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DIFFER is one of three research institutes of the Foundation for Fundamental Research on Matter (FOM).
FOM is part of the Netherlands Organization for Scientific Research (NWO).

DIFFER
Dutch Institute for
Fundamental Energy Research

Annual Report 2015

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Colophon

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Cover image	Ellen Williams (director of the US energy research agency ARPA-E, left) and Sander Dekker (State Secretary for Education, Culture and Science, middle) officially opened the new DIFFER building on Thursday 19 November 2015

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Preface

Looking back at 2015, I am struck by the commitment our people have shown for DIFFER. They faced the major challenge of relocating the entire institute to the new building on the TU/e campus. New lab spaces had to be designed and set-up, new research groups, working on topics such as photonics and nanomaterials were established, while our research on fundamental science for future energy was continued. This major and ongoing effort is well under way.

We decided to move the experiments in phases, and to relocate all our people to their new offices during one weekend in May. In Eindhoven, we were welcomed by FOM director Wim van Saarloos. Even before officially receiving the keys to our building, an eager team of our engineers, researchers and support staff was on site, setting up essential infrastructure to give us a running start. Of course this would not have been possible without the support by TU/e, who gave us a warm welcome to their campus with full access to their facilities.

It was a major effort to relocate and rebuild Magnum-PSI, and to set-up the temporary and permanent lab space for the expanding solar fuels theme. But as the highlights on pages 10 to 21 show, it was also a year of top notch research and results. I want to make special mention here of the highly motivated Pilot-PSI team. Together with our international partners, the team ran double shift working weeks at the Rijnhuizen site until November to optimize the scientific output for the Plasma Surface Interactions facilities.

At the new location we not only rebuild our existing research infrastructure, we are also expanding by bringing in new researchers. Our themes are being organized into smaller, more flexible groups headed by tenure trackers on their way to a permanent position. In this way, we bring in expertise from many disciplines, and stimulate cross-disciplinary collaboration in- and outside the institute.

I see DIFFER's own transition as a miniature of the changes happening at NWO, the Dutch organisation for scientific research: by lowering barriers for experts from different fields to collaborate, you enable radically new approaches. On the national scale, DIFFER is active in building research networks on the national scale. To realize a sustainable energy infrastructure, we are developing the Energy Transition route for the National Science Agenda (NWA). This document will become available mid 2016, where it will be part of a plea for a long term research and development plan to accelerate the energy transition.

State Secretary Sander Dekker recognized the value of DIFFER's strengthening ties to the research, education and industrial communities during the grand opening of our building in November 2015. His call was clear: we can only succeed by bringing together differing views on energy research. With the relocation to our new building and its state of the art facilities, I am confident that DIFFER is ready to rise to this challenge.

Richard van de Sanden,
Director

Opposite page: DIFFER's management team, from left to right:
Wim Koppers, Richard van de Sanden, Marco de Baar

1 About DIFFER

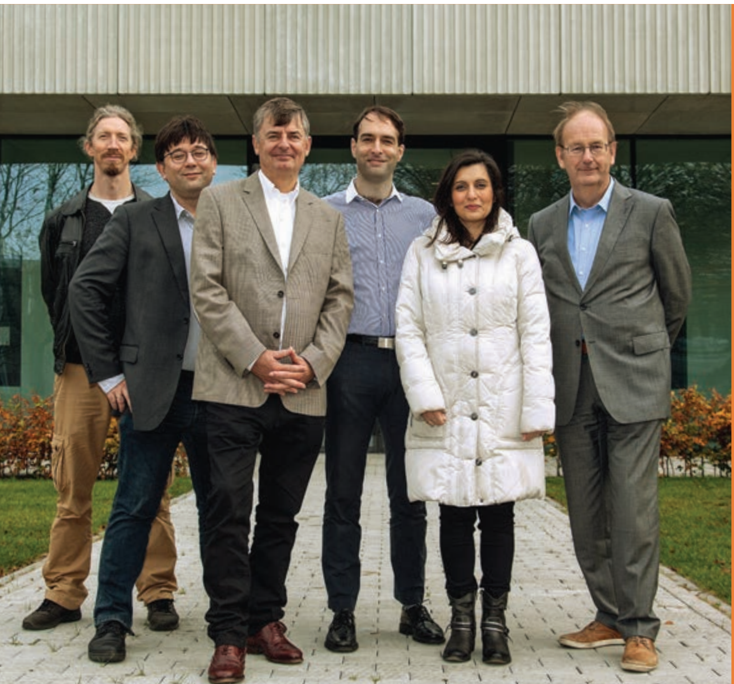
DIFFER is the Dutch Institute for Fundamental Energy Research. Our mission is to conduct leading fundamental research in the fields of fusion and solar fuels. We work closely together with science and industry and are actively building a national community for energy research to transfer fundamental scientific results to society at large.

Science for future energy

Climate change and rising energy demand require us to transform our current fossil-dominated infrastructure into a fully sustainable system by the end of the century. Scientific research plays a key role in developing the solutions to this grand challenge. As national institute for fundamental energy research, DIFFER seeks to build the interdisciplinary networks capable of solving the score of scientific questions involved. Our own research efforts are focused on two themes: solar fuels for sustainable energy storage and transport, and fusion as a clean, safe and inexhaustible power source.

Fusion energy has the potential to provide concentrated, safe and clean energy from the process which powers the sun and stars. The international fusion project ITER aims to demonstrate the technical feasibility of fusion as an energy source. DIFFER is part of the EUROfusion consortium which supports the development of the worldwide ITER project. Our fusion research program addresses high priority topics in the European Fusion Roadmap. With our unique high-flux plasma generators Magnum-PSI and Pilot-PSI, we explore plasma surface interactions under the extreme conditions near the reactor wall. Our program on control in burning plasmas develops the understanding and tools to control the highly non-linear plasma in ITER.

Solar fuels address the global challenge of energy storage and transport by converting intermittent sustainable energy into fuels. DIFFER is investigating both indirect conversion of sustainable electricity into hydrocarbon fuels, and a direct ‘artificial leaf’ approach to convert solar energy into chemical bonds. The research involves the synthesis and design of novel materials and processes to obtain scalable, efficient and cost-effective systems.



Collaboration with Syngaschem

DIFFER and the Eindhoven-based research enterprise Syngaschem BV announced their future collaboration on 16 April 2015. The intention is to establish an Industrial Partnership Programme that focuses on the storage of green electricity by producing synthetic fuels, as a contribution to a future sustainable energy supply. Syngaschem BV will move into the DIFFER building in 2016 to use offices and lab space. As an expert in the creation of complex hydrocarbons from syngas, the company is a perfect partner for DIFFER’s research into sustainable solar fuels.

New home base for DIFFER

On 19 November 2015 State Secretary for Education, Culture and Science Sander Dekker and director Ellen Williams of the US government agency for energy research ARPA-E officially opened our new institute building. DIFFER's new home base offers ample space to expand our scientific groups and spacious laboratories for new and existing research facilities. The central location on the TU/e campus in Eindhoven is ideal to build and strengthen ties with talented students, researchers and industrial partners in the Netherlands and abroad. DIFFER's new building is the first in the Netherlands to receive the 'Excellent' BREEAM-NL sustainability rating, reflecting our role as national institute for fundamental energy research.

