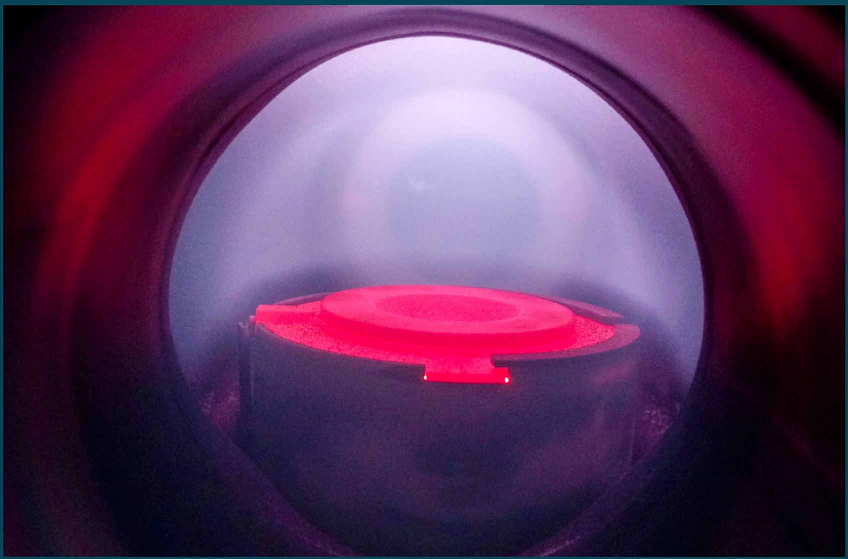
DIFFER ANNUAL REPORT 2020



COVER

A piece of calcium carbonate releases absorbed CO_2 into a water plasma (ionized gas), which helps the material retain its original structure.

DIFFER ANNUAL REPORT 2020

CONTENTS

The year 2020 was a special year for DIFFER. We can now reflect on the drastic measures we had to take in response to the Covid-19 pandemic.
The rapid developments forced us to close our institute within a fortnight after the first infection cases emerged in the Netherlands. The whole organization had to work from home, with hardly any time to prepare for the transition. Later we had to switch to hybrid forms, with limited attendance of key personnel only. These extreme measures, taxing as they may have been on our staff, have not been reflected in our scientific output.
I want to thank our staff for the flexibility they have shown. The resilience of the DIFFER staff in adapting to this situation is truly impressive.

2020 was also the year in which Richard van de Sanden completed his second term as director of the institute. During the 10 years of his leadership, Richard strategically repositioned the institute, initiated a completely new department for a new field of research, and realized the relocation. The institute moved to Eindhoven five years ago, and we have celebrated the first generation of PhD researchers that has fully carried-out and concluded their work at our new institute in Eindhoven.
We are happy that Richard remains connected to DIFFER as group leader, in addition to his directorship of the Eindhoven Institute for Renewable Energy Systems (EIRES). We celebrated his achievements in an online talkshow in November. I want to thank Richard for all the great work he did for our institute.

The development and operation of world leading research infrastructure is in DIFFER's DNA. In 2020, we decided to extend our facilities with unique equipment for the precise synthesis and in-situ and operando analysis of active materials for conversion and storage of renewable energy. This entails a major programme, that will take years to complete in close partnership with academia and private companies.

An accident in 2019 in one of our laboratories in December 2019 led to a broad investigation. The outcome was that the right procedures were in place, but that we needed to improve our safety culture. We started working on a more proactive safety culture; a culture in which every single person at DIFFER is actively responsible for safety.

This year, the DIFFER people showed optimism. They showed they care for each other. I am very proud of all of them.

May 2021,
Marco de Baar
Director DIFFER

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.

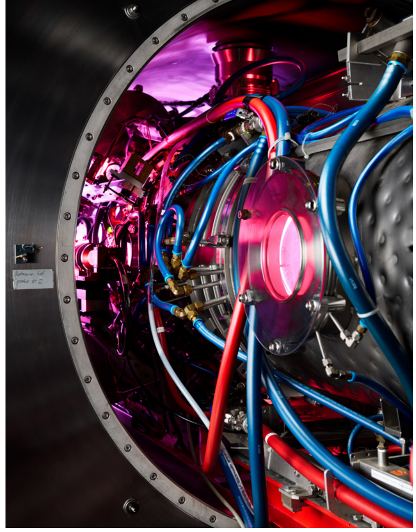
Energy is vital. Sustainable solutions are the future. Ensuring plentiful energy supplies is a societal challenge for this century. Energy sources, infrastructure, and usage must become sustainable, given the quickly evaporating carbon emission budget that must be zero by 2050. And all of this needs 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 important building blocks for a sustainable society: clean, safe, and inexhaustible energy from nuclear fusion, and conversion and storage of energy in fuels and chemicals. The institute provides larger research facilities to the national community.

2020 was a year of planned and unexpected organizational flexibility. Marco de Baar took over the directorship from Richard van de Sanden. Institute manager Freya Senf restructured the support facilities. DIFFER would like to strengthen its role by repositioning around larger-scale research user facilities. And then there was Covid-19, which drastically changed daily life for the institute. The scientific output, however, was still surprisingly steady.

The accident at a chemical lab at the end of 2019 in which an employee was injured led to a careful examination of DIFFER's safety culture. In consultation with its safety officers, Maikel Vennix and Henk Thuis, DIFFER decided to adopt a more proactive safety culture.

Opening up user facilities



Magnum-PSI

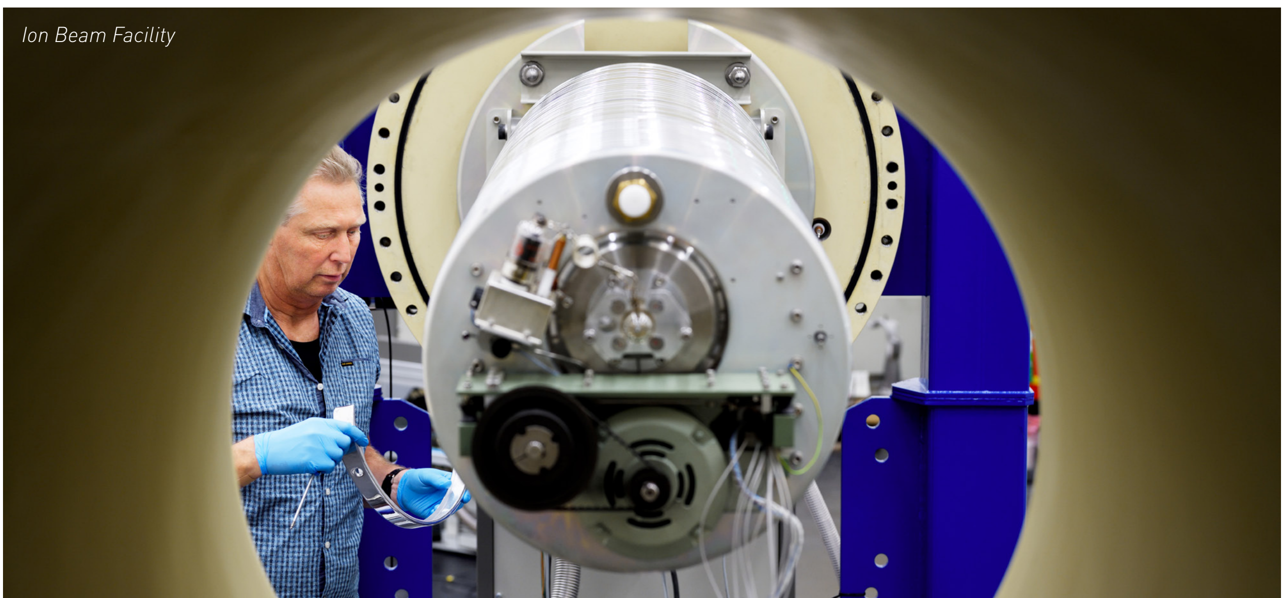
DIFFER wants to expand the user facilities for energy research: for its own research as well as national research into materials for energy applications. A taskforce is investigating which equipment is needed most.

Thanks to their permanent staff and good technical support, institutes can design, construct, operate and maintain larger research facilities. As a result of this, they can perform challenging experiments. "We see that we can play a distinguishing role in this area," says Marco de Baar, director of DIFFER. "If we build such large facilities anyway, we would not want to keep them to ourselves. We intend to design them in such a way that others will want to use them too."
That already happens with the plasma device Magnum-PSI, in which wall materials for future fusion reactors are tested under extreme conditions. The deployment of improved measurement equipment in 2020 has increased the possibilities of this user facility. Plasma-setup Upgraded Pilot-PSI (UPP) is nearing completion. This will also be a user facility connected to the Ion Beam Facility. UPP can be used to perform ion beam analysis during the extreme loading of the material. External parties can also use the Ion Beam Facility for materials research.

DIFFER would like to expand its user facilities so that materials research for energy applications can make further advances. In 2020, an internal taskforce was established, led by Anja Bieberle-Hütter, theme leader Solar Fuels. The workgroup will itemize what infrastructure is needed to propel its scientific themes. Furthermore, the Dutch research landscape is being taken into account because DIFFER wants to provide complementary facilities. "We see the need to build new, large-scale measuring equipment for research into materials required for the energy transition. That equipment can also be made available for other people in the field, also with a view to industrial applications. Furthermore, we want to design and develop this measuring equipment together with high-tech companies: a win-win situation," says Bieberle-Hütter as she summarizes the conclusions.

