization providing Europe's contribution to ITER. During the roundtable event ITER Netherlands, director-general Bernard Bigot of the ITER Organization outlined goals, progress and achievements at the project's construction site in Cadarache, France. Johannes Schwemmer, director of Fusion for Energy, presented the benefits of industrial participation and upcoming business opportunities. An industry fair was held with companies Cocoon, HIT, VDL, Mat-Tech, Cryoworld and ATG.

Guided tour of the Magnum-PSI laboratory



A culture of giving back

Polish-born experimental physicist Beata Tyburska-Pueschel discovered a close symbiosis between industry and academia at the University of Wisconsin-Madison's accelerator lab. As the new project leader of DIFFER's ion beam facility, she now wants to open up the laboratory to outside users and introduce that same culture of 'giving back'.

Crossing borders to other communities comes naturally to Tyburska-Pueschel, who knew she wanted to become a physicist when she was five years old. "Sadly, Poland did not have the infrastructure for cutting edge experimental research," she recounts, "so I applied for internships and later a PhD position at the German Institute for Plasma Physics (IPP) near Munich. Initially, I hardly spoke German or English, but I worked hard. In return, I got to learn a lot about ion accelerators."

In the coming years, Tyburska-Pueschel wants to open up DIFFER's ion beam lab to outside users from many fields. "Now we already investigate material properties for our in-house group on fusion wall materials, and I hope to attract our solar fuels researchers for work on catalysts and photovoltaics. And there is so much more you could do: screen paintings for forgeries or simulate the impact of cosmic rays on delicate electronics in satellites."

"I would like to open up DIFFER's ion beam lab to outside users from many fields."

Crossing borders
Tyburska-Pueschel's PhD project used ion beam analysis and ion-irradiation in IPP's accelerator lab to study how tungsten reactor walls get damaged by fast particles that fly out of a fusion plasma. "With our ion accelerator, our group was one of the first to simulate such damage. A big open question was how much of the fusion fuel gets absorbed into the reactor walls."

A postdoc followed at the University of Wisconsin-Madison, and crossing borders paid off once more. "I worked on neutron-damaged materials again, but this time in the context of fission power plants. I discovered that the fission people had been studying neutron damage for decades. I'm lucky to have seen both fields so I can share that knowledge. It's vital to connect to other fields and discover what they have to offer."

As manager of the local accelerator lab, Tyburska noticed the close relationship with nearby accelerator manufacturer NEC. "Americans call it 'giving back': we trained their future employees, they provided free repairs, we allowed them to test new techniques at our facility - I hadn't seen that level of symbiosis in Europe." At DIFFER, Tyburska wants to build up the same close relationship with HVE, the Dutch manufacturer of the institute's own ion beam accelerator.

DIFFER's accelerator is the only facility of its kind in the Netherlands, and Tyburska-Pueschel thinks demand will be high. "I plan to set up lectures and expert workshops on what you can do with a facility like this." First, however, there is work to be done: "Before we open for outside users, I want to upgrade our systems. For example, I want us to run all the controls from one control room, automate the safety systems, and keep all measurements on one central storage system. It will take some effort, but then we will be able to do exciting research here."

SOLAR FUELS

The efficient and scalable conversion and storage of sustainable energy into fuels and chemicals is a vital component of the future energy infrastructure. After all, not everything can be electrified: chemical industries require feedstock molecules and airplanes need high-energy-density fuels. The DIFFER Solar fuels program examines key enabling technologies to produce chemicals and fuels starting from the building blocks CO_2, H_2O, N_2, and sustainable energy.

Three major chemical pathways can be distinguished: water electrolysis and thermocatalysis; electrochemistry; and photoelectrochemistry & photocatalysis. The scientific and technological challenges boil down to controlling the chemical reactions from the molecular level to the macro scale.

DIFFER is coordinating a European consortium to boost sustainable aviation. It is codeveloping a chain of technology steps to synthesize green kerosene from air and water, using renewable electricity. This four-year, Horizon 2020 project KEROGREEN has reached the halfway mark and is building on recognition for the topic. It is also boosting the collaboration between DIFFER groups: CPPC, CEPEA, AMD, PSFD, and SFFI. Topics are connecting oxygen separation membranes, computational searching for catalysts, developing a CO_2 plasma reactor, and plasma chemistry modelling. KEROGREEN will combine these steps into a prototype kerosene reactor.