Read more about DIFFER's new home base on pages 26-28

People

Tenure track for YES!-fellow Baldi

In 2015, Andrea Baldi started a tenure track at DIFFER as group leader in Nanomaterials for Energy Applications. He received one of the five Young Energy Scientist Fellowships of the Dutch physics agency FOM in 2010. With these fellowships, young high potential energy scientists got the opportunity for a post-doc position at a top institute abroad, then returned to start their own research group in the Netherlands. Andrea Baldi worked on characterization of nanoparticles in the group of professor Jennifer Dionne at Stanford University from 2011 to 2014 and returned to the Netherlands in 2015 to start up his own research group on energy conversion and storage at DIFFER.

For more about this researcher, see page 17

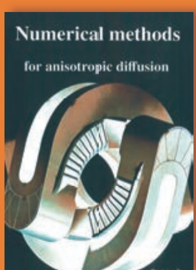
CSER tenure track for Paola Diomede

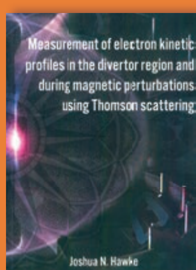
Paola Diomede won one of the six tenure track positions within the Computational Sciences for Energy Research programme of Shell, NWO and FOM. With her new research group at DIFFER, she will first apply computational and modeling approaches to the conversion of CO_2 and water into fuels, and then broaden the group to look at plasma-materials interactions at the wall of fusion reactors. "I look forward to starting this project. By working in

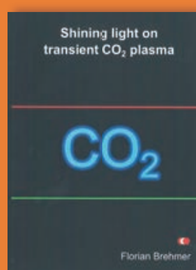
synergy with the experimentalists at DIFFER, I hope to give insight in this promising technology that will help to reduce the environmental problems caused by CO_2," says Diomede. "I can use the experience gained during the years I spent working with plasma modeling to help achieve major scientific advancements in a field that has a strong need for advanced computational techniques."

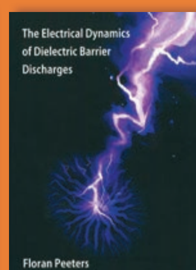
PhD theses in 2015

Bram van Es, Matthijs van Berkel and Joshua Hawke completed their Phd research at DIFFER and successfully defended their thesis at a Dutch University in 2015. Richard van de Sanden acted as first promotor for TU/e's PhD students Florian Brehmer, Jan-Willem Weber and Floran Peeters.









Relocating to Eindhoven

In 2015, DIFFER completed its relocation of people, experiments and facilities from the old Rijnhuizen site in Nieuwegein to the new laboratory building in Eindhoven. This major operation was planned carefully by a well-motivated team of researchers, technicians and support staff, to ensure a smooth transition and a as small as possible impact on the research activities.

When the keys to the building were formally delivered on 2 April 2015, DIFFER had already been actively building up infrastructure and experimental facilities. In February 2015, the Magnum-PSI team had received access to their experimental hall to start building up the infrastructure for DIFFER's biggest research facility. On 3 March 2015, the first of five big transports started to move the Magnum-PSI facility to its new experimental hall. Likewise, the ICT team were active in installing and setting up equipment for the building's data networks. The mechanical workshop started their relocation early in April to be able to welcome and support experimental facilities to the building.

On 11 May 2015 almost the entire DIFFER staff moved their offices to the Eindhoven site. The Pilot-PSI experiment remained in Nieuwegein until November to continue experiments with international collaborators. Read more about the PSI relocation on page 14.

After the relocation of the staff, work began on extending the laboratory infrastructure. When the building and the labs in particular were designed, the solar fuels theme was only just set up, and it was decided to design lab spaces with only basic infrastructure in place. Work is now under way to build up the labs spaces for the different research groups. Read more about the solar fuels labs on page 20.

Relocating Magnum-PSI (top) and workshop machinery (bottom)

EUROfusion postdoctoral grant for Matthijs van Berkel

"Heat transport in fusion plasmas"

Matthijs van Berkel received a EUROfusion postdoctoral grant for the study of heat transport in fusion reactors using system identification techniques. This research is a continuation of the PhD research he completed at DIFFER, TU/e, VUB (Brussels) and at the Japanese fusion reactor LHD in 2015. Van Berkel's new experimental designs and its resulting models are a crucial ingredient to control and optimize reactor performance.

Matthijs van Berkel, Control Systems Technology, PhD thesis defence 2 June 2015

EUROfusion

Research 2

Fusion energy

Sustainable energy production

Fusion of light atomic nuclei is the process powering the sun and has great potential as a concentrated, safe and clean energy source on earth. The fusion research at DIFFER addresses two of fusion's grand challenges: developing tools to control the hot, turbulent fuel of charged particles (plasma) in a fusion reactor, and learning how wall materials for fusion reactors will interact with the extreme plasma conditions at the reactor exhaust.

The international fusion project ITER aims to demonstrate the technical feasibility of fusion energy. At peak performance, ITER will generate 500 MW of power from hydrogen nuclei fusing together to form helium, at only 50 MW of input power.

The burning plasma in ITER represents a fundamentally new regime for control engineering. For the first time the plasma's own power output will be larger than the power of the reactor's control systems. Sensing, predicting and controling the behavior of the many possible instabilities in the hot, magnetised plasma is crucial to optimise the reactor performance.

At the ITER exhaust, wall materials face extreme plasma surface interactions in an environment similar to the surface of the sun or a spacecraft's re-entry heat shield. DIFFER's linear plasma device Magnum-PSI is the only laboratory facility in the world capable of exposing materials to such extreme conditions. This research line is developing new materials and new concepts for reactor components. In addition to new insights in the behavior of ITER's material of choice tungsten, the PSI lab investigated fundamental processes such as dust migration in the plasma near the reactor wall.

European connection

DIFFER's two lines of fusion research focus on developing insights for the successful operation of ITER, while testing and developing systems at mid-sized fusion reactors worldwide. The research is well-connected with EUROfusion, the European fusion research programme within Horizon2020. The research at DIFFER addresses two high priority topics in the European Fusion Roadmap, and the institute acts as a linking pin to connect Dutch researchers and companies to the international fusion research community.

Program leaders

Marco de Baar, Ivo Classen, Paola Diomede, Hans van Eck, Thomas Morgan, Egbert Westerhof

Funding

FP-75 - PSI-lab; FP-148 - Magnum-PSI; FOM-TU/e Impulse program; EUROfusion consortium, ITER Organisation service contract, Erasmus Mundus Fusion DC

Grants

Matthijs van Berkel – EUROfusion Engineering Grant

Collaborations

ASIPP, Hefei, China; ANSTO, Sydney, Australia; ANU, Canberra, Australia; Beihang University, Beijing, China; CEA Cadarache, France; CIEMAT, Madrid, Spain; Dalian University of Technology, China; Delft University of Technology, NL; EPF Lausanne, Switzerland; ENEA, Frascati, Italy; F4E, Barcelona, Spain; FZJ, Jülich, Germany; IFPCNR, Milan, Italy; IOFFE Institute, St Petersburg, Russia; IPP Garching, Germany; ITER IO sections, divertor, ECRH, RH Cadarache, France; KIT, Karlsruhe, Germany; KTH, Stockholm, Sweden; Manchester University, UK; MIT, Boston, USA; Nagoya University, Japan; NIFS, Toki, Japan; Tartu University, Estonia; INFLPR, Bukarest, Romania; Oak Ridge National Laboratory, USA; Osaka University, Japan; PPPL, Princeton, USA; Purdue University, West Lafayette, USA; SCKCEN, Mol, Belgium; Sichuan University, Chengdu, China; TEKES, Finland; Tsinghua University, Beijing, China; TU/e, Eindhoven, NL; Twente University, Enschede, NL; UCSD San Diego, USA; University of Basel, Switzerland; University of Ghent, Belgium; University of Hyogo, Kobe, Japan; University of Illinois, Urbana Champaign, USA; University of Nancy, France; University of Tsukuba, Japan

A good day

How can one research institute make a global impact? For DIFFER's fusion theme, the answer lies in building unique experimental setups to draw in scientific collaborators. And eager engineers. Erik Vos and Miranda van den Berg talk about the fun to be had in building up Magnum-PSI and the Ion Beam Facility.