The workgroup reached a pre-selection of three medium to large sized devices: Pulsed Laser Deposition (PLD), environmental TEM and an X-ray facility. The feasibility is now being investigated. "We hope to be able to take the step from idea to concrete plan in 2021," says director De Baar.

Ion Beam Facility



A bumpy way up

Marco de Baar always knew that he would eventually hold a senior position in research. But he never thought this would be possible at DIFFER, the institute that he has called his home since 2007. Nevertheless, he is now DIFFER's scientific director, albeit in a challenging year.

It seemed to be an unwritten rule at DIFFER that directors always came from outside of nuclear fusion research. That way, they could bring fresh blood to the traditionally fusion-oriented institute. With the appointment of Marco de Baar, that rule has now been broken. De Baar is firmly rooted in fusion research, but no one can accuse him of having a narrow focus. His vision of where the institute should head to is crystal clear.

"Two fields are vitally important in the transition towards sustainable energy," says De Baar."They are materials science and system and control. I know that DIFFER can be a key facilitator in both these fields. In materials science, our next step into the future is acquiring some highly specialized larger-scale equipment, and inviting researchers from all Dutch universities to work with us. We already use the same model in fusion research, where we work together with guests on our Magnum-PSI, Upgraded Pilot-PSI, and Ion Beam Facility."

"It is not easy to combine all of this, but it needs to be done."

Besides materials science, the other breakthrough field in energy research is system and control, according to De Baar."This approach is already strongly developed in our fusion research. I want to unroll it in our solar fuels research too. The plan is to develop effective systems and control engineering methods that are interesting for science and relevant for industrial applications. If we succeed, DIFFER can become an even greater player in energy research at the national level than we already are, of that I am quite certain."

Dreadful Covid business

It must be quite challenging to lead the institute through major changes while most of the staff work from home. It is, confirms De Baar. "For one thing, I miss the coffee machine and all the natural everyday contacts it brings. Without these, it's hard to have an antenna for what's really going on at the institute. And, of course, all our meetings are online now, which is fine, as long as they are about the business at hand. But doing a brainstorm online is quite another matter. It's hard to stimulate people, hard to get wild ideas together."

"Oh well," sighs De Baar. "Let's hope there is an end to this dreadful Covid-19 business."

Despite being the director at DIFFER, De Baar still does his own research and teaches as a professor of control systems technology at Eindhoven University of Technology. "I want to avoid becoming an administrator pur sang," he says. "I think it's essential that, as a scientific director, I keep pushing back the limits of science myself. You have to know how your field is developing, what the bottlenecks are, and where breakthroughs can be expected. I'm not saying it's easy to combine all of this in one life. But it needs to be done."

TWEETS

DIFFER @DIFFERenergy
21 Jan 2020
Quiet at DIFFER today: we wish all the physicists of the Netherlands a great Veldhoven. Our colleagues Paola Diomede, Thomas Morgan and Richard van de Sanden will host sessions today and tomorrow on plasma and fusion physics and physics for energy. #DutchPhysics

Andrea Baldi @calippoebbira
24 Jan 2020
Congratulations Guus for an amazing bachelor project on #plasmon driven chemistry @DIFFERenergy 10/10

Marion Hinderdael @mhinderdael - *17 Feb 2020*
Today, on #warmjumperday @Brainport_ehv @TomvanderLee received @GroenLinksAnne at @DIFFERenergy and @TUeindhoven. With @VDL_Groep and @Nouryon. For a successful energy transition, technology is the key. Thank you all!

ITER @iterorg
3 Apr 2020
At #ITER workers have begun to remove the first segments of the bioshield's temporary lid in preparation for #fusionmachine assembly. Components will be lowered into the #tokamak pit through the top opening. #WeAreITER #fusionenergy #cleanenergy

iter
china eu india japan korea russia usa

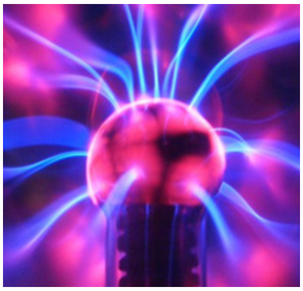
DIFFER @DIFFERenergy
9 April 2020
Now enjoying our first remote seminar: Beata Tyburska talks about all the cool research you could do with DIFFER's ion beam accelerator. Here's one case: mimicking the effect of cosmic rays on sensitive satellite electronics. differ.nl/news/projectleader-ion-beam-facility

Gieljan de Vries @gieljandevries - *9 Apr 2020*
Benefit of both working from home: getting called into your wife's astronomy meeting so you can explain where fusioneers plan to get their tritium fuel from. (Basically: create it on the spot by shooting fusion neutrons at modules filled with lithium)

DIFFER @DIFFERenergy
1 May 2020
DIFFER group leader Gerard van Rooij has been appointed professor of Plasma Chemistry at Maastricht University - congratulations Gerard! tinyurl.com/48j97bte

DIFFER @DIFFERenergy
14 May 2020
DIFFER group leader Andrea Baldi @calippoebbira has been appointed associate professor at Vrije Universiteit @VU_Science - congratulations on this exciting step!

Mustafa Amhaouch @MustafaAmhaouch - *10 Jul 2020*
As a technology-optimist, I went into hiding in #technology at @carbyon at @high-techcampus @Brainport_ehv. "Masterclass" on how to get #CO_2 out of the air! Beautiful innovative collaboration with @TNO_Research @TUeindhoven @DIFFERenergy @ASMLcompany @NTSGroupNL #cleanenergy #makeindustry out in the group of @calippoebbira at @DIFFER-energy and @UAmsterdam



IOP Publishing @IOPPublishing - *26 Sep 2020*
Researchers @DIFFER energy @TUeindhoven @HFML_FELIX modulate CO_2 #MicrowavePlasma to investigate gas heating dynamics and its relation to dissociation efficiency ow.ly/Gk4S50BgZam

DIFFER @DIFFERenergy
30 Nov 2020
An old-timer on e-fuel, how realistic is that? Richard van de Sanden spoke at the annual conference of @FehacF. Can be seen now, from minute 24 fehac.nl/fehac-congres-2020/

Ingrid van Engelshoven @ivanengelshoven
8 Dec 2020
Yesterday, a fascinating conversation with @DIFFERenergy about what is needed for #energy transition. @DIFFERenergy contributes to this through research into solar fuel and nuclear fusion energy, among other things. The social sciences and humanities are also essential in the transition.

Minister Ingrid van Engelshoven

Minister of Education, Culture and Science visits DIFFER

Minister of Education, Culture, and Science Ingrid van Engelshoven paid a visit to DIFFER in December. Due to Covid-19, this happened online. Earlier in the year, a delegation from the political party GroenLinks also came for a working visit.
Ingrid Van Engelshoven was given a virtual tour of the research themes Fusion Energy and Solar Fuels. The minister spoke to director Marco de Baar, institute manager Freya Senf, and head of Theme Solar Fuels Anja Bieberle-Hütter. The conversation included the research needed for a successful energy transition. De Baar: "It was a good, substantive conversation about how to organize research for the energy transition." The conversation also touched on the role of the national institutes in the research landscape.

In February, before Covid-19, a delegation from GroenLinks also paid a working visit to DIFFER and Eindhoven University of Technology. This was organized by Brainport. Tom van der Lee (Dutch House of Representatives) and Anne van Diemen (States Provincial) came to visit. The companies Nouryon and VDL and the Province of North Brabant were also present during the visit. The participants discussed how the government could accelerate the energy transition. The topics covered included large-scale generation of hydrogen, electrolyzers, CO_2 as a raw material for fuel and chemicals, batteries, and metal fuels.

Former director Richard van de Sanden emphasized that the energy transition should be seen as an opportunity for Dutch industry: "In this high-tech Brainport region, we are in the lead to develop the equipment needed for a sustainable energy supply."

GroenLinks delegation at DIFFER

Towards a more proactive safety culture

The accident of December 2019 in which an employee got injured, had a big impact on DIFFER and its perspective towards safety. DIFFER started working on further improving its safety culture with the aim to go from a reactive to proactive safety mindset.

An important conclusion of the accident investigation report was that the safety culture at DIFFER was mainly reactive: DIFFER was triggered to improve existing safety procedures on the basis of incidents. The accident marked the start of upgrading the DIFFER organization to a proactive safety culture in the next two years: an organization where safety is part of daily routine. In a proactive safety culture, everyone is involved in safety, not primarily the management and the safety coordinator.

Safety leadership

The first stage is working on structures and documents: identification and (re)assessment of the biggest risks, and a planned approach on how to prevent and control these risks. The second stage focusses on the involvement of all employees at DIFFER: to create the safety leadership and ownership at all levels that is needed to make safety as normal as doing research.

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. EUROfusion aims to have DEMO 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.