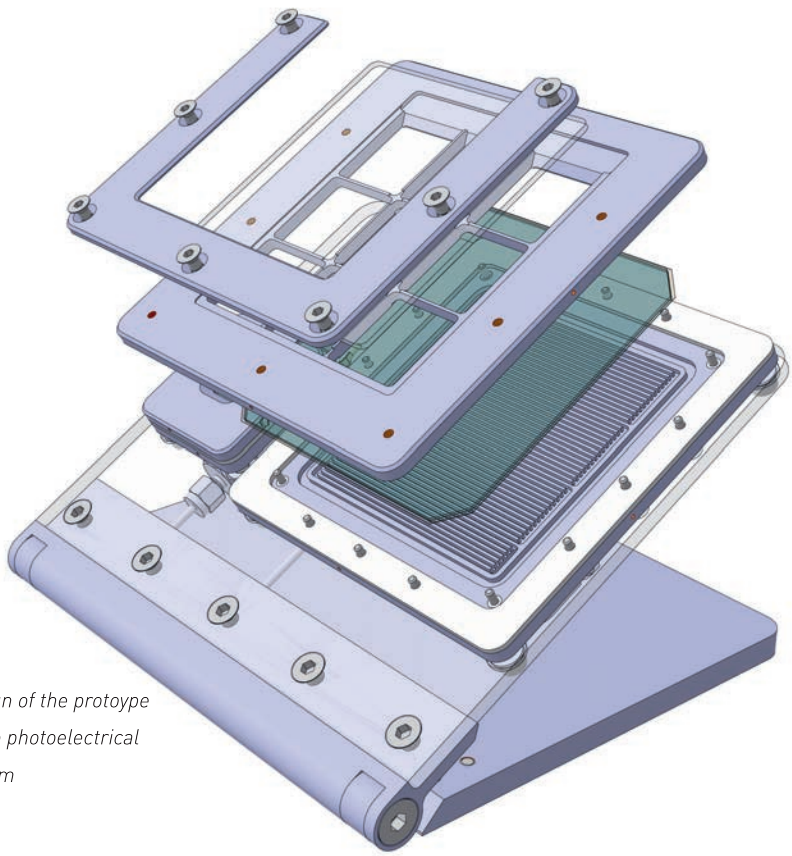
A fundamental understanding of electrochemistry is the vital 'black box' information needed to link experimental observations to predictions from simulations. In 2019, group leaders Anja Bieberle and Matthijs van Berkel teamed up to bring control engineering approaches to the field of electrochemical data modelling. This turned out to be a promising way of linking experiments to simulations without needing to know the details of that electrochemical black box.

DIFFER is a pioneer in the plasma-chemical conversion of CO_2 and water into CO and H_2, feedstocks for sustainable fuels. In 2019, the ProtoSF reactor was constructed, a scaled-up version of the InitSF reactor. ProtoSF will be used to further develop the plasma process that is coupled to an oxygen separator, together with Karlsruhe Institute of Technology.

Hydrogen fuel from thin air

DIFFER and Toyota are collaborating to produce hydrogen directly from humid air. The researchers are developing a photoelectrochemical system that absorbs water vapor and sunlight, and uses the sun's energy to directly convert water into hydrogen and oxygen.

To achieve a sustainable society, we need long-term methods for storing solar energy, for example, as chemical fuels. The concept of photoelectrochemically splitting water to produce hydrogen combines the harvesting of solar energy and the electrolysis of water into a single device. DIFFER and Toyota are exploring an innovative way to produce hydrogen directly from humid air. After starting a collaborative feasibility study, the project was awarded a LIFT grant from the NWO ENW PPS Fund in February 2019. This fund supports cooperation between companies and knowledge institutes. The research is realized in a collaboration between Toyota's Advanced Material Research Division and DIFFER's workgroup Catalytic and Electrochemical Processes for Energy Applications, headed by Mihalis Tsampas. This group had been working on a method to split water in the vapor phase instead of in the liquid phase, as most experimental devices do. Tsampas explains the advantages: "Liquids introduce some technical problems, like unwanted bubble formation. Furthermore, by using water in the gas phase, we do not need expensive installations to purify the water. And finally, since we only use the water present in the surrounding air, our technology can also be used in remote places where no liquid water is available."



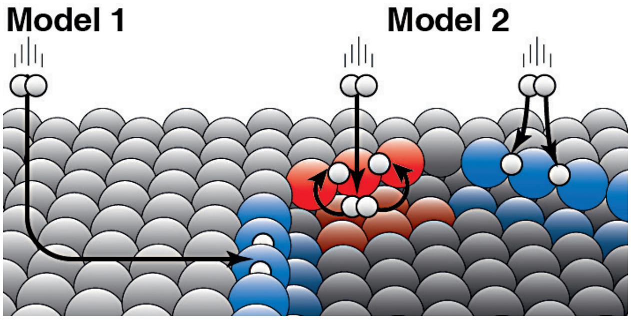
Design of the protoype of the photoelectrical system

Prototype

During the feasibility study, DIFFER and Toyota Motor Europe (TME) focused on developing a device structure that could capture water from ambient air and then generate hydrogen when illuminated by sunlight. This concept has so far achieved an impressive 70 percent of the performance obtained when an equivalent device is filled with water. The system consists of polymeric electrolyte membranes, porous photoelectrodes, and water-absorbing materials, combined in a specially designed membrane-integrated device.

The prototype has already been demonstrated outdoors. The results were published in *ACS Applied Materials & Interfaces* in October 2019. The researchers will further optimize the materials used to increase both the water intake and the amount of sunlight absorbed.

Hannah Johnson, Advanced Material Research Specialist at TME: "Renewable hydrogen production research is part of our activities for the Toyota Environmental Challenge 2050, where we aim for zero CO_2 emissions throughout the entire life cycle of our vehicles."



The two existing models for how hydrogen molecules dissociate during a collision with a platinum surface. Model 2 was demonstrated to be correct.

Persistent catalyst problem solved

After almost four decades, chemists from Leiden University and DIFFER have resolved the discussion about the correct model regarding one of the simplest chemical reactions in heterogeneous catalysis – the dissociation of hydrogen on platinum, which is essential for fuel cells. Using a unique curved surface, they showed which model correctly describes this reaction. Two existing models gave different predictions about how the reaction rate depends on surface structure. By means of measurements the researchers could directly determine this and thus prove which model was correct. Richard van Lent, Michael Gleeson and colleagues from Leiden published the findings in *Science*.