Relocating DIFFER's massive installation Magnum-PSI to Eindhoven was a major operation, and so the team took on extra hands like Erik Vos. "I started out as an operator. Each visiting researcher has his own requirements - it was a great way to get to know Magnum. But I only really understood how extensive the experiment is during dismantling and rebuilding. I help out the specialists where I can in very diverse areas. Vacuum and mechanical systems, cooling, control and safety, the plasma source,... Fortunately everyone is happy to explain how systems work and how they fit together. The variation is what makes it fun: a good day is when I go home having learned something new."

Miranda van den Berg echoes the sentiment. "I started out on Magnum-PSI's cooling system and by creating thermal models for high heat load components I got directly involved in experiments. Helping investigate liquid metal walls for fusion reactors is exciting work! And I will definitely stay involved in the research. But I also wanted to broaden my experience as engineer."

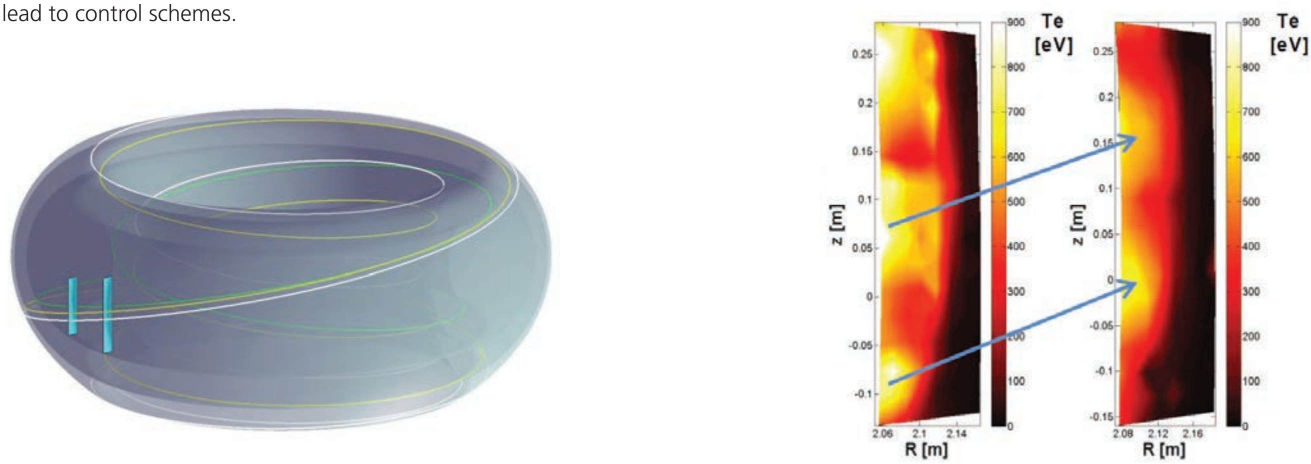
When DIFFER acquired an ion accelerator from nearby AccTec BV to expand it into the new Ion Beam Facility for materials research, Van den Berg was interested immediately. "It was a double challenge; getting to know this complex technology and coordinating the rebuilding project. The support we get is amazing. Advice from AccTec, borrowing equipment to align the beam lines. In Nieuwegein I never felt I missed interaction with companies or researchers. But now that we are on the campus, I really appreciate how much easier some things go when your collaborators are right next door."

First 3D images of fusion energy outbursts

Controlling periodic energy bursts from the plasma is one of the big challenges to fusion power plants. A new diagnostic is unraveling the 3D shape and underlying physics of these energy bursts.

Ivo Classen and Branka Vanovac are investigating ELMs or Edge Localised Modes, periodic energy bursts from the edge of the fusion plasma that can leak precious heat from the reactor and damage its walls. With a new diagnostic they installed on the ASDEX Upgrade tokamak, the researchers combine images from two locations along the reactor edge. This way they can determine whether the energy bursts spread out over an entire magnetic field line, or are instead bunched up in a shorter pulse traveling along the field line. First data taken in 2015 show that the diagnostic is capable of measuring this 3D nature of ELMs, which will help unravel the underlying physics of these outbursts and lead to control schemes.

The figures below show two images taken simultaneously of the field-aligned structures in the ELM instability. It was observed that the temperature response of the surface to identical ELMs rose by 40% during a series of ELMs. This indicates a progressive change in the thermal response of the tungsten target, which could be of concern for the divertor long term performance.



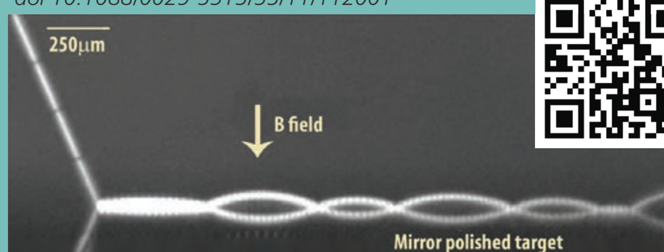
Two observation windows (blue) enable 3D measurements (left). The figures at right show two images taken simultaneously of the field-aligned structures in the ELM instability.

The mystery of hot dust solved

An international team used an extremely high-resolution camera to unravel one of the mysteries of dust moving in a dense plasma. This helps tackle the issue of where dust will end up in a fusion reactor.

Being able to predict where dust eroded off the walls of a fusion reactor will end up is a major challenge. Dust particles can cool the heart of the plasma, or become a safety hazard when sticking loosely to a surface. An unresolved mystery of dust was how it managed to keep a high temperature while 200 µm/pixel cameras saw it sliding along in direct contact with a colder surface. Experiments in DIFFER's setup Pilot-PSI with an extremely high resolution camera now finally solved this puzzle. The 9 µm/pixel imagery shows that the particles bounce, only cooling a little bit each time they touch the cooler surface. These and other dust tracking results will feed into computer models to predict dust movement throughout a fusion reactor like ITER.

Highly resolved measurements of dust motion in the sheath boundary of magnetized plasmas, Nuclear Fusion (2015), doi 10.1088/0029-5515/55/11/112001



Looking at fusion plasmas in a new light

A new imaging system will help optimise the shape of hot plasma at the exhaust of a fusion reactor.

Conditions at the exhaust (divertor) of future fusion reactors are similar to those at the surface of the sun. DIFFER and the Swiss fusion experiment TCV (Tokamak à Configuration Variable) investigate new shapes for the plasma to reduce the heat load at the divertor.

How the intense divertor plasma responds to shaping is not yet fully understood. There is limited data, which makes it a challenge to untangle the interactions between heat and particle transport to the divertor.

To improve the understanding, DIFFER is building the multi-spectral imaging system MANTIS, which can determine the plasma state and shape for the entire divertor at once, and at high time resolution. When attached to a digital control system, MANTIS will help keep the plasma in the optimal shape and temperature to keep the reactor wall safe.