DIFFER is the Dutch beneficiary of EUROfusion. This research program, part of the EU Horizon2020 framework, was successful and ran until 2020. Some tasks were postponed to 2021, like the JET DT campaign for which DIFFER researchers are running simulations on the isotope mix and impurity transport. The EUROfusion consortium prepared a new work program within the EU Horizon Europe framework. DIFFER continues its work on plasma wall interaction and the divertor. It is also increasing its efforts to develop the essential control tasks for DEMO.

A novel instrument in the program is the Theory, Simulation, Verification and Validation (TSVV) tasks for code development. DIFFER will work on an integrated tokamak modeling suite. The new research group Plasma Micro-Turbulence (PMT) of MJ Pueschel will dive into plasma edge transport and the first principles prediction of turbulent transport in negative triangularity discharges. These have the potential of providing high-performance simulations of plasma discharges without edge instabilities, a requirement for reactor scenarios.

Machine learning speeds up modeling of nuclear fusion reactors

The use of machine learning is a trend in modeling the behaviour of plasma inside a fusion reactor. DIFFER researchers are pioneering very fast neural network models for plasma turbulence.

On the long road to commercial nuclear fusion energy, predicting the super-hot plasma's behavior inside the reactor is one of the crucial building blocks. This includes understanding the heating of the plasma, its magneto-hydrodynamic properties, and its turbulence.

For the turbulence part, Aaron Ho, Karel van de Plassche, and Jonathan Citrin achieved a considerable speed-up of the modeling time by using neural networks, a specific type of machine learning. Citrin, head of the Integrated Modeling and Transport group, predicts a great future for machine learning in fusion. "I expect that we will use neural network surrogates for all computational bottlenecks for which no other model reduction is feasible. My group is pioneering a neural network model for turbulence. This same technique could also be used for modeling additional physics components."

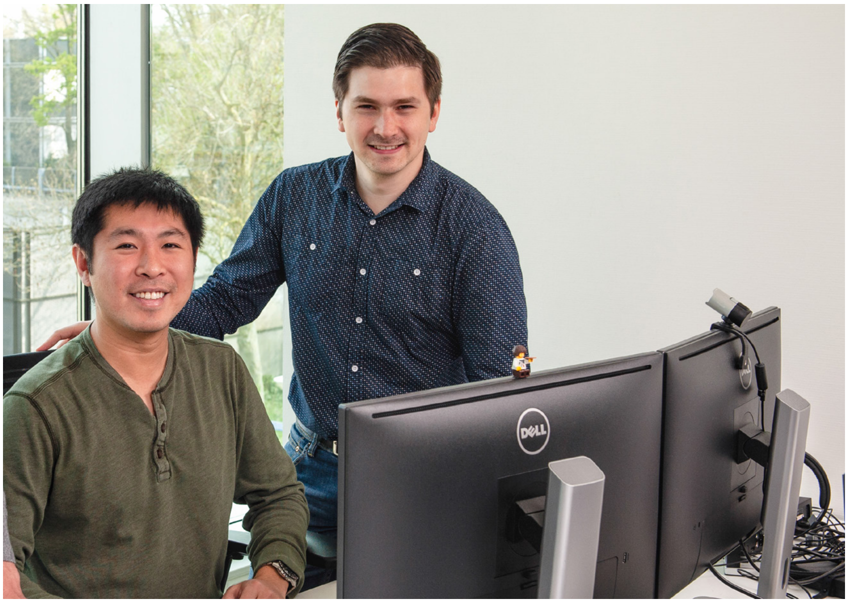
Physicists Karel van de Plassche and Aaron Ho both developed neural network models for plasma turbulence. They demonstrated that their neural network models could replace the currently used reduced-physics model.

Ho, who defended his PhD thesis in March 2021, built a model that was trained on data from the tokamak JET. It is 10,000 times faster than the original turbulence model and is no longer the bottleneck in reactor modeling, which has become 100 times faster.

Twelve orders faster

Van de Plassche developed a model that is slightly less accurate than Ho's, but can be used on various reactors, such as ITER. Van de Plassche: "We want to get close to a real-time simulation of the plasma, bridging twelve orders of magnitude in calculation speed when simulating the full physical equations."

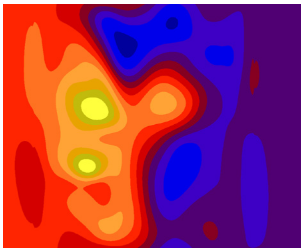
In 2021, a European project will start on the fully integrated modeling of the plasma. DIFFER will be part of this.



Researchers Aaron Ho (l) and Karel van de Plassche

Antimatter plasma surprisingly unstable

Plasmas consisting of electrons and positrons may exhibit a previously unexpected instability, which can have an impact on astrophysical and lab-based phenomena. DIFFER scientists investigated this exotic state of matter in an international team. Found mainly in energetic astrophysical settings and specially tailored experiments, electron-positron pair plasmas are generally thought to be stable under pressure gradients in homogeneous magnetic fields. M.J. Pueschel and his colleagues demonstrated through simulations that they can develop turbulence when physical conditions inject them into a magnetic field. They formulated a mathematically accessible fluid model that captures the instability dynamics. The results can be used in research on fusion relevant plasmas.



Electric fields in magnetic reconnection turbulence in space plasmas

Tin in fusion reactors

For any wall material in a fusion reactor it is important that little of the hydrogen isotope fuel is trapped within it but instead can be burned in the core. Tin is an attractive option for a liquid metal wall material, but little data existed about hydrogen trapping. To test this, PhD candidate Wei Ou and his colleagues exposed tin targets to a deuterium plasma in Nano-PSI and Magnum-PSI, to simulate the conditions in a fusion reactor. It was found that almost no deuterium is trapped in the tin itself, but instead the retention is dominated by gas frozen in small bubbles and cavities.

Stoking the fire with ice

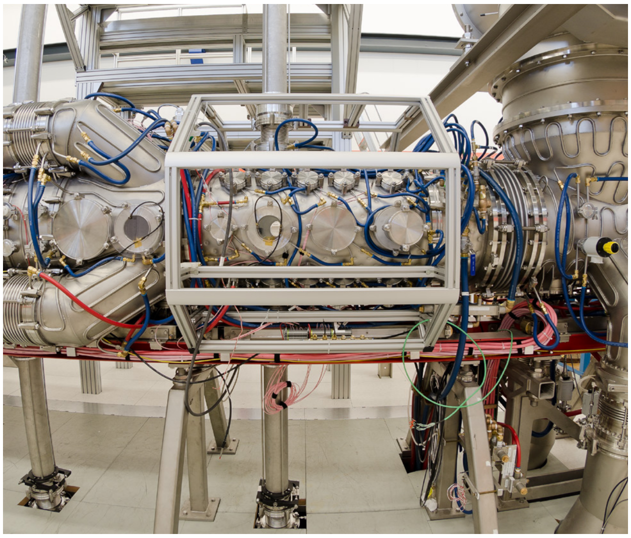
Future fusion reactors will be fueled by continuous injection of solid pellets of hydrogen ice. Accurate modeling of this process is crucial to obtain a feel for the fueling efficiency and fusion burn control.

In recent Joint European Torus (JET) experiments, deuterium pellets were injected into a hydrogen plasma. A rapid increase of deuterium was observed deep in the plasma core, faster than expected.

DIFFER's Integrated Modeling and Transport group, with researchers from JET and CEA, explained the phenomena using the reduced turbulent transport model QuaLiKiz, co-developed by CEA and DIFFER. Their modeling successfully reproduced the plasma temperatures and densities during the pellet injection cycle. The results are encouraging with regard to reactor fueling capability and burn control.

New diagnostics on Magnum-PSI

The linear plasma generator Magnum-PSI has acquired a new measurement method: Collective Thomson Scattering (CTS). This diagnostic is intended for measuring the plasma's flow rate and temperature. The equipment was built at DIFFER, originally for Pilot-PSI, Magnum's predecessor. It has been updated for use on Magnum-PSI. The CTS diagnostic is suited for research into the plasma-wall interaction, a hot topic in research into sustainable nuclear fusion reactors. The first measurements reveal that the plasma in Magnum flows more slowly than thought; this indicates a strong interaction between plasma and gas close to the wall. Based on such measurements, predictions for plasma-wall interactions in large machines such as ITER can also be refined.

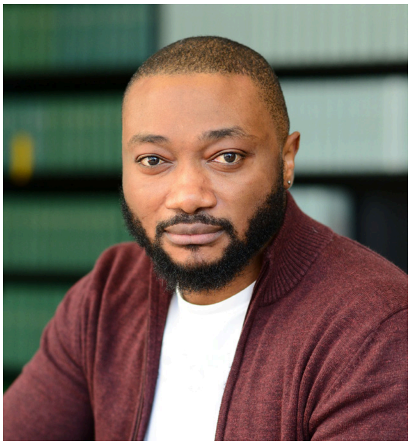


Magnum-PSI

Hotel Ruthenium: hydrogen checks in but never leaves

Hydrogen can form blisters in ruthenium mirrors for extreme ultraviolet (EUV) lithography machines. The blistering process is explained in the journal *Physical Chemistry Chemical Physics*. This M2i research project was done by Chidozie Onwudinanti and colleagues at DIFFER, Eindhoven University of Technology and University of Twente.