Two birds with one stone: plasma-activated electrolyzer

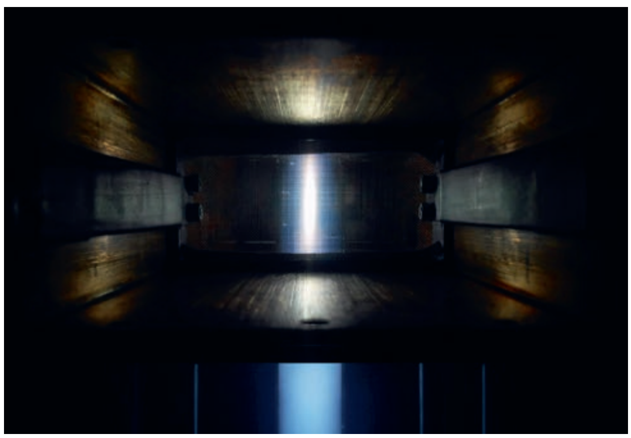
DIFFER researchers have constructed a plasma-activated electrolysis device that effectively breaks nitrogen gas and splits water into hydrogen and nitric oxide, energy-rich and chemical valuable products. Water reduction and nitrogen fixation are key processes in providing fuels and chemical feedstock for wide variety of societal purposes. The challenge lies in designing all-electric sustainable pathways to replace the conventional, high-temperature industrial processes, where high carbon dioxide emissions are needed to produce these molecules. The DIFFER device integrates both processes.
The results were published in *ACS Energy Letters.*

Database water solubility of compounds

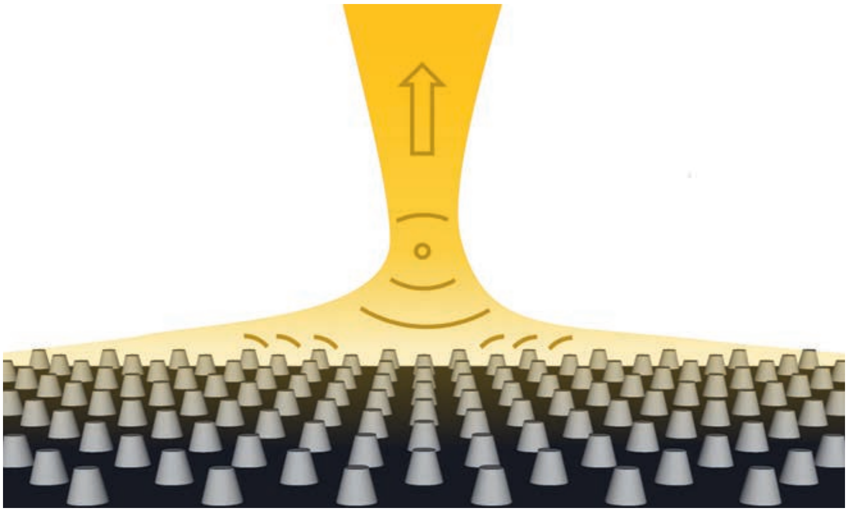
DIFFER researchers have developed AqSolDB, a large, human- and machine-readable database of water solubility of compounds and their cheminformatic descriptors. The database is open-access and easy-to-use.
Aqueous solubility of compounds plays a key role in energy storage. However, predicting the solubility of compounds is a prevailing challenge in chemistry.
AqSolDB contains standardized and validated data on approximately 10,000 compounds.
Suleyman Er: "AqSolDB serves two purposes. It is a reference database, for benchmarking new experimental and physics-based modelling results. It is also a reliable machine-readable resource, for improving the solubility prediction performance of machine learning approaches". The results were published in *Nature Scientific Data*.

To climb, or not to climb

In the search for ways to produce CO_2-neutral synthetic fuels to replace fossil sources, Bram Wolf and his colleagues at DIFFER have explored the use of microwave plasmas to efficiently break the CO_2 molecule. The research addresses a long-lasting discussion on the nature of fundamental chemical processes in the plasma. "While the non-equilibrium process of vibrational ladderclimbing has long been considered the holy grail for efficient conversion of CO_2, we found that the microwave plasma does not behave that way. Even the most promising results in the literature appear to be described best by thermal chemistry", Wolf says. The result is published in *Plasma Sources Science and Technology*.



The CO_2 dissociation process through the rectangular microwave cavity: a CO_2 flow is converted to CO.



Nanoparticles focus light from nearby molecules

An array of metallic nanoparticles enhances light emission from nearby fluorescent molecules. Researchers of DIFFER and Eindhoven University of Technology showed why. Fluorescent molecules shine brighter when they are on top of an array of metallic nanoparticles. Surprisingly, most fluorescent molecules do not emit more light in total. Rather, the rows of nano-antennas cause constructive interference, focusing the emitted light in the forward direction. Researchers of DIFFER and the University of Eindhoven published these findings in the scientific journal *ACS Nano*.

Super-resolution microscope

Arrays of metallic nanostructures have a strong interaction with light, both in emitting and picking up electromagnetic waves. Understanding that process could open the way to applications from light harvesting in energy conversion devices, to sensing chemicals and solid-state lighting. The nanoparticles were too small to study with conventional optical microscopes. In recent years, however, several optical microscopy techniques have been developed to image deeply sub-wavelength structures. Andrea Baldi: "At DIFFER we have assembled a super-resolution microscope capable of measuring the light emitted by a single molecule and finding its position within a few nanometers."

Ruben Hamans (DIFFER): "We can resolve nanoscale details of how light is emitted by individual molecules in the vicinity of these arrays. By combining our experimental imaging technique with numerical calculations, we discovered that nanoparticle arrays can 'force' the emitted light into a specific direction." This insight has implications for photonic devices based on nanoparticle arrays, such as solid-state lighting and optical sensors.