The first MANTIS prototype is currently undergoing testing at DIFFER

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Should ITER shape its tungsten divertor blocks?

Misaligned tungsten blocks in the ITER exhaust face the full impact of the incoming plasma. Experiments in Pilot-PSI suggest that shaping the tungsten blocks can avoid this damage.

At the exhaust of the ITER fusion reactor, the plasma is guided onto 180,000 tungsten blocks at very shallow angles to dissipate the heat. When a block accidentally sticks out, its leading edge would face heat loads from 10 MW/m^2 to 1000 MW/m^2 during sudden energy outbursts from the so-called ELMs. Erosion of the tungsten blocks and polluting the core plasma are but a few of the risks.

To help ITER decide if it should take action, Pilot-PSI used its pulsed plasma system to expose misaligned tungsten blocks to the harshest conditions possible at the ITER exhaust. The work shows that misalignment is a serious issue, and suggests that shaping the tungsten blocks could prevent sharp edges from having to face the full power of the plasma.

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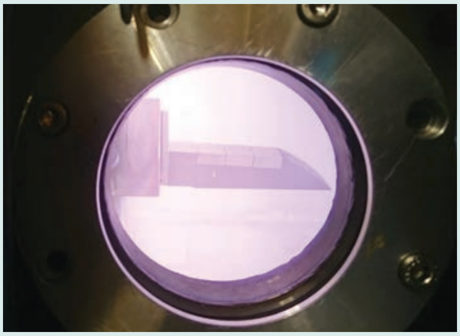
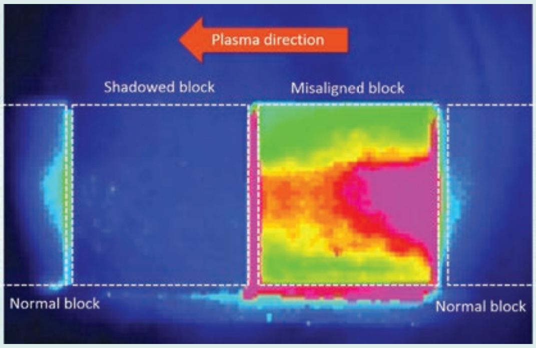
china eu india japan korea russia usa





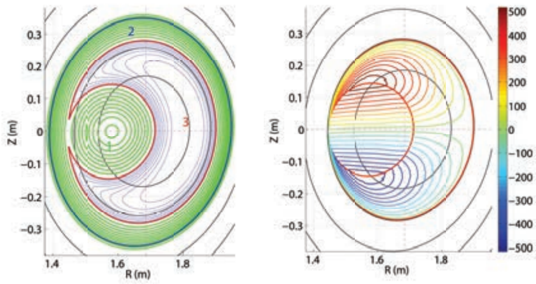
Exposing a misaligned tungsten block to the plasma in Pilot-PSI (left) reveals an increased heat load on exposed leading edges (IR-view, right)

Redistribution of fast ions

Instabilities in the mix of magnetised particles or plasma in a fusion reactor can drastically influence the reactor's performance.

Detailed simulations by PhD student Fabien Jaulmes now clear up how fast helium ions, spit out by the fusion process can influence these instabilities. As one application, he modeled how fast helium ions can modify the so-called sawtooth instability. This periodic crash of the plasma pressure leaks heat from the plasma and improved understanding can lead to better management of the instability.

The models that Fabien Jaulmes created show the interplay between particles and forces in great detail. After developing and benchmarking such codes, they can be used to design models that can predict the essential behavior fast enough to spot, predict and control fusion instabilities as they start to develop in the reactor.



Kinetic behaviour of ions in tokamak inductive scenarios (2016), PhD thesis Fabien Jaulmes at Eindhoven University of Technology

Relocating the PSI experiments

Magnum-PSI is DIFFER's unique contribution to the field of plasma surface interactions under fusion reactor-like exhaust conditions. Although smaller than a full fusion reactor, relocating the facility was a major effort. After the shutdown in November 2014, Magnum-PSI was dismantled, its components were moved to Eindhoven in five stages, timed with the rebuilding activities.

At the new site, Magnum-PSI will be upgraded with a superconducting magnet system to allow truly longterm exposure of materials to the dense plasma beam. The experiment will also be connected to the new Ion Beam Facility for (sub)surface materials research that DIFFER is building up - see page 11. PSI experiments at DIFFER will restart by July of 2016.

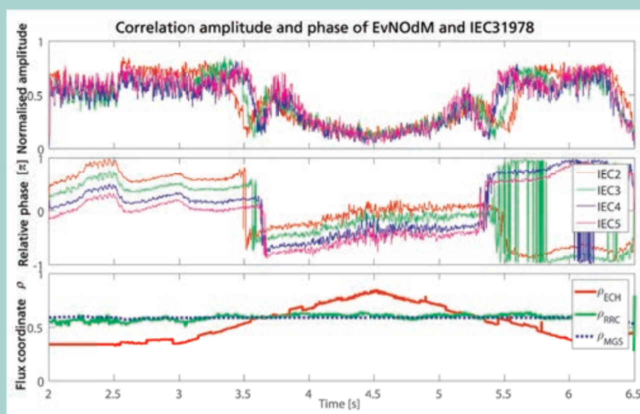
Pilot-PSI, Magnum-PSI's smaller sister experiment, continued operations in Nieuwegein up until November 2015 to minimize downtime of the plasma surface interactions-experiments. Together with visiting researchers, the team produced exciting results such as the highlights at the bottom of these two pages. After its relocation to Eindhoven, Pilot-Upgrade will be connected to the Ion Beam Facility to identify what is happening down to a few micrometers below the surface during high flux plasma exposure.

Detecting and suppressing magnetic islands through one reactor port

A compact new control system for fusion reactor instabilities promises to keep the plasma at peak performance without complex targeting calculations.

When the plasma in a fusion reactor develops magnetic island instabilities, its performance is reduced. Suppressing an island requires a precise hit with microwaves and the usual control strategy takes up two of the reactor's view ports. Complex computer codes translate the detection signal from one port into targeting data for the microwave system at another.

A DIFFER team is testing a more efficient control system using only one port and without complex calculations. When their system spots a magnetic island, it fires its microwave beam back along the same line of the sight. This requires extreme filtering to spot island's nanowatt signal against the microwave's megawatt glare. In 2015 the system successfully determined where the microwaves should be deposited in the ASDEX-Upgrade reactor. The team hopes to also apply this technique at the fusion reactor ITER.