EUV machines are extraordinary pieces of technology, which sometimes run into problems when pushing the limits of what is physically possible. One such problem is the damage suffered by the EUV mirrors.
The light in the machines comes from a tin plasma. It is focused and directed by mirrors in near-vacuum. Mirrors topped with ruthenium direct the light, and hydrogen gas acts as a buffer and cleaning agent for the mirrors. This otherwise perfect dance is ruined by the formation of blisters, high-pressure pockets of hydrogen, when tin debris lands on the mirrors. Chidozie Onwudinanti: "Hydrogen solubility in ruthenium is low. So we faced the question: how do so many hydrogen atoms get through the ruthenium layer to form blisters? Calculations revealed that the layer of tin contamination on top of the mirrors acts like a valve. "It lets hydrogen into the underlying ruthenium, but blocks it from leaving. We found a similar surface-blocking effect in different experiments with hydrogen permeation through metals."



Researcher Chidozie Onwudinanti

Compensation magnet straightens ion beam

With the Magnum-PSI plasma device, measurements can now be done that were not possible before. The magnetic field of Magnum-PSI can now be better compensated. Therefore the amount of hydrogen the wall components of a fusion reactor 'swallow up', can be determined with greater accuracy.

DIFFER researchers have been using the ion beam facility to perform Nuclear Reaction Analysis (NRA) on the Magnum-PSI device for several years. With the NRA technique one can find out how much hydrogen is retained by wall materials of fusion reactors. "That knowledge is important to be able to run a fusion reactor like ITER properly," says Hennie van der Meiden, deputy project leader at EUROfusion. The problem was, however, that NRA could previously only be used when the magnetic fields of Magnum-PSI were low. At high field strengths, the magnetic field disrupted the NRA ion beam too much. As the process of switching off the large Magnum magnet takes time, the samples could only be measured after the experiments. By then, part of the hydrogen had already disappeared from the metal.
With a 'compensation magnet', which ensures that the ion beam arrives at the right place, this problem can be solved. The magnet had already been part of the setup for some time, but the control gave problems.
Now that those issues have been resolved, the sample can be measured with NRA immediately after having been exposed to the Magnum-PSI plasma.

A big step forward, according to Van der Meiden. It also makes it easier to compare the results with the LIBS measurement method - Laser-Induced Breakdown Spectroscopy.
Van der Meiden: "By combining both techniques, we know more precisely how much hydrogen is stored by the plasma in reactor wall materials."

Hora est! Artur Perek

Artur Perek built the MANTIS camera, rewrote the software, and contributed to solving the difficult problem of divertor detachment: cooling plasma before it hits the tokamak wall. Perek loved every inch of his PhD.

"My PhD involved solving problem after problem. Luckily, I really enjoy solving problems." Perek worked on the MANTIS camera system that monitors the plasma within a fusion reactor. It helps controllers to make sure that the plasma that ends up at the exhaust - the divertor - is not too hot. "When I started my PhD, the components of the camera were ordered and piling up. My goal was to build it, install it on the Swiss TCV tokamak of EPFL, and enable its use for control."

"I really enjoy solving problems."

Hacking the software

The MANTIS camera was of a high quality, but the software that came with it was not designed to match this performance. "We analyze the plasma 800 times per second. The software turned out to be too slow, so I decided to improve it. "It became Perek's most challenging and successful project. He had to go down to the most essential bits and bytes. He built an exploit (a piece of code) that bypassed the original software and improved the stability to microseconds. He sent the new software to the camera manufacturer. They acknowledged the quality and offered him a job. He declined, preferring to work in research instead.

More work to do

The MANTIS camera is installed on the TCV tokamak. Perek developed an analysis to obtain plasma densities and temperatures from the images. These reveal the temperature at the divertor and allow the operators to control that temperature. Recently, a full control system earned the researchers a *Nature Communications* paper.

Perek expects to defend his PhD thesis in fall 2021. He might apply for a job on the follow-up project at DIFFER and EPFL: "MANTIS actually has ten cameras, not just the one we use. Using them all would drastically improve detachment control, but it requires far faster models."

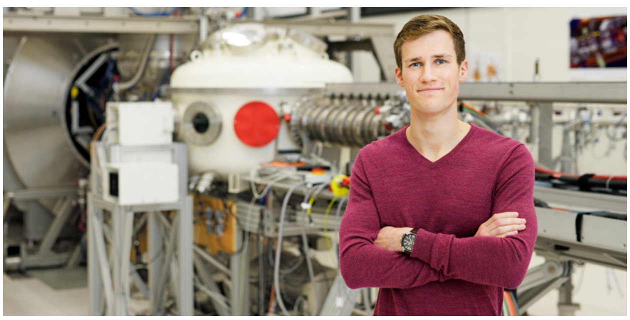
Another unsolved problem to go. Perek likes it.

MJ Pueschel leads new Plasma turbulence group

In September 2020, MJ Pueschel started the research group Plasma Micro-Turbulence. He brings unique theoretical expertise on plasma micro-turbulence simulations to DIFFER. "Without instability and turbulence, the fusion pioneers' optimism would have been justified and we would have an abundance of clean fusion energy by now", says Pueschel to point out the importance of his field. He is an expert on GENE, a model for plasma perturbation processes. The results help experimentalists to keep the plasma better confined, for less heat loss and more fusion efficiency. The trick is to simplify the simulations and speed them up.

Tijs Wijkamp awarded KHMW Prize

Tijs Wijkamp won the Shell Graduation Award for Physics 2020 for the master project he carried out at DIFFER. The award is one of the annual Young Talent Awards from the Royal Holland Society of Sciences and Humanities (KHWM), and the winner receives a sum of 3,000 Euro. During his master project, Wijkamp demonstrated that an existing optical measurement system, MANTIS, was suitable for observing superfast 'runaway' electrons in a fusion reactor's plasma. For commercial fusion, these electrons need to be dealt with properly. Wijkamp is now doing doctoral research at DIFFER and Eindhoven University of Technology in the same field.



Beata Tyburska member Euratom STC

Beata Tyburska-Pueschel, project leader of DIFFER's Ion Beam Facility, has been appointed as a member of the Euratom Scientific and Technical Committee (STC).
This committee provides the European Council with advice on all nuclear-related research and training in the EU. The European Council appoints the 42 members following their nomination by the Member States.
The STC advises on all aspects of nuclear technology, such as radiation protection standards, nuclear fission reactor systems, waste management, and fusion. Within the STC, Tyburska-Pueschel will join two subcommittees on Fusion and Nuclear Knowledge and on Skills and Competences.

Hans van Eck on NBTF Advisory Committee

Hans van Eck, head of the Fusion Facilities & Instrumentation group, was selected as EUROfusion representative to the Neutral Beam Test Facility (NBTF) Advisory Committee for three years. ITER's most powerful external heating system, neutral beam injection, will be tested at the NBTF in Padova, Italy. It will offer scientists the possibility to investigate challenging physics and technology issues before the system is installed on ITER.
The Committee reviews and advises on science and technology aspects as well as the planning and efficiency of the project.
Van Eck was selected due to his experience on large technological projects.

Always in motion

Egbert Westerhof started out at DIFFER in 1983 as a PhD student. He saw the institute evolve from an exclusively fusion-focused 'family' inhabiting a medieval castle to a more business-like community committed to fundamental energy research and situated on a modern university campus. As interim head of fusion research, Westerhof is now preparing the next round of evolutions.

Fusion research at DIFFER is currently in excellent health, says Egbert Westerhof. "We are working towards the first international plasma experiments in the large ITER tokamak in the South of France.These are planned to start in 2025. Hopefully, they will demonstrate that it is technically feasible to keep a plasma stable for a sufficient length of time and to extract energy from it."

But fusion research never stands still, and members of its community continuously look towards new horizons. After ITER, the next phase in fusion research will be a demonstration power station, at an even larger scale than the experimental ITER tokamak. This offers new scientific challenges, says Westerhof."The wall of the reactor will have to withstand even bigger forces from the plasma, for instance. A solid metal with a high melting point, like tungsten, may not be strong enough. That is why together with Eindhoven University of Technology we developed plans for a new experimental facility: LiMeS. In this program, we would like to experiment with both tungsten and liquid metals to contain the plasma. The fluidity may prove an effective and elegant solution, since in a fluid state the metal renews itself automatically, which makes it more resilient."

"Not only the research facilities make us popular, people just like to work with us."

Bridges to be built

Now that Westerhof leads the fusion research theme at DIFFER, he feels responsible for recruiting researchers from fresh disciplines into the field. "When we start working on the DEMO reactor, we will need not only fusion physicists, but system engineers, industrial design engineers, electrical engineers, nuclear scientists, and innovation scientists as well. DIFFER is the Dutch port of entry for international fusion research, so it is my ambition to build some bridges. Both parties can profit: our field offers opportunities for challenging, interesting,and meaningful research to Dutch groups. On the other hand, the Netherlands harbors a lot of talent that fusion can capitalize on."