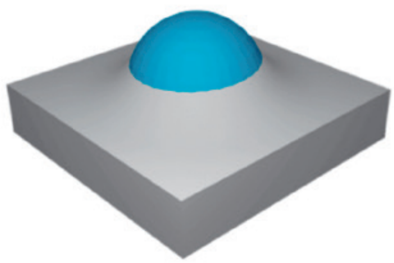
Atomic wrestling for oxygen

An international research team observed the controlled formation of nanoparticles in inorganic perovskite materials. "It's like watching lanthanum, calcium, nickel, and titanium atoms wrestle for too few oxygen atoms in their perovskite atomic lattice", DIFFER researcher Vasileios Kyriakou says.

Clusters of nickel atoms are pushed out in a controlled manner, as they appear to be the weakest in holding on to the oxygen. Colleague Mihalis Tsampas: "You end up with evenly distributed nickel nanoparticles, partly embedded in the host oxide."

Perovskite surfaces covered with nanoparticles are used in various energy applications.

Kyriakou and Tsampas teamed up with researchers from the universities in Newcastle and Lyon to model and observe the exsolution of the nanoparticles with an advanced electron microscope. The results were published in *ACS Nano* and highlighted by *Science*.



Exsolution of nickel from the perovskite oxide structure.

Hora est! Teofil Minea

Methane, the main component of natural gas, is mostly used as fuel. A long-standing dream of the chemical industry is to fully utilize its molecular value too, explains Teofil Minea: "To make plastics with natural gas as feedstock, for example." Minea completed his PhD project on the conversion of methane in February 2019.

The crucial step for doing this is to merge two methane molecules, to synthesize ethylene or acetylene. "The hypothesis was that using a plasma would help in this process." This way, he could selectively eliminate one single hydrogen from the methane molecule to start the merging process. Another important advantage is that using plasma technology could help make plastic production more environmentally friendly, since green energy could be used to fuel the plasma.

Minea worked in Gerard van Rooij's research group. "Gerard and I go back a long way. He taught the fusion course 'Plasma-wall interaction' of my Applied Physics master." Minea decided to do his master thesis on this topic. He stayed for his doctorate, while the research group transitioned to solar fuels research.

"The challenge was to activate the stable methane molecules."

Minea's research focused on converting methane into methyl radicals. "The challenge was to activate the stable methane molecules." Conventional chemistry invokes oxygen for the coupling of two methane molecules. However, the unwanted side reaction is essentially burning of methane, which produces CO_2 and CO. Therefore, it never became an economically viable process. Instead, Minea used a microwave plasma reactor, the oxygen was omitted. "Hence, CO_2 and CO are no longer produced", he explains the major advantage of the approach. "I fine-tuned this process."

Loss instead of electrons

The end goal was to let the methyl radicals interact with catalytic surfaces to produce ethylene. Minea: "Catalysis helps to obtain the right product. You need selectivity to avoid expensive separation and purification." While high concentrations of methyl radicals where successfully measured with a novel implemented diagnostic, interfacing the plasma activation with catalysis remains a challenge.

Minea now works at Rabobank as a risk manager: "It's a similar world with just a few name changes. Instead of electron distributions, I now deal with distributions of loss."

Flight to the future: green kerosene

Aviation is one of the least tractable of industries to decarbonize. The European research project KEROGREEN offers a pathway to synthesizing sustainable kerosene from air and water. In November 2019, researchers and industry from over Europe gathered at DIFFER to share their work and views.

Container sized unit

Aviation fuel from air: the KEROGREEN project develops an innovative conversion route for the production of sustainable aircraft grade kerosene from water and air. The project aims at building a container sized unit producing one liter per hour of kerosene. The conversion route is based on plasma driven dissociation of air-captured CO_2, solid oxide membrane oxygen separation and Fischer-Tropsch (F-T) kerosene synthesis. Green kerosene for aviation offers the advantage that already existing infrastructure for storage, transport and distribution can be used without change.

"The workshop at DIFFER was on the first steps of the processing chain, the production of synthetic gas - syngas - from CO_2, including the extraction of CO_2 from air", KEROGREEN coordinator Adelbert Goede (DIFFER) explains. A future workshop on the system integration with synthesis of fuel from syngas is planned for 2021, in Karlsruhe. "In the end, all our research needs to be translated into working systems for our prototype", Goede adds.

Annemie Bogaerts (University of Antwerp) in plenary discussion

Solar-to-Products: converting solar to sustainable

The symposium Solar-to-Products brought together the broad research community working on converting solar energy to sustainable fuels and products. DIFFER co-organised the symposium with NWO and TKI-BBE, the Top Consortium for Knowledge and Innovation for the Biobased Economy. The symposium was held on 6 November 2019 and was attended by 100 people.

The main incentive was to bring together researchers from various disciplines to examine progress and explore possible future collaborations on this topic. In particular, researchers were invited from the related NWO programmes Solar-to-Products, Materials for Sustainability, CO_2-Neutral Fuels, and Towards Biosolar Cells.

Triple helix

The day was packed with short updates by the principal researchers of the projects granted in these NWO programmes, ranging from biological-inspired and (photo)electrochemical to plasmachemical routes. Later on, a triple helix panel discussion took place to gain more insight into the potential and challenges of these innovative techniques and processes, with representatives from technology and manufacturing companies (Avantium, Siemens, VDL-ETG), research (TNO and the audience of scientists) and the government (Province Noord-Brabant). The last session of the day focused on larger funding initiatives being worked on in the Netherlands and Europe.