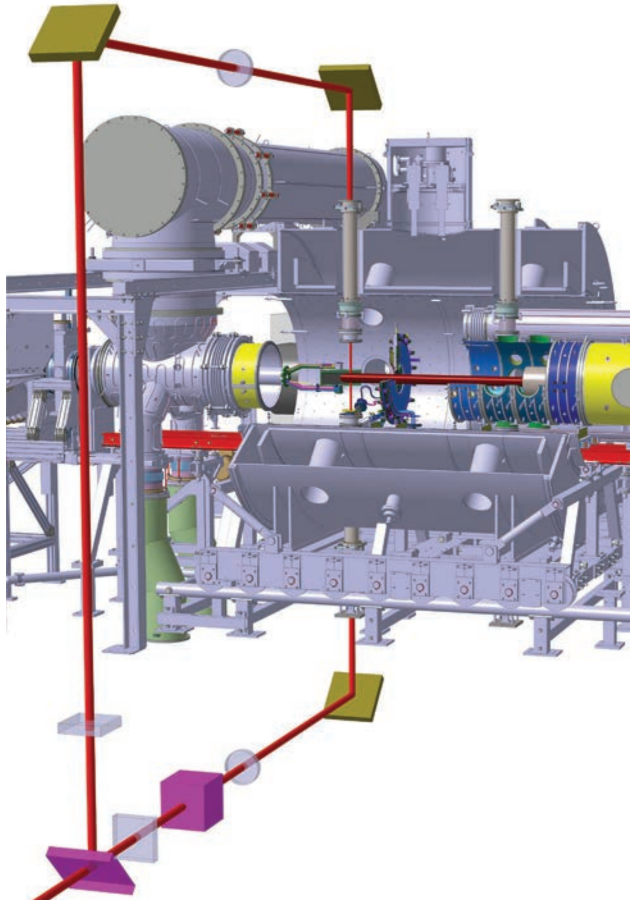
Combined Electron Cyclotron Emission And Heating For The Suppression Of Magnetic Islands In Fusion Plasmas, First EPS Conference on Plasma Diagnostics (2015)

Collective electron behavior reveals ion properties

A new detection system for the hard-to-measure ion properties in a plasma improves DIFFER's testbed Magnum-PSI for wall materials in a fusion reactor.

DIFFER's research facility Magnum-PSI investigates how materials for fusion reactors like ITER will evolve under the extreme conditions at the reactor wall. Magnum-PSI mimics this environment by a bombardment with a hot, dense plasma - a mix of charged ions, electrons and neutral particles. We need precise measurements of the plasma conditions to compare results from the linear Magnum-PSI experiment to models for torus-shaped fusion reactors. Ways to exactly characterise the light electrons exist, but not for the ions.

Hennie van der Meiden and Jordy Vernimmen developed a novel state-of-the-art system to measure ion properties such as their temperature and flow velocity. They obtained this information from the collective behavior of electrons clustered around the ions. Work is now underway to increase the sensitivity of this Collective Thomson Scattering system even further.



Multi-pass Collective Thomson Scattering system for Magnum-PSI. The injected laser beam is captured inside the cavity, enhancing the signal strength 15 times.

Solar fuels

Sustainable energy storage

Our future energy infrastructure will be based on sustainable energy generation from wind, solar and potentially fusion. In addition to such electricity generation, we will need to convert sustainable energy into fuels or other chemicals. DIFFER's research into solar fuels investigates both direct and indirect conversion of solar-to-products. We aim to realise CO_2-neutral fuels and products by converting sustainable energy into chemical bonds.

The solar fuels research and development program at DIFFER is driven by the need for cost-effective and energy efficient production of solar fuels and products through the use of abundantly available materials. The central theme is working towards power efficient dissociation of CO_2 or H_2O (or both). Subsequently, established chemical conversion methods (Fisher-Tropsch, Sabatier, etc.) may be applied to convert the resulting CO and H_2 into the fuel or products of choice. The concrete research areas are plasmolysis, where non-equilibrium plasma is used to efficiently dissociate CO_2 and H_2O, the artificial leaf approach, and novel materials synthesis, preparation, and characterization for solar fuels production.

Photonics, simulation and lab infrastructure

In 2015 two new groups have started, both looking to use light-matter interaction to enhance solar fuel or chemicals production. Tenure track researcher and former YES!-Fellow Andrea Baldi aims to exploit plasmonics to control the synthesis of novel nanomaterials for photocatalysis, as well as to enhance catalytic processes relevant for the production of solar fuels. Jaime Gómez Rivas, who came from our sister institute AMOLF, will use strong light-matter coupling to improve charge transport in artificial leaf systems.

In addition to the new photonics groups, tenure track researcher Paola Diomede joins the solar fuels theme. Her work will focus on modeling plasma activation of CO_2, using kinetic approaches for plasma chemistry. Finally, Stefan Welzel heads a new group responsible for the solar fuels facilities and instrumentation. His team is presently building up the lab infrastructure of the solar fuels groups, which involves both basic facilities and advanced instrumentation and diagnostics.

Program leaders

Andrea Baldi, Anja Bieberle, Waldo Bongers, Paola Diomede, Michael Gleeson, Jaime Gomez-Rivas, René Janssen, Gerard van Rooij, Mihalis Tsampas, Hindrik de Vries and Stefan Welzel

Funding

ERC grants THz Plasmon and MicroMap; FOM-Fujifilm IPP atmospheric plasma processing of functional films; FOM-Philips IPP Nanophotonics for Solid State Lighting; NWO program CO_2-neutral fuels; NWO program New Chemical Innovations; STW-Alliander project plasma conversion of CO_2; STW project Flexible Solar Cells; STW project LedMap; Syngaschem collaboration; TKI Gas; Topsector Chemistry NCI; Topsector Energy

Tenure-track within the 'Computational sciences for energy research' program of Shell, NWO and FOM

Collaborations

Science

AMOLF, NL; CNRS-Ecole Polytechnique, France; CSIC, Spain; Eindhoven University of Technology, NL; EPFL Lausanne, Switzerland; IPP Stuttgart, Germany; Radboud University Nijmegen, NL; Sichuan University, Chengdu, China; Stanford University, USA; Universidad Autonoma, Spain; University of Antwerp, Belgium; University of Bari, Italy; University of Leiden, NL; University of Twente, Enschede, NL; University of York, UK

Industry

Alliander, NL; Atlantic Hydrogen, Ca; Evonik, D; Facebook, US; Fujifilm Research, Tilburg, NL; Philips Research, NL; Protemics GmbH, Germany; Sasol, SA; Shell, NL; Syngaschem, NL

An opportunity to get creative

Nanophotonics expert Jaime Gómez Rivas and materials researcher Andrea Baldi are blending light and matter at the nanoscale in order to transport, transform and store renewable energy. With their crossdisciplinary approach, these two new group leaders are bringing novel techniques and a deep passion for knowledge transfer to DIFFER.

"I have seen how many amazing things can be done when you get a physicist, a chemist and an engineer together", says tenure track researcher Andrea Baldi. The chemist-turned-physicist comes to DIFFER from the Materials Science and Engineering group at Stanford University, where he completed a post-doc supported by one of FOM's prestigious Young Energy Scientist-grants. "You get an opportunity to get creative in a different field, where the approaches are different than in your own discipline."

At DIFFER, Baldi wants to direct that creativity to turning sunlight into clean fuels or other chemicals, by using light-responsive nanoparticles to drive highly specific chemical reactions: turning sunlight into fuels. "An amazing property of matter is that reducing its size allows you to change its properties tremendously. For instance, a gold nanoparticle of a few hundred atoms across has very different electronic properties and surface chemistry than either a single atom or a chunk of gold. And so you find that these gold nanoparticles are for example very interesting catalysts, because they are so selective towards certain reactions.

Baldi: *"I remember taking my first high res TEM image of a nanoparticle, where you could see the individual rows of atoms. It gave me the chills. I kept on taking images, trying to get the best resolution ever, because it was so cool."*

For Jaime Gómez Rivas, this drive to turn fundamental insights into practical applications is also never far away. His topic is nanophotonics, the interaction of light with matter at the nanoscale. "When the applications of fundamental research like sensing or solid state lighting are so apparent, I think it is only natural to give back something concrete to society."

(continued on page 21)

Finding the limitations of water splitting

Modeling and simulations can clear up what factors limit the conversion of sunlight into fuel.