As a veteran at DIFFER, does Westerhof ever get homesick for that other era, when the institute was still located in a more isolated but beautiful spot, the estate of Rijnhuizen Castle? His answer is a resolute "no". "That was also a good time; we were almost a family then. But it was inevitable for us to move in a more business-like direction. We have now a more international staff, and people from all over Europe come to us. Not only for our unique research facilities, but also because of the excellent reputation of our staff.
The relocation to Eindhoven has also brought us a lot: many more students on the work floor and shared research programs with the university, like the new LiMeS project. We just got the news we receive a NWO Investment Grant Large to build it [in January 21, Ed.], that is great news."

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, using both experimental and modeling approaches.

2020 was a productive year for the Solar Fuels groups. One outcome was six successful PhD defenses. The research focus on combining electrochemistry with plasmas on the one hand and control on the other resulted in high-level research publications and is connecting the expertise of several DIFFER groups.

The Solar Fuels research and expertise finds its way into (inter) national consortia and initiatives. DIFFER is coordinating and taking part in several European projects like KEROGREEN, MuMo4PEC, and Sun-to-X. The researchers also play an agenda-setting role in European Joint Programs (AMPEA, Energy for Digitalization) and EU COST actions to foster and fund scientific collaboration.

DIFFER would like to further improve Dutch energy research by developing a large-scale research infrastructure as a user facility. The institute sees opportunities to realize user facilities to address physical and chemical interactions at material interfaces and in the bulk. A particular challenge is to do this under relevant operating conditions of the energy devices. DIFFER envisions a pulsed laser deposition tool, an environmental transmission electron microscope, and/or a high-brilliance, tunable X-ray facility in synergy with its present PSI facilities (Magnum-PSI and Pilot-PSI Upgrade) and the Ion Beam Facility.

All-electric green ammonia production

DIFFER researchers found an alternative sustainable, all-electric way to produce ammonia from nitrogen and water. Ammonia is an important precursor of fertilizers, as well as a potential carbon-free energy carrier. The researchers published this method in the journal *ACS Energy Letters*.

Nowadays, ammonia is synthesized via the Haber-Bosch process, a capital- and energy intensive process with an immense CO_2 footprint. Alternative processes for sustainable and decentralized ammonia production from N_2 and H_2O using renewable electricity are therefore needed.

However, the N_2 molecule is thermodynamically stable, and the triple bond holding the two nitrogen atoms together is one of the strongest known. Therefore, the key challenge is the efficient activation of the N_2 bond. DIFFER group leader Mihalis Tsampas: "What makes our approach groundbreaking is that we use plasma activation to boost the nitrogen reactivity and an electrolyzer to provide the hydrogen species for the reaction."

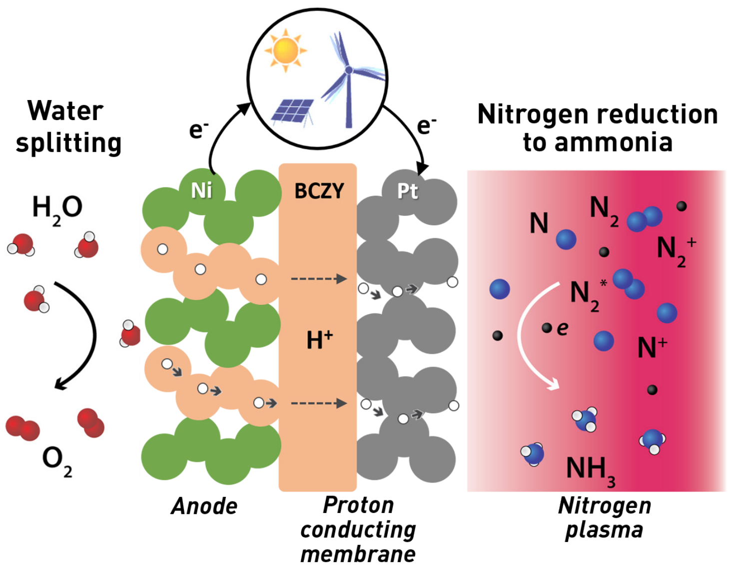
Plasma aided electrochemical approach

The researchers found an all-electric method for ammonia production, using a plasma-assisted electrochemical approach: a plasma-activated proton-conducting solid oxide electrolyzer. The plasma basically serves as a means to activate the nitrogen just before it encounters the hydrogen species generated by the electrolyzer.

Researcher Rakesh Sharma: "We have effectively demonstrated NH_3 synthesis by allowing this activated nitrogen to react with the hydrogen species from the water splitting." The production rate of this method is higher than for similar approaches, but the productivity and energy efficiency are not yet up to the mark for commercial application. Sharma and his colleagues would like to further improve the performance. Future research will focus on finding a suitable electrocatalyst that can efficiently utilize the plasma-activated nitrogen.

Food production

Ammonia is a valuable material. Fertilizers produced from ammonia are important for food production. Ammonia is also a potential fuel source. Sharma: "That's why it is so important to work on sustainable ways of producing it."



Ammonia production overview

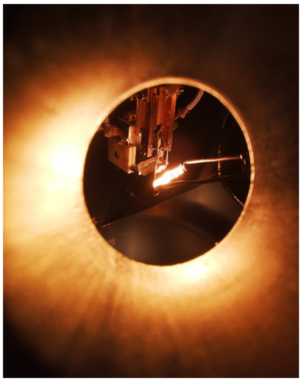
Capturing CO_2 with thin films

To mitigate global warming, we will need to recapture CO_2 from emissions we cannot prevent. DIFFER is joining forces with Carbyon and Eindhoven University of Technology to further develop Carbyon's innovative system to capture CO_2 from the atmosphere.

The Eindhoven Engine initiative supports a research project to develop commercially viable technology for direct air capture of the greenhouse gas. The Direct Air Capture system developed by the Dutch start-up Carbyon uses ultra-porous, thin films with a huge internal surface to capture CO_2. Mike Gleeson: "At DIFFER, we will try to maximize the energy efficiency of releasing CO_2 from the capturing material."

Syngaschem cobalt surface

The worldwide production of synthetic hydrocarbons relies heavily on the Fischer-Tropsch process, but the basic steps in the formation of the carbon chains remain elusive. Scientists working at Syngaschem and DIFFER used advanced spectroscopic studies to understand what happens at the surface of the catalyst. Kees-Jan Weststrate from research company Syngaschem:



Detail of the synchrotron

"Creating a more selective process, in which only hydrocarbons of the desired length are produced, requires a deeper understanding. We clarified that CO spectators promoted the formation of carbon-carbon bonds and determined what the ideal intermediate carbon species is for further chain growth. "The researchers published their results in *Nature Communications*.

XS grants for bright ideas

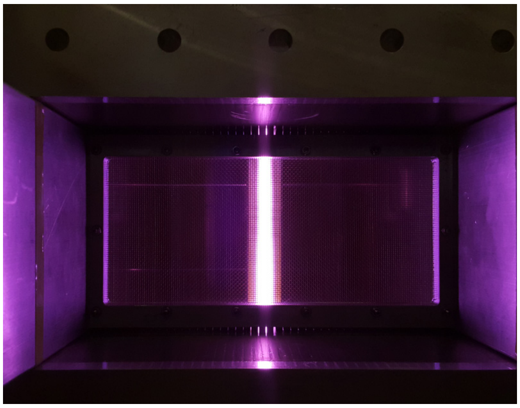
NWO XS grants are intended to support promising ideas. The research has to be groundbreaking and high-risk. The Solar Fuels theme acquired two of these grants in 2020. Edwin Devid (top photo) received an NWO XS grant to convert an induction based

Edwin Devid

lamp into a cheap, efficient chemical reactor that will convert gasses (air, H_2O, CO_2) into basic chemicals (NO, H_2, CO). Hopefully, the reactor will provide major benefits for the production of synthetic fuels and high-value chemicals. Floran Peeters and Richard van de Sanden received a grant for a novel plasma-aided electrochemical reactor concept to cost-effectively convert small, common molecules into useful building blocks for the production of materials, chemicals, and synthetic fuels. Peeters: "We merge two developing electrochemical technologies."

First plasma in KEROGREEN project

KEROGREEN is a European project on producing green kerosene. The goal is to build a container size production unit. DIFFER developed a 6 kW labreactor to provide experimental data for the project. The DIFFER researchers are working on a container-sized plasmolysis module as well. Stefan Welzel, member of the KEROGREEN team at DIFFER: "This thrilling project translates results from fundamental research on individual aspects and building blocks of the energy transition into a container-sized plant." Project partners across Europe will deliver modules for the plant; they will be combined at Karlsruhe Institute of Technology (KIT). At DIFFER, the construction of the plasmolysis module for the production unit is ongoing; this module will be ready in 2021.