New calculations reveal what's happening in plasma

Imagine converting CO_2 into useful molecules, only by heating it to a plasma with a microwave. Researchers at DIFFER can, but nobody really understands the processes that take place in the plasma. Let alone that they can make the process efficient. DIFFER researcher Luca Vialetto can calculate what is going on.

A plasma is difficult to study, says Luca Vialetto. "A lot of mechanisms are coupled together such as flow, power and interaction between the particles." The third-year PhD student developed an innovative method to simulate the behavior of electrons in a low-temperature plasma. "With my model, we can study how electrons drive the reaction and how we can improve the dissociation of CO_2 efficiently."

Following an idea of his supervisor, plasma chemistry expert Paola Diomede, Vialetto modified the Monte Carlo Flux method, a much-overlooked method from the 1990s. This is a smart combination of Monte Carlo (MC) calculations – accurate but computing-time-consuming – and the electron transport equation which is usually solved numerically by implying many assumptions and approximations.

Vialetto explains: "First, I do an MC simulation of the motion of the electrons but only for a very short time. Then I use a deterministic method, that means I solve a system of linear equations to obtain the full energy distribution of the electrons. Since I use no approximations, it has the same accuracy as MC, but it is much faster, minutes instead of days."

The researchers checked their results by comparing them with experimental data from the literature and showed that they are in excellent agreement with alternative solutions, obtained under two-term or multi-term approximations.

Then Vialetto worked with colleague Pedro Viegas who is simulating heavy particles such as molecules. "By coupling our models, we can study what is happening during the experiments. They can measure electron density, composition, and gas temperature, which are all inputs for the model. We compare our model to the experiments and vice versa. The aim is to describe what happens in an experiment."

"The aim is to describe what happens in an experiment."

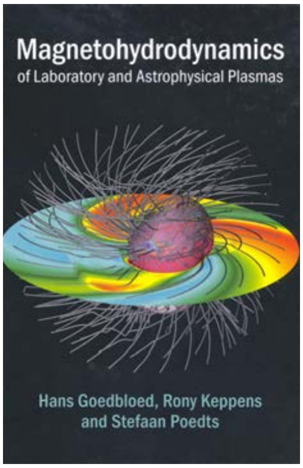
Start from scratch

"What I like about my project is that we started from scratch. Normally, you would use an existing software package to run your simulations and then compare these with experiments. I wrote my own code from the start, which allowed me to build up knowledge about the correct rules and assumptions so that the code is computationally efficient and also very accurate. Eventually, we will release the code as an open-source package. Others can then use and modify it for their own experiments."

Vialetto's work requires a substantial knowledge of plasma physics and considerable skill in programming. Nevertheless, he says he is learning an even more difficult skill during his time at DIFFER, namely teaching students. "I think it is important to communicate with students who are a few years younger, but really smart. We need their ideas. Explaining my work in a way that is understandable but precise, was one of the most difficult challenges I faced. But I enjoy it so much that I now definitely want to pursue an academic career after my PhD."

Text book on plasma theory

Hans Goedbloed finished his trilogy of text books on magnetohydrodynamics. This third book is for students and researchers interested in plasma physics, astrophysics and thermonuclear fusion. It brings together the two former books by Goedbloed, Rony Keppens and Stefaan Poedts.
With ninety per cent of visible matter in the universe existing in the plasma state knowledge of magnetohydrodynamics is essential for anyone looking to understand solar and astrophysical processes, from stars to galaxies - as well as fusion energy on earth.
Magnetohydrodynamics of Laboratory and Astrophysical Plasmas is on the theory of plasma behaviour. The numerical techniques needed to apply magnetohydrodynamics are explained, allowing the reader to move from theory to applications. This book combines *Principles of Magnetohydrodynamics* and *Advanced Magnetohydrodynamics* – updated with new examples, insights and applications. It is published by Cambridge University Press.



Dazzling Fusion Show

DIFFER participated in the Fusion Days at the University of Antwerp, which were visited by 3500 high school students and teachers. The DIFFER's Fusion Road Show and Energy Quiz starred as the central events during the four days. The Fusion Days are the closing event of the university's elective lessons module on fusion energy for the upper two years of high school. The event is organized once every two years in November by the University of Antwerp's education center. Visiting schools mostly come from Flanders, with some from the southern Netherlands.

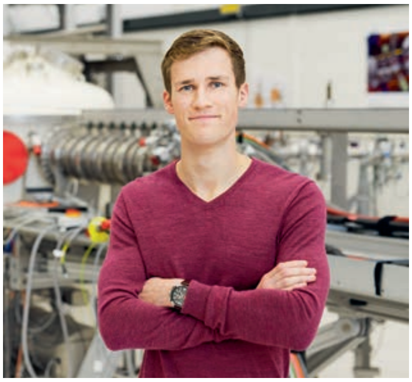
Theatre
DIFFER was present at the exhibition section and demonstrated science experiments ranging from the concept of magnetic confinement so critical for nuclear fusion to a demonstrator concept of Solar Fuels. Research development Officer Erik Langereis (picture bottom left) also presented the Energy Quiz: "A fun way to learn a lot on the energy transition and climate change based on facts and current trends."
The Fusion Road Show (picture bottom right) was the main event: an energizing show with live experiments and theatrical techniques. Former DIFFER employee Erik Min presented the show and entertained the next generation on the science and potential of fusion energy.