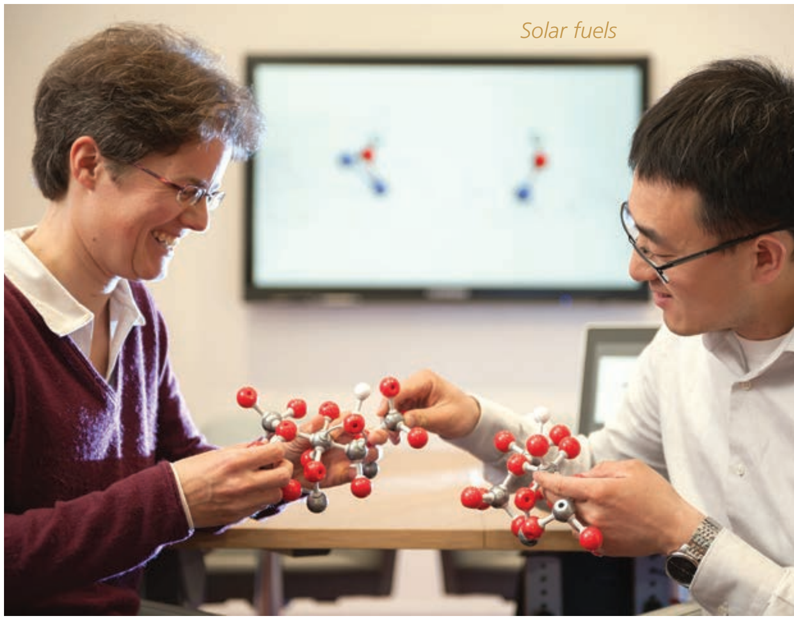
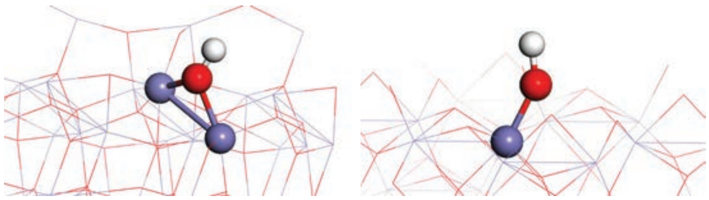


Photo-electrochemical water splitting is an elegant way of using sunlight to make fuels for diverse energy applications. However, experimental efficiencies are still low and the limitations at the photoelectrode-electrolyte interface are not well identified. To close the gap between experimental data and electrochemical models, Xueqing Zhang and Anja Bieberle-Hütter simulated oxygen formation at various iron oxide surfaces. This process is the twin to hydrogen production at the other electrode in photo-electrochemical water splitting, and the overall efficiency depends on both processes running smoothly. They found that the way in which oxygen interacts with the surface is crucial to easing the path towards efficient oxygen formation. The lowest resistance is found when oxygen creates a bridge between two iron atoms in the photoelectrode and can be lowered even further by sub-surface vacancies. The result will be used in further simulations of experimental photo-electrochemical data.

Modeling & Simulations in Photoelectrochemical Water Oxidation: From Single Level to Multi-scale Modeling, ChemSusChem (2016), doi 10.1002/cssc.201600214



Hydroxyle (OH) adsorption on iron oxide: oxygen bridge site (left) and oxygen terminal site (right). The bridging site (left) shows the lowest resistance to oxygen gas formation in these calculation.

Climbing the ladder to solar fuels

Breaking up CO_2 is the first step to recycling the greenhouse gas into clean fuels. A plasma approach already shows greater energy efficiency than what is possible with thermal conversion.

Using renewable energy to convert CO_2 back into fuels would create a truly circular clean energy infrastructure without the disadvantages of fossil fuels. The crucial step in this 'reverse combustion' is breaking up the CO_2. A joint research team at DIFFER, Radboud University and Eindhoven University of Technology now demonstrate that their technique to break up CO_2 can reach a 50% energy efficiency, already more efficient than the 42% possible by simply heating up the molecule.

In their charged mix (plasma) of heavy CO_2 ions and light electrons, the team concentrate all of the energy in the electrons so that the heavy molecules do not have to get up to speed. Collisions between fast electrons and heavy molecules make the CO_2 molecules vibrate more and more until they shake themselves apart.

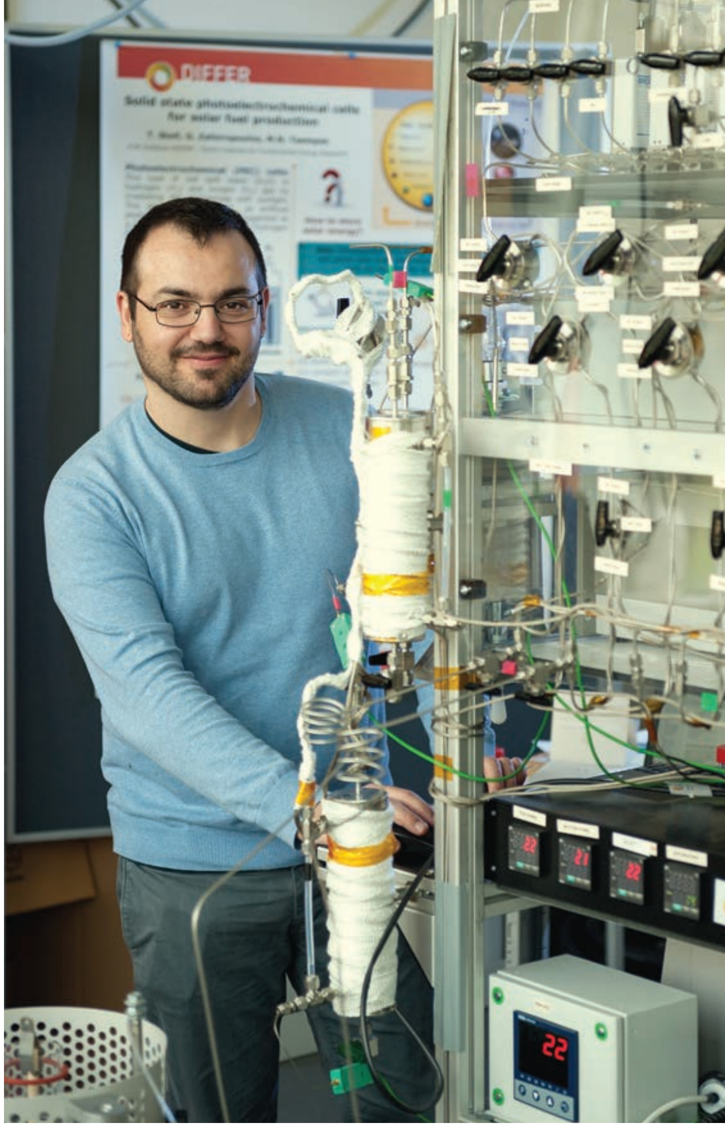
Taming microwave plasma to beat thermodynamics in CO_2 dissociation, Faraday Discussions (2015)

Turning sunlight into chemicals

A photoelectrochemical cell built around a polymeric membrane could be the way forward to high performance conversion of sunlight to chemicals.

With a new design of photoelectrochemical cell (PEC), researcher Mihalis Tsampas and his team want to turn sunlight into chemicals at record efficiency. The heart of the new PEC is a polymeric membrane instead of the regular liquid electrolyte. This membrane can transport protons between electrodes on either side to drive reactions, but prevents gases from taking the same route. This means that the electrodes can take their reactants directly with gases, at higher possible temperature and performance, instead of having to sit in a liquid. First experiments show that the design can split water into hydrogen as a first step to clean artificial fuels. Run in reverse, the system can detect and clean volatile organic compounds by detecting the small current they set up in the cell.