Argon plasma in newly built 6 kW labreactor

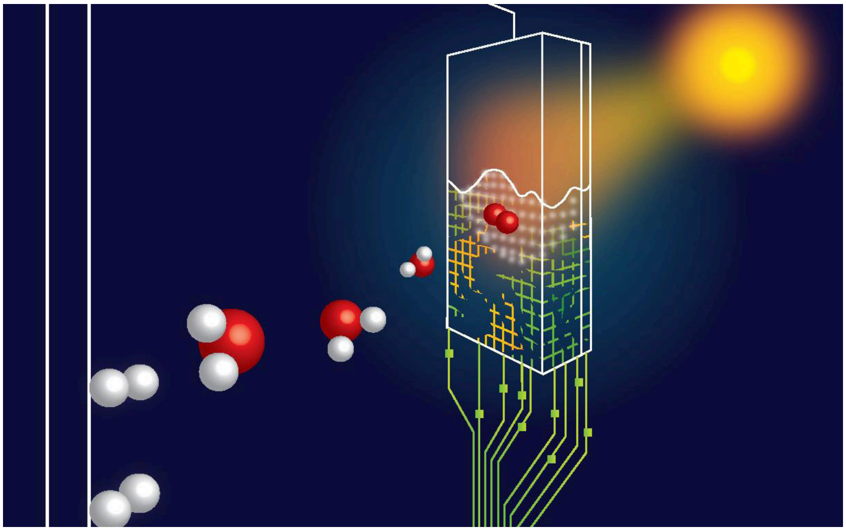


Photo-electrochemical water splitting: illustrative sketch of the new modeling approach for identifying the limiting processes at photoelectrodes

Model what you cannot measure

Improving photoelectrochemical cells requires a detailed understanding of everything that happens at the electrode-electrolyte interface. However, our current knowledge of this is limited. In an *ACS Catalysis* paper, the Bieberle-group therefore developed a novel modeling approach and used it to interpret data from their experimental colleagues.

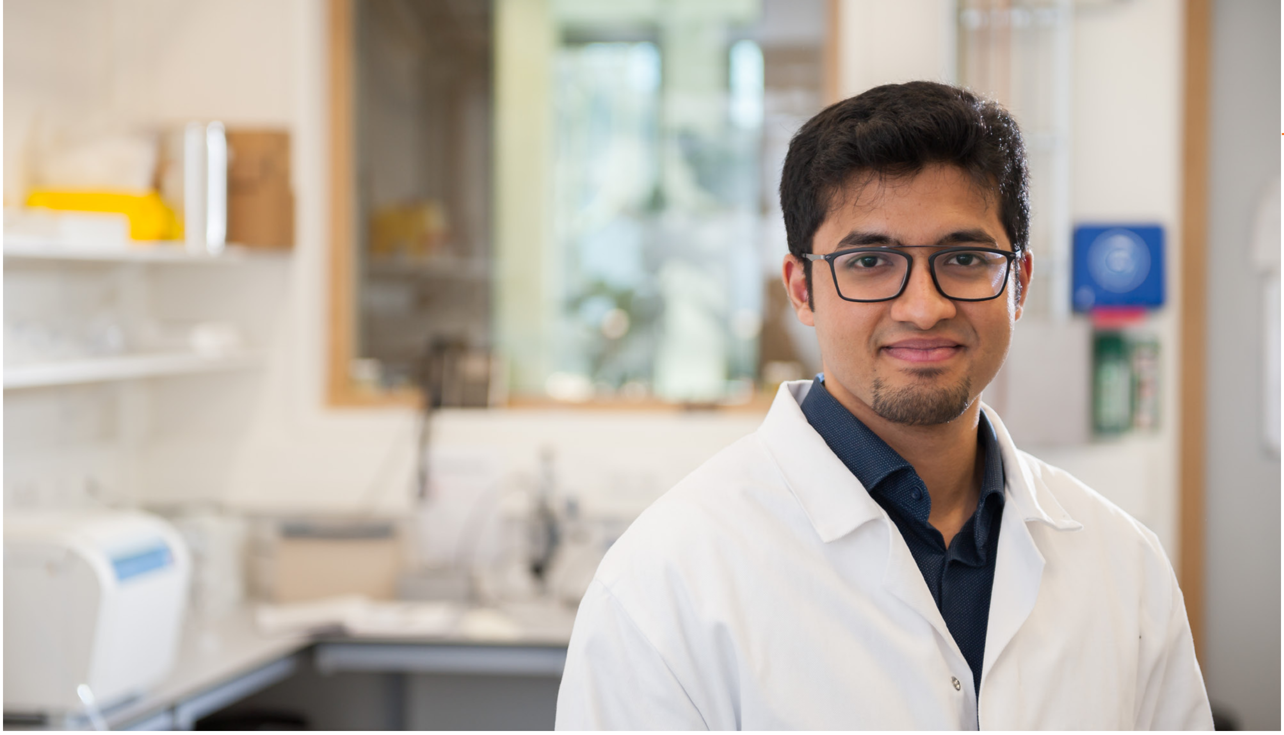
Anja Bieberle-Hütter, group leader Electrochemical Materials and Interfaces: "Photo-electrochemical cells convert water into hydrogen. However, important material issues remain, and we don't yet know what the limiting mechanisms for the performance are. Therefore, we don't know what the best material for the electrodes is."
A particular bottleneck is the formation of oxygen at the photoanode. "Experimental evidence showed that two surface effects are involved," says first author Kiran George. "These effects are extremely difficult to measure and to separate. Which effect is limiting the performance? So, we set out to model and simulate what we cannot measure."

Important step forward

With the novel modeling approach, the two surface effects and their impact on the performance can be investigated separately, which is an important step forward. George: "With our models, experimentalists can now better understand what is happening in their system."
Besides gaining a deeper understanding, Bieberle points to the possibility of a more rational choice for the material when the generic model is transferred to other materials.

Zinc removes CO_2 from flue gas

Can CO_2 be filtered faster and in larger quantities from the flue gas of power stations and factories? Tesfaye Belete, Michael Gleeson, and Richard van de Sanden discovered how they can give the CO_2 capture material a boost by adding a touch of zinc. The modified material captures up to 1.5 times as much CO_2, they write in the journal *Sustainable Materials and Technologies*.
The work is good news for the CO_2 capture from concentrated industrial emissions. 'Calcium looping' is a commonly used CO_2 capture process. It involves a material cycle in which calcium oxide absorbs CO_2 to form calcium carbonate, from which the CO_2 is subsequently released. Unfortunately, CO_2 is slow to penetrate into the bulk of the material. In addition, the uptake capacity decreases with repeated cycling.
The performance of the calcium looping needs to be improved in order to keep costs down. Belete, Gleeson and Van de Sanden did that by adding low concentrations of metals such as zinc, copper, iron, cobalt, and nickel to calcium carbonate. Doping calcium oxide with zinc had a fantastic effect on the subsequent uptake and uptake rate of CO_2 during cycling. "In our best sample, we saw up to 50% more carbon dioxide being absorbed, and the uptake was up to 12 times faster," says Gleeson. Furthermore, it seems that the variant with zinc incurs the least damage during use.



Hora est! Rifat Kamarudheen

When Rifat Kamarudheen was in high school in Kerala, India, it was predicted that nanotechnology would change the world. He wanted to be part of this. In July 2020, he defended his PhD thesis on illuminated nanoparticles. Kamarudheen now works at EPFL, Switzerland, on a similar topic.

When he arrived at DIFFER, Kamarudheen found an empty lab: "My supervisor Andrea Baldi had just started his research at DIFFER. I felt lucky and was eager to learn how to organize a new lab and how to set up a research group."

Plasmon-driven chemistry

The grand idea behind Kamarudheen's research is to use a phenomenon called localized surface plasmon resonances to drive chemical reactions, for example to reduce CO_2 as an important step in making sustainable chemicals. These plasmons arise when nanoparticles of gold, silver, and copper are illuminated. But there is still a lot of controversy surrounding the activation mechanism of plasmon-driven chemistry. No one knows exactly what happens after the nanoparticles are illuminated: they may scatter light to generate electromagnetic hotspots on their surface, release hot charge carriers like electrons, or heat up the nanoparticle in a photothermal process. Often, all these processes occur simultaneously and at timescales less than a few nanoseconds, which makes it challenging to distinguish the contributions of each process. "My aim was to quantify these different phenomena. It is important to know the mechanism of the reaction you are studying."

"I was playing with LEGO at the nanoscale level."

Green gold turning orange

His favorite chapter of his thesis is the last one, where he was able to control the growth of an individual nanoparticle. "These experiments were amazing. I could see the individual nanoparticles under an optical microscope. For example, gold nanoparticles would look like green dots, and after performing a chemical reaction, I would see them turn orange or yellow." He was often in a dark room alone, but he was enjoying every minute of it. "What amazed me most was that I was able to precisely control chemical reactions to assemble hierarchical structures at a nanoscale level. I was playing with LEGO at the nanoscale level."

Horizon 2020 projects on green fuels

DIFFER Solar Fuels research groups participate in three major Horizon 2020 projects: KEROGREEN, Sun-To-X and ORACLE. All three projects contribute to the European Commission's targets for clean energy for all and a circular economy.

Sun-To-X is a project on green fuels, it had its kick off in September 2020. Goal of the project is developing a system for the conversion of solar energy into storable chemical fuel. This fuel could then be used in the energy and transport sectors. The project is coordinated by Toyota Motor Europe. DIFFER will work on the membrane photoelectrode assemblies and lab- scale prototype operation for converting light and humidity of ambient air to hydrogen.