Graduating at DIFFER: runaways, milling machines and zeolites

DIFFER is not just a research institute but also a place where students are trained. In 2019, DIFFER welcomed 70 interns and graduating students. A large group of engineering students come from Fontys University of Applied Sciences. Lector Peter Thüne has been specifically appointed at DIFFER to supervise them. Each year, DIFFER also welcomes interns from the Leiden Instrument Makers School. DIFFER has established a taskforce for the recruitment of students, particularly from universities. Now there is a webpage for internships too. Furthermore, the contacts with study associations have been intensified: researchers from DIFFER regularly hold lectures at these. All of these initiatives have jointly resulted in more students, also from other places such as Amsterdam, Utrecht, Delft and Twente.

- **Eveline Mens**
- **Third-year Research Instrument Maker**
- **Leiden Instrument Makers School**

"I was given the freedom to learn, with help if I needed it." Eveline Mens describes her four months at DIFFER as the ideal internship. She started in the Instrument-Making Workshop, with a large hall full of lathes and milling machines: a paradise for a trainee instrument maker. "I received the drawing of the parts and then made those." She chose the right material and programmed the milling machines. The second part of the internship was in the Drawing Office where, amongst other things, she designed a component for a cooling system of an experiment.



- **Tijs Wijkamp**
- **Master's student Science and Technology of Nuclear Fusion**
- **Eindhoven University of Technology**

"Really cool. What we saw in the measurements, he saw in his model." Physicist Tijs Wijkamp did a graduation project for one year. He investigated whether the optical measurement system Mantis was also suitable for observing superfast 'runaway' electrons in the plasma of a fusion reactor. "During measurements in Lausanne, we saw a butterfly-like figure. Were those the runaways? The answer was yes; a theoretician had seen a figure just like that in his models." Wijkamp is working on an article about the measurements and will do his PhD at DIFFER.

- **Thijs Jansman**
- **Graduating student Applied Science**
- **Fontys University of Applied Sciences**

"Thanks to this internship, I know that I want to continue further in the sustainable energy sector." Thijs Jansman did an eight-month internship within the KEROGREEN project during which sustainable synthetic kerosene will be produced. Jansman's research partly concerned the adsorption of CO_2 by zeolites, a porous material that serves as a molecular sieve to separate CO_2 from CO and oxygen. "Guest researcher Sofia Calero made simulations to determine which type of zeolites adsorbed the best. We did tests to validate the simulations." The results will be published in *Catalysis Today.*

“Our teething problems are over”

Five years after relocating to Eindhoven, DIFFER is entering a new phase, says institute manager Freya Senf. “It’s time to reinforce our position.”

Freya Senf started as DIFFER’s institute manager in August 2019. Her view on the institute so far is two-fold. “Our fusion research is well-established. Our solar fuels research is relatively young. We started out as pioneers, but are no longer a frontrunner. We now need to make some sharp choices and build research facilities that make us unique.”

Senf is sure DIFFER will be able to make such choices, and she believes she came at the right time. “Five years ago, DIFFER relocated to Eindhoven. Now the dust has settled, it was definitely worth the effort. We currently receive so many interns and young talents that the personnel department can barely keep up. Furthermore, our researchers can easily meet with colleagues from the university, which is bearing fruit. So now we have the energy to make the next moves.”

“We are receiving more interns and young talents than ever before.”

Second-year dip

Once upon a time, Senf wanted to become a professor herself, in molecular biology. However, in the second year of her PhD on toxic bacteria, the big question got lost in the details. Senf doubted whether her research would have the impact she had hoped for. After obtaining her doctorate, she did not pursue a career in research. “However, because I’ve been a researcher, I can relate to the passion and struggles that come with the job. And now I can make a difference by creating the best possible conditions for our researchers in clean energy.”

DIFFER has four pivotal roles to play, Senf says: a place for excellent fundamental science, a breeding ground for young researchers, advanced infrastructure, and a highly appreciated source of specialised expertise for industry, entrepreneurs, and policymakers. The latter two roles will require the most effort in the short term, Senf thinks. “We specifically focus on two areas of energy research and in these, our research institute needs to be the obvious place to go to for experiments, and for inspiring ideas.”

The DIFFER community already participates in many discussions. But this needs to be taken a step further, according to Senf. She wants to align different functions within the institute, so that they add to each other’s strength. The technical services can count on Senf’s special attention. “Our treasure”, she says. “Without them, we could never operate at the limits of technology. So we must ensure the work remains attractive for our technical staff.”

Shortage of women

Senf also wants to improve the male-female balance, a thread throughout her career. The female employment rate at DIFFER has increased to 20 percent in recent years. However, the overwhelming shortage of female scientists and technicians is an issue that Senf wholeheartedly wants to resolve. “Why should we miss out on half of the available thinking power?”

Senf hopes to be an open and accessible manager. “My possible weakness is wanting to act too fast when people approach me with their problems.” And she feels very welcome at DIFFER: “Could you please write down that DIFFER is not only a place of excellence, but also of warmth?”