Applications of Yttria Stabilized Zirconia (YSZ) in catalysis, Catalysis Science and Technology, 5 (2015) 4884-4900, doi 10.1039/C5CY00739A



Mihalis Tsamapas (top) in the new laboratory on photo-electrocatalysis for solar fuels

Gerard van Rooij (left) and Dirk van den Bekerom at the setup for nonequilibrium fuel conversion

TU/e Technische Universiteit Eindhoven University of Technology

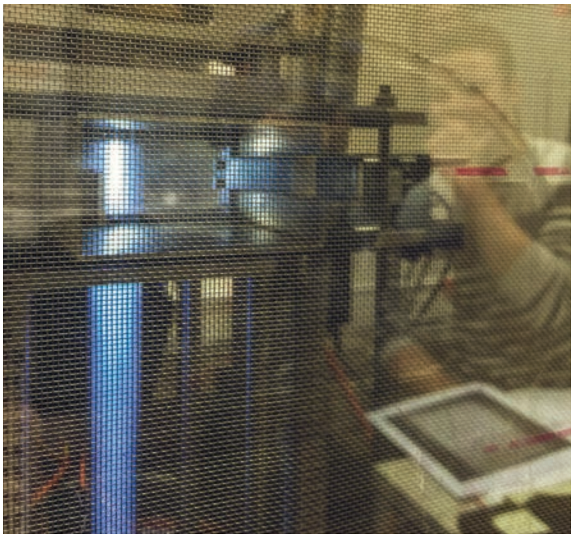
Radboud Universiteit Nijmegen

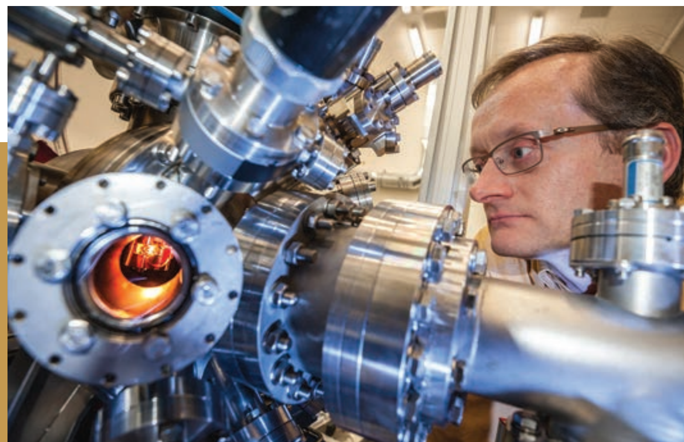
Diverse and complimentary

After its start in 2011, DIFFER's solar fuels theme has brought together a variety of disciplines and approaches to energy conversion.

These disciplines include physics and chemistry approaches such as plasmas and photonics, photo-catalytical and photo-electrochemical methods, and nanomaterials research. The definition of the indidvidual research groups was just finished in 2015. Additionally, setting up new experiments at the Nieuwegein site proved to be impractical. Hence, several experiments were set up and performed at partner institutes and universities throughout the Netherlands such as TU/e, Leiden and Radboud University, as well as the High Tech Campus in Eindhoven and the Tilburg Research Laboratories of Fujifilm.

With DIFFER's relocation to a new, larger building, we are bringing together our solar fuels laboratories and efforts under one roof. A dedicated Facilities and Instrumentation group similar to the group on fusion facilities and in strumentation started in 2015 to design and reconstruct the new dedicated lab environments such as chemical and optics labs. This includes for instance the installation of additional exhaust capacity while simultaneously, deposition and surface science facilities, setups for plasma-assisted gas conversion and analysis tools are acquired, upgraded and installed in the new labs.





Temporary lab spaces: first plasma experiment (left), chemical room (right, top) and surface science experiment (right, bottom)

First joint Solar Fuels-CIDS papers

2015 saw the appearance of the first publications arising from direct collaboration between researchers of the Solar Fuels department and of the Center of Interface Dynamics for Sustainability (CIDS), Chengdu, China. CIDSis headed by Aart Kleyn, former director of DIFFER.

In these two publications, the researchers investigate the interaction between nitrogen atoms and an oxygen-covered ruthenium surface, and collision induced desorption of CO from ruthenium by argon and nitrogen. The research is part of a larger programme which looks at combining in one step the release and conversion of CO_2 to CO at a CO_2-capturing material.

Kinetic analysis of interaction between N atoms and O-covered Ru(0001). Journal of Chemical Physics (2015), doi: 10.1063/1.4934602

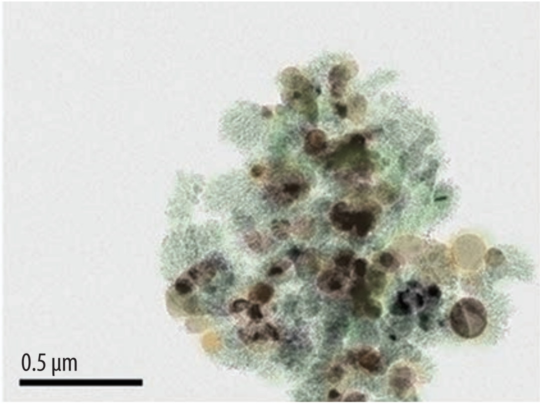
Collision-induced desorption of CO from Ru(0001) by hyperthermal argon and nitrogen, Surface Science (2016), doi: 10.1016/j.susc.2015.12.016

Sizing up nanoparticle and their chemistry

By scattering light off of nanoparticles, Ilker Dogan manages to determine their size and chemical properties. This will help to incorporate them in solar panels, batteries and catalysts.

Nanosized fragments of semiconductor can enhance solar panels and batteries. How efficiently they process energy or matter greatly depends on their size. Sizing techniques can either take hours, or destroy the sample under investigation. Ilker Dogan now shows that ringing the particles like a bell with a pulse of light is enough to size up nanoparticles in a few minutes and without destroying them.

The technique can be potentially used to quickly determine if a production process delivers the right nanoparticles. This can save expensive and time-consuming analyses. In follow-up research, the researcher wants to also tease chemical reactivity from the data. The experiments looked at silicium nanoparticles, but in principle, any semiconductor nanoparticle can be sized this way.



Characterization of Nanocrystal Size Distribution using Raman Spectroscopy with a Multi-particle Phonon Confinement Model, Journal of Visualized Experiments (2015), doi 10.3791/53026

Continued from page 17

"Applying nanophotonics to a topic like energy appeals to me very much", says Gómez Rivas, who moved his research groups at AMOLF and Philips Lighting to DIFFER in the summer of 2015. "The nice thing about it is that you are talking about optimal interaction of matter with visible light and that means you have a very natural fit with solar power." At DIFFER, his team will investigate how to use nanophotonics to further improve energy distribution and conversion in photovoltaics and photo-electrochemistry. Together, Baldi and Gómez Rivas are setting up a programme to bring together nanophotonics and energy nanomaterials. Gómez Rivas: "You need both worlds to make this research successful - you cannot just make the best material from a chemical point of view, it also needs to have an optimal interaction with light." Beneath the pair's enthusiasm for energy applications is a deep passion to know - and to share that knowledge. Gómez Rivas: "Getting young people to become enthousiastic about science is important. What I like is when I can think of a way to capture the students' attention, because when they get excited, I get excited. Tomorrow I will teach a university course where I will show the students a surface plasmon-polariton by naked eye. With just a laser pointer and the right material you will see this mixed photonic and electronic wave bound to a metal surface. I love coming up with little demonstrations like that."