KEROGREEN is a running project on synthesizing green kerosene from air and water. DIFFER coordinates this four-year project with research partners KIT and VITO and SME's Cerpotech, HyGear and INERATEC. The project enters its final phase of system integration, building a container size test module for decentralized fuel production.

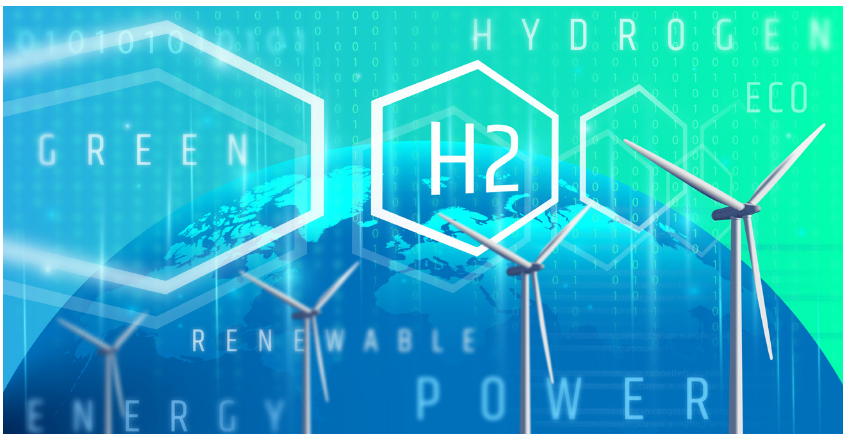
ORACLE is a new Horizon 2020 project, funded in December 2020. This project is on the development of scalable reactor technologies for decentralized production of ammonia. Ammonia can serve as a carbon-free renewable fuel - synthesized from air and water, powered by renewable electricity. Three strands of ammonia synthesis will be developed and validated.
The three-year project will be carried out by Aarhus University, DIFFER, VITO and Jožef Stefan Institute, with SMEs Casale and C2CAT, in international collaboration with Japanese research centers AIST and ORIST.

Green hydrogen generation

The SCALE consortium headed by DIFFER will investigate a new approach to generate green hydrogen.

Water electrolysis can produce green hydrogen by using renewable energy to split water. Group leader Mihalis Tsampas: "Existing electrolysis technologies have drawbacks. They use either scarce and expensive materials or have limited compatibility with renewables." Anion exchange membrane (AEM) electrolyzer sare a promising alternative, but fundamental questions remain about the materials, electrode design, and scale-up. "SCALE will investigate these systems. Within DIFFER, we focus on the design and novel electrode architectures and prototypes."

SCALE partners are DIFFER, Eindhoven University of Technology, Fontys University of Applied Sciences, ISPT, Syngaschem BV, VSPARTICLE, Veco Precision, Toyota Motor Europe and FORTH institute. The project is funded through the Dutch Research Agenda program Electrochemical Conversion and Materials.



"I like to look at the bigger picture"

We have free sunlight every day, but still we dig in the ground for oil and gas to provide us with energy. That has always intrigued Anja Bieberle-Hütter. As interim head of DIFFER's solar fuels research theme, she is determined to help solving the paradox.

During her career as a solar fuels researcher, Bieberle has seen the political climate become more responsive to the urgency of climate problems.

This is important, she says, since there is undeniably a political dimension to the adoption of sustainable energy technologies. "If politics would decide that we really have to move away from fossil fuels right now, this would give a boost to some technologies. Fuel cells, for instance, are in principle ready to use, even though they are not as cheap, stable, and efficient as we would like them to be." Bieberle worked in fuel cells research for over fifteen years, but now she finds her challenge in less mature energy systems, such as photoelectrochemical water splitting. She is "cautiously optimistic" that many of our present political leaders see the need for developing different parallel clean energy solutions.

Bieberle is group leader Electrochemical Materials and Interfaces, but she also likes to look at the bigger picture. The role of interim theme leader is cut out for her, especially during such an exciting time when DIFFER wants to focus more on its role as a national institute in both solar fuels and fusion research."After working with small-scale setups for several years, we now want to acquire some highly specialized, large-scale equipment that will make us an attractive partner," Bieberle explains.

Three pieces of equipment have been identified so far: a processing tool for complex metal oxide thin films, a high-resolution microscope for the characterization of surfaces during operation, and an X-ray facility that could fill the gap between lab tools and synchrotrons. "Together, these instruments will really serve the larger community that is looking for high-performance materials for clean energy. They will also enable DIFFER researchers to keep doing top science in the long-term, together with our EXTERNAL partners."

"That we are such a closely knitted research community is a big advantage."

Still work to be done

Seven years ago, when Bieberle was at international conferences,she always had to explain to everyone what DIFFER was. "I had to tell the whole story. That has since changed. I am also frequently asked to join national committees, another sign that we enjoy a growing reputation. But this upward trend has to continue; there is still work to be done. I believe that DIFFER has some unique qualities, particularly our coherence as a closely knitted research community where various groups do totally different science while using similar tools. For example, I am now cooperating in DIFFER with a fusion group, borrowing their control theory to study electrochemical surfaces, which is entirely new. We have a big advantage there that we can exploit. It will help us to continue to grow and become a respected player at the national level."

Celebration director Richard van de Sanden

Photo left: table partner Wim van Saarloos. Middle: Richard van de Sanden with his spouse, and at right with host Monique Ooms

DIFFER organized an online event to thank former director Richard van de Sanden for giving ten years of guidance to the institute. In July 2020, Van de Sanden handed over the symbolic key of the institute to his successor Marco de Baar (see page 7). In November, it was time to commemorate and celebrate Van de Sanden's directorship with his colleagues and network. With his visionary and personal guidance, Van de Sanden was DIFFER's director from 2010 to 2020. He strategically repositioned the institute and its research, and started the research theme Solar Fuels. He realized the relocation of the institute from Nieuwegein to Eindhoven.
The online event was centered around an informal talk show, filmed at DIFFER. Former FOM director Wim van Saarloos, fusion expert Clarisse Bourdelle, and solar fuels expert Roel van der Krol joined as special guests. Maarten Steinbuch of Eindhoven University of Technology (TU/e) shared his memories in a farewell speech, and the DIFFER singers honored Van de Sanden with a personalized version of the song 'I did it my way'.
Van de Sanden has become the scientific director of the newly formed EIRES – the Eindhoven Institute for Renewable Energy Systems at TU/e. He will maintain a strong connection with DIFFER as scientific group leader on Plasma Solar Fuel Devices.

Gieljan de Vries communications officer EUROfusion

Head of communication Gieljan de Vries is leaving for EUROfusion. There, he will put European fusion research in the spotlight in the coming years. De Vries has been responsible for communication at DIFFER since 2008. He saw the institute as a playground full of relevant and exciting stories about researchers and their work. De Vries was responsible for open days and lab visits, field trips for journalists, and for maintaining a steady news drip. His background in physics and journalism came in handy.
Together with colleague Arian Visser, he created the support for DIFFER's repositioning and relocation to Eindhoven by means of news flashes and on-site visits, as well as the official opening ceremony with former State Secretary for Education, Culture and Science Sander Dekker.
Visser (now NWO-I) describes De Vries as creative: "He was always involved in the elaboration of ideas, a demo or a setup." De Vries knew how to express DIFFER's message aptly in annual reports, evaluation reports, newsletters or in tweets.
De Vries will remain seconded at EUROfusion in the coming years. After all, his motto "always some new and exciting science worth sharing" is just as relevant there.

Out into the world: nest leavers

This year, six DIFFER PhD students completed their PhD projects: Bram Wolf, Rochan Sinha, Rifat Kamarudheen, Georgios Zafeiropoulos, Kiran George, and Matteo Parente. They flew out to other research institutions, and to industry. One of them is building a startup in software for e-mobility. Over the years, roughly half of the DIFFER PhD students find jobs in industry after their PhD. About a third continue in science. DIFFER interviewed three former PhD students about their current jobs and asked them, what their time at DIFFER had brought them.

- **Wolf Weymiens (34)**
- **PhD in 2014**
- **Coordinator business operation at Trainees in Onderwijs and Advisor at Het Onderwijsloket**

"I really enjoyed my time at DIFFER, but when I finished I wanted to explore jobs outside of research." Wolf Weymiens chose to make a career switch, and ended up as a teacher. "This work appealed to me because of the difference you can make for the students. So I did a traineeship in education and taught physics at a highschool for four years." Right now he is involved with setting up new traineeships for aspiring teachers and advising people who consider working in education. "Luckily I am still surrounded by supportive people, reminding me of the good atmosphere at DIFFER."

- **Fiona Elam (33)**
- **PhD in 2017**
- **Application Engineer at ASML**

"When I left DIFFER, I wanted to find a job in a similar atmosphere. I was very lucky to end up in another NWO institute that had the same kind of enthusiastic and collaborative people."
For the last two and a half years, Fiona Elam worked as a postdoc in the Contact Dynamics group at ARCNL, where she looked into the corrosion of materials at the nanoscale.
"It was a good thing that DIFFER taught me to persevere in research, because I had to set up a whole new research line. And I am also glad I can take these skills to my new job at ASML."