FACTS & FIGURES

Output 2019

10	PhD theses
113	Publications
78	Open access
92	Invited talks
75	Other talks
127	Posters
9	Editorships
3	Book (chapters)

Organizational chart

Theme leader
M.R. de Baar

THEME FUSION ENERGY

- Computational Plasma Physics and Chemistry – P. Diomede
- Energy Systems & Control – M. van Berkel
- Fusion Facilities and Instrumentation – H. van Eck
- Integrated Modelling and MHD – E. Westerhof
- Integrated Modelling and transport – J. Citrin
- Plasma Edge Physics and Diagnostics – I.G.J. Classen
- Plasma Material Interactions – T. W. Morgan

Director / theme leader
M.C.M. van de Sanden

THEME SOLAR FUELS

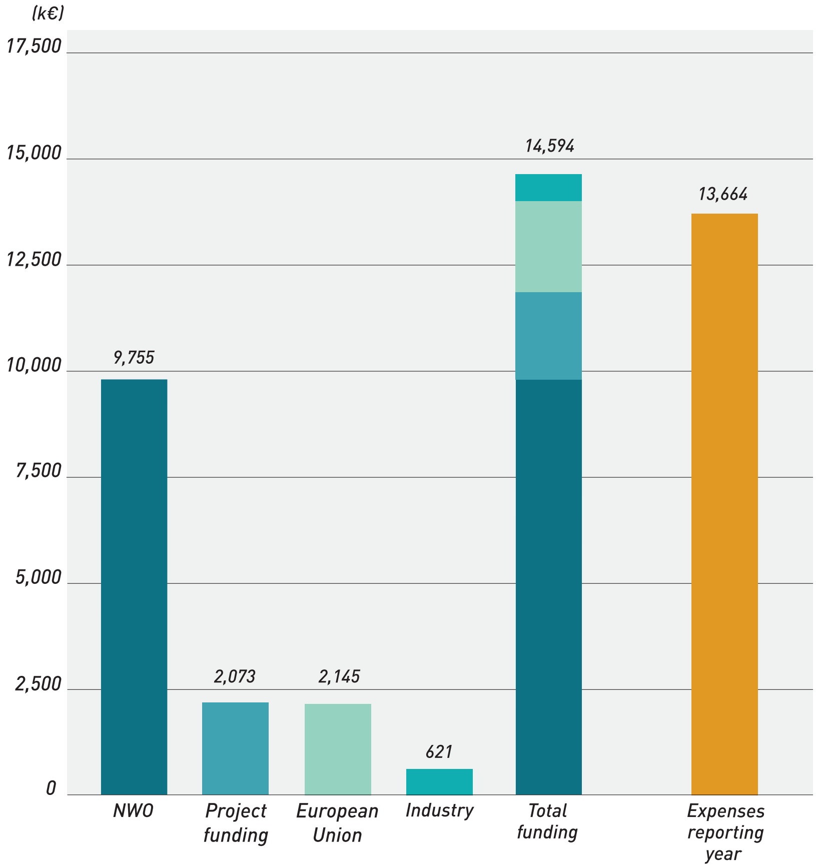
- Catalytic and Electrochemical Processes for Energy Applications – M. Tsampas
- Electrochemical Materials and Interfaces – A. Bieberle
- Materials and Surface Science – M.A. Gleeson
- Molecular Solar Energy (TU/e) – R. Janssen
- Nanomaterials for energy applications – A. Baldi
- Nonequilibrium Fuel Conversion – G.J. van Rooij
- Plasma Solar Fuels Devices – M.C.M van de Sanden a.i.
- Solar Fuels Facilities & Instrumentation – S. Welzel

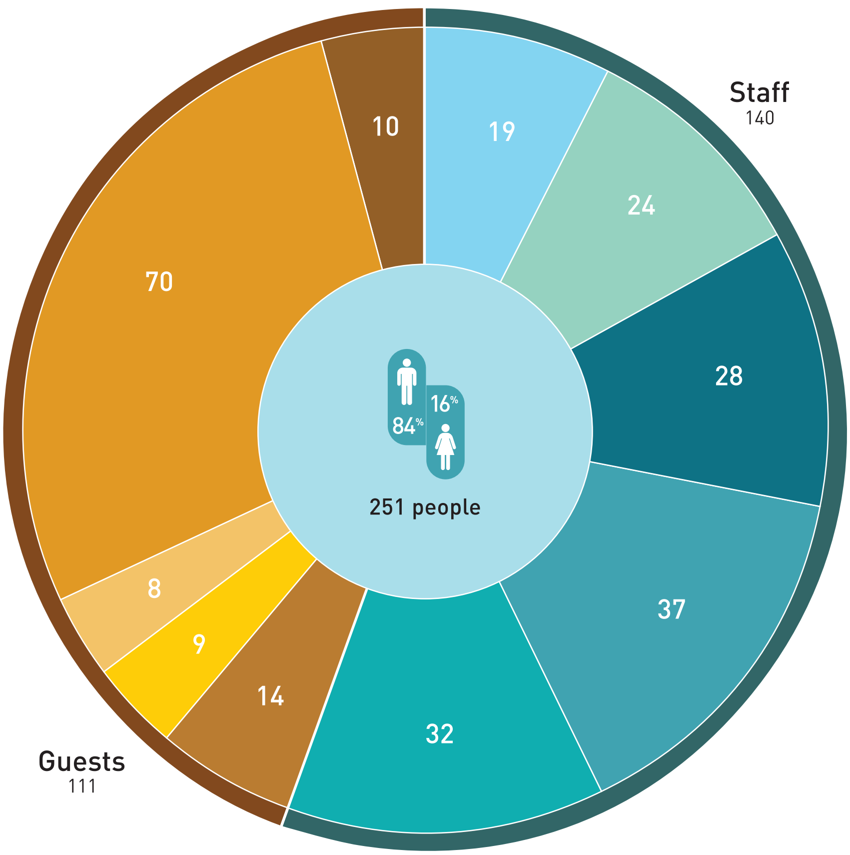
Institute manager
F. Senf

SUPPORT FACILITIES

- Communication – F.T.M.E. de Vries
- Electronics & ICT – F.J. van Amerongen
- Facility Management – J.E. Kragten
- Financial Administration – M.P.M. Schoonen
- Management Support – F. Senf
- Mechanical Techniques – F.J. van Amerongen
- Occupational Health & Safety – A.M.M. Arends
- Personnel & Organization – H. Tamsma
- Technical Service – K. Grootkarzijn

Funding and expenses 2019





People

DIFFER staff (20% women)

- Permanent science staff (18.8 ppy)
- Temporary science staff (21.1 ppy)
- PhD students (27.9 ppy)
- Technical support (35.4 ppy)
- Support staff (23.4 ppy)

Guests

- Senior scientists
- Postdocs
- PhD students
- BSc and MSc students
- Support staff

COMMITTEES

Management team
Richard van de Sanden, institute director, theme leader Solar Fuels
Freya Senf, institute manager
Marco de Baar, theme leader Fusion Energy

Scientific Advisory Committee
Henri Werij, chair (Delft University of Technology)
Clarisse Bourdelle (CEA)
Ursel Fantz (Augsburg University)
Roel van der Krol (Helmholtz Zentrum Berlin)
Two vacancies

Institute Advisory Committee
Paulien Herder (Delft University, NWO-TTW)
Kitty Nijmeijer (Eindhoven University of Technology)
Anne-Marie Spierings (D66, NB Provincial Executive)
Wim Sinke (ECN, University of Amsterdam)
Marco Waas (Nouryon/AkzoNobel)
Peter Snijder (NWO-I)

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Chidozie Onwudinanti, secretary
Frank van Amerongen, vice-secretary
Jonathan van den Berg
Qin Ong
Sander van Schaik

31-12-2019

Colophon

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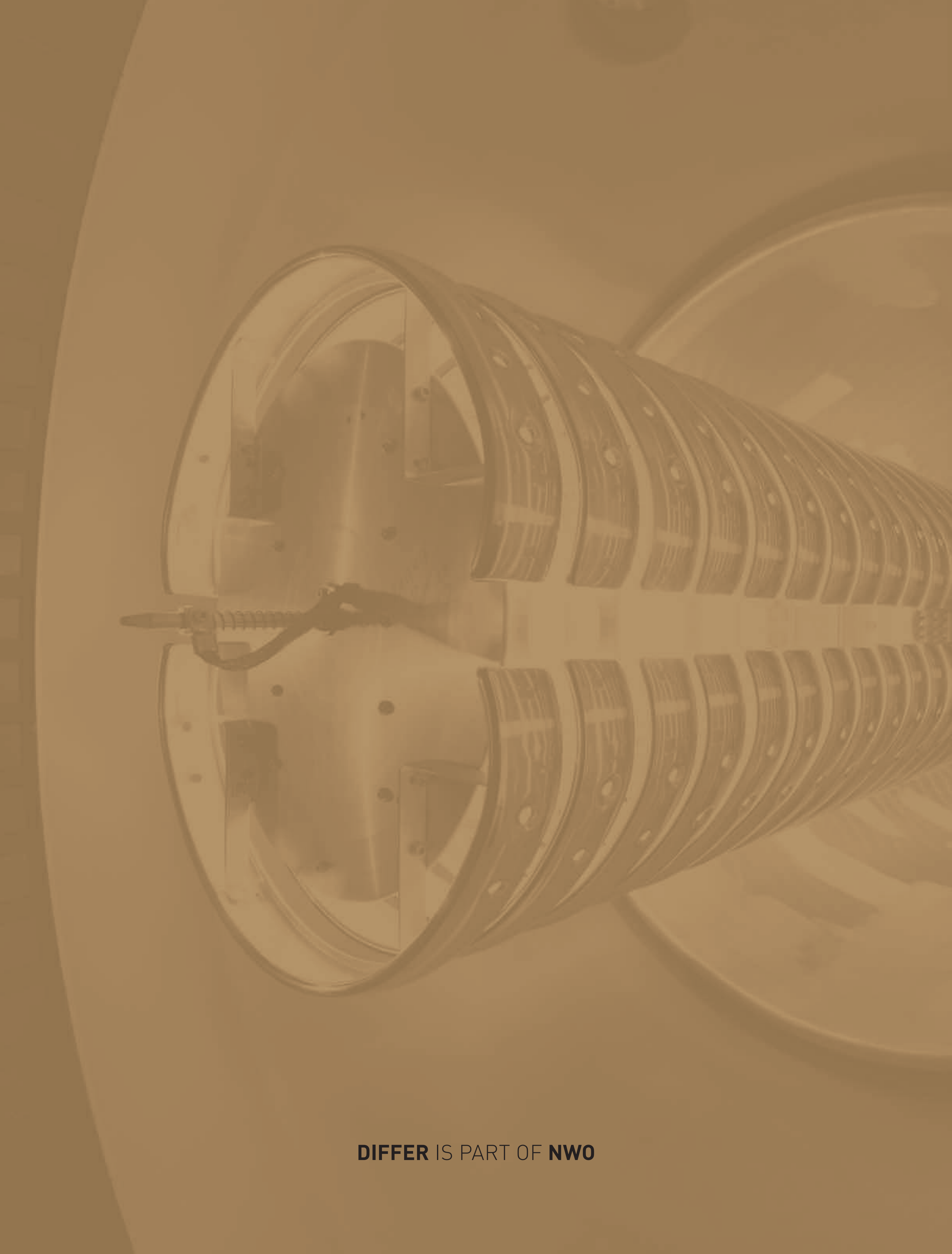

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