Gómez Rivas: "For an experimentalist like me, working with light is very accessible and rewarding: I can literally see what I am doing. I always tell my students: "use your eyes!", because often the phenomena they are studying are visible by naked eye."

Baldi has obviously been bitten by the same bug. "When you learn something new and you understand it, the first thing that you want to do is share it. When I learn something new, I cannot shut up about it; and explaining it to friends or students is a way to fix that knowledge into my brain. That is why I set up a journal club at DIFFER to share and discuss exciting new papers. Even, no, especially those from outside our own field. We started with analysing the Gravitational Waves discovery. It is great to be exposed to innovative ideas, to the amazing creativity of other people."

Community building 3

Network collaboration on energy research

To accelerate technology innovation, we create an active and well-connected community on energy research because that is a promising soil for scientific collaboration and breakthroughs. A multidisciplinary network based on openly sharing information and insights between various scientific disciplines, fundamental and applied research & development, and actors with a focus on short, mid and long term. Moreover with the ability to strengthen the Dutch position in European and international energy initiatives. We contribute by participating in (inter)national consortia and networks and organizing workshops.

Multidisciplinary scientific workshops

Over the years, DIFFER has been building and structuring the national energy research network, for example expressed by facilitating the workshop format Science & the Energy Challenge (www.scienceandtheenergychallenge.nl). We aim to position the institute as a natural national point for contact on (fundamental) energy research. That is both for academia and other research institutes as well as the technological institutes, enterprises and industries.

To illustrate, in September 2015 DIFFER hosted in its new building the NWO workshop *Research challenges in harvesting and converting solar energy,* bringing together around 100 researchers. Besides exchanging science on biological and artificial approaches to make chemical products power from solar energy, the workshop was used to present and discuss the new NWO program Solar-to-Products. The scope of the workshop was highly appreciated by the participants and will likely be organised yearly to closer connect the fields.

Connecting basic to applied research

Accelerating innovation can be achieved by connecting the relevant players in the innovation chain. We actively pursue ways to crosslink basic research to the work done at polytechnical schools, technological institutes, and enterprises. Some of the initiatives in 2015 are the following.

VoltaChem

DIFFER was asked to connect its fundamental research agenda to the VoltaChem initiative started by the large technological institutes TNO and ECN. This initiative works on research and development of technology and processes for electrification of the chemical industry. With one side of their activities aligned to enterprises and industries, now the focus on the long term research is included to build on a balanced more year strategic program. For DIFFER it is an opportunity to probe use-inspired research questions, while giving the opportunity to align its basic research to the expertise of TNO and ECN.

Syngaschem BV

DIFFER and research enterprise Syngaschem BV are preparing a future collaboration on the storage of green electricity by producing synthetic fuels from syngas, a mixture of hydrogen and carbon monoxide. In a way the research of DIFFER in making green syngas will be directly connected to the next step of synthesizing hydrocarbons by novel catalytic materials and process explored by Syngaschem. This partnership is inspired by the success of the public-private collaborations with Heemskerk Innovative Technology on remote handling, and with Fujifilm Manufacturing Europe BV on processing functional materials.

Fontys University of Applied Sciences

The high-tech facilities and infrastructure of DIFFER, such as Magnum-PSI and the new ion beam facility, clearly demonstrate that design and operation of advanced systems and setups is essential to address basic science questions. This is also recognised by NWO NRPO-SIA by initiation of a new funding scheme to strengthen the ties between basic research at NWO institutes and applied research at polytechnical schools. DIFFER immediately followed up and signed a memorandum of understanding with Fontys University of Applied Sciences in Eindhoven to set-up collaborative research programs and to create an inspiring learning environment for their students.

Nienke Meijer (chair of the Fontys executive board) and Richard van de Sanden (DIFFER) sign a memorandum of understanding about collaboration between DIFFER and Fontys Hogeschool.

Participants to the NWO workshop Research challenges in harvesting and converting solar energy *discussed biological and artificial approaches to make chemical products power from solar energy.*

Route Energy Transition

The Dutch government took the initiative of the Dutch National Research Agenda (NWA, www.wetenschapsagenda.nl), in which an overwhelming number of 12.000 science questions were collected from the public. From the diversity of questions posed and condensed in the cluster questions, it became clear that the topic sustainable energy clearly resonates in society. DIFFER was asked by the Netherlands Energy Research Alliance (NERA, www.nera.nl) to develop the NWA route Energy transition. This route addresses the urgency for novel collaborative, multidisciplinary approaches in the Netherlands to make the necessary steps in this societal and global energy transition.

Director Richard van de Sanden is co-chairing the process together with Wim Sinke (ECN, UvA) and Kornelis Blok (TUD, Ecofys), supported by secretary Erik Langereis and a NERA project team. With this NWA route, DIFFER is helping the Dutch energy community to make a strong case for an integrated approach to the energy transition and the role of science therein. By involving universities, polytechnic schools, research and technological institutes, the Energy transition route links society, policy, to enterprises and industries and addresses the role, potential and direction of a coordinated research effort in the Netherlands.

4 Outreach

Knowledge transfer to society

One of DIFFER's goals is transfering knowledge to society at large. DIFFER pursues strong contact with high-tech SME's and industry, both as an inspiration for research questions and to translate our fundamental research into practical applications. Our institute welcomes young talent for research projects in the upper levels of high school, in the bachelor and master phase, and as technical apprentices. Finally, DIFFER runs a strong outreach program to the general public, either via the media or directly in the form of open days.

Minister Kamp (Economic Affairs) visits the DIFFER stand at the Hannover Messe 2015

Hannover Messe 2015

The Hannover Messe is the world's leading industrial trade fair, drawing an average of 6,500 exhibitors and 250,000 visitors to its many exhibits and events. We presented DIFFER's use-inspired research into sustainable energy generation and storage in a joint pavillion with our fellow NWO institutes from 13 to 17 April 2015. The Hannover Messe again had the warm attention of the Dutch government, with Minister Henk Kamp of Economic Affairs visiting the NWO institute. DIFFER's director Richard van de Sanden introduced Minister Kamp to the DIFFER-HIT haptic system for remote handling studies, and discussed DIFFER's research into efficient storage of sustainable energy in solar fuels.

First open day in Eindhoven

DIFFER held its annual open day on Sunday 2 October 2015, as part of the national Science Weekend. The institute welcomed over 800 visitors for lab tours, talks and live experiments. Although this was our first open day at the new location, the number of visitors already equalled the average of open days at our former location in Nieuwegein. Many were attracted to the Energy Q&A with DIFFER's MT members Marco de Baar and Richard van de Sanden, hosted by prominent science journalist and Science Weekend ambassador Diederik Jekel. Polling of our visitors' postal code reveals that over 70% of them hail from the Eindhoven area, which shows that DIFFER is already becoming well known in the region and manages to attract attention in this area of high profile high-tech companies and institutes for higher learning.

Fifth edition of Fusion Days in Antwerp

In November 2015 DIFFER's Fusion Road Show drew 3600 high school students and their teachers from 80 Belgian and Dutch schools to the fifth edition of Antwerp University's Fusion Days. Using a mix of theatrical techniques and live experiments, DIFFER's