- **Rianne 't Hoen (35)**
- **PhD in 2014**
- **Technical consultant at DNV**

"During my PhD at DIFFER, I realized that the real challenge of the energy transition is to find ways to store sustainable energy." After her PhD, Rianne 't Hoen was motivated to help find solutions to this challenge, so she started working for DNV. "I started with projects including labwork, but right now I work as a technical consultant and advise people about energy storage solutions." For this job, she frequently refers to skills she picked up at DIFFER. "The analytical way of thinking and the drive to always ask questions really helps to get to the core of things."

“This suit fits me like a glove”

Protecting DIFFER from minor and major financial catastrophes, that is the mission of René Schoonen, head of finance and control. With large and complex equipment and many temporary, externally funded projects, anything can go wrong. Therefore, Schoonen is always on the lookout for potential hazards and ways to control them.

After his business administration training, René Schoonen started to work at an accountancy firm. “There I had to wear a three-piece gray suit; it literally and figuratively felt like a straitjacket,” he recalls. Schoonen made a radical switch and for several years managed the finances of a care home where people with multiple disabilities lived. In 2011 he came to DIFFER. Another big transition, for sure?
“Oh no”, says Schoonen. “People in science have a totally different background from those in health care, of course. But they share a passion for their work, and they need a similar approach: as a financial specialist I do not transgress into their field of expertise, but listen to them attentively and offer my help.”

“Scientists and health care workers share a passion for their job.”

Sometimes, Schoonen has to confront overly enthusiastic researchers, who in his view are too optimistic about the financial future of their project and endanger DIFFER’s financial stability. That is the toughest part of his job, he says. “But when I play my cards right, and they see my point and see that I can be of service to them, then I am happy and round off my workday with a smile. Working at DIFFER suits me well because I enjoy the freedom and responsibility. This suit is more comfortable; it fits me like a glove.”

“The concept of risk management emerged in the interaction with other financial specialists within NWO-I, the overarching organization of all research institutes governed by the Dutch Research Council (NWO),” Schoonen says. “I find it interesting to broaden my horizon and look behind the scenes at other institutes. One of the things I learned is that you can gain maximum control by making an inventory of all the risks: what will it cost to install this expensive new equipment, who is going to use it, who can contribute, what are the maintenance costs, and how long will the equipment last? It sounds so obvious to map all this, but it only works when you put everything in black and white and then keep monitoring what really happens.”

New financial system

In the spring of 2021, all NWO institutes adopt a new financial system. It is based on the original UNIT4Business World system used by DIFFER and some other institutes, and it will go by the name of New Financial System (“as financial specialists, we are not particularly creative with names”). Schoonen was on the steering committee of the introduction project. He explains that for DIFFER, the new system will not change much since it looks a lot like the one already in use. “The main advantage of the harmonization is that the board of NWO-I has more oversight, which means it can do a better job of risk management.”

FACTS & FIGURES

Output 2020

- 6 PhD theses
- 112 Publications
- 76 Open access
- 27 Invited talks
- 48 Other talks
- 30 Posters
- 8 Editorships
- 23 Media output

Organizational chart

Director
Marco de Baar

Theme Leader
Egbert Westerhof (a.i.)

Theme Leader
Anja Bieberle-Hütter (a.i.)

Institute Manager
Freya Senf

THEME FUSION ENERGY

- Energy Systems & Control – **Matthijs van Berkel**
- Fusion Facilities and Instrumentation – **Hans van Eck**
- Integrated Modeling and MHD – **Egbert Westerhof**
- Integrated Modeling and Transport – **Jonathan Citrin**
- Plasma Edge Physics and Diagnostics – **Ivo Classen**
- Plasma Material Interactions – **Thomas Morgan**
- Plasma Micro-Turbulence – **MJ Pueschel**

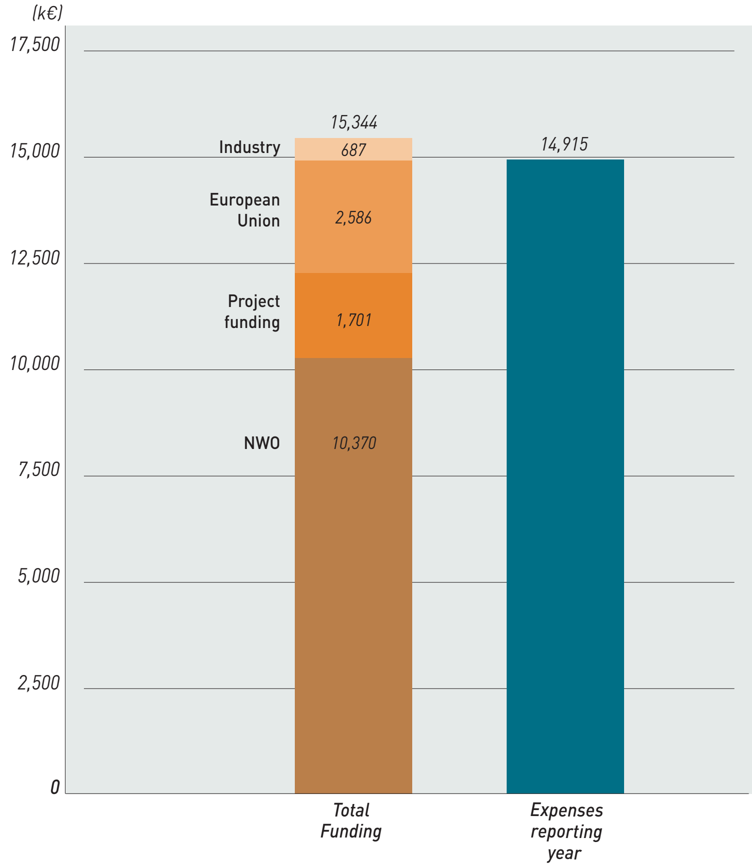
THEME SOLAR FUELS

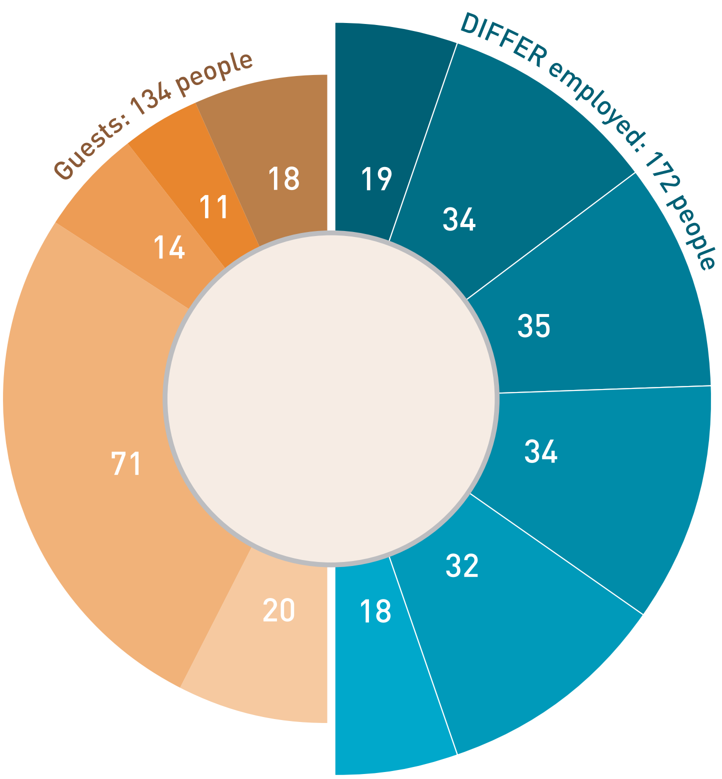
- Autonomous Energy Materials Discovery – **Süleyman Er**
- Catalytic and Electrochemical Processes for Energy Applications – **Mihalis Tsampas**
- Electrochemical Materials and Interfaces – **Anja Bieberle-Hütter**
- Materials and Surface Sciences – **Michael Gleeson**
- Plasma Solar Fuels Devices – **Richard van de Sanden**
- Solar Fuels Facilities & Instrumentation – **Stefan Welzel**
- Storing Solar Energy (DIFFER - TU/e) – **René Janssen**

SUPPORT FACILITIES

- Engineering Support – **Ed van Wijk**
- Facility Management – **Sander van Schaik**
- Finance and Control – **René Schoonen**
- Human Resources Management – **Henk Tamsma**
- ICT Services – **Marco Burgers**
- Management Support – **Freya Senf**
- Occupational Health & Safety – **Maikel Vennix (a.i.)**
- Strategic Support – **Freya Senf (a.i.)**

Funding and expenses 2020





People (306 total)

DIFFER employed (172)

- Permanent science staff (19)
- Temporary science staff (34)
- PhD students (35)
- Technical support (34)
- Support staff (32)
- Trainees (18)

Guests (134)

- Senior scientists (18)
- Postdocs (11)
- PhD students (14)
- BSc and MSc students (71)
- Support staff (20)

COMMITTEES

Management team
Marco de Baar, director
Freya Senf, institute manager
Anja Bieberle-Hütter, theme leader Solar Fuels a.i.
Egbert Westerhof, theme leader Fusion Energy a.i.

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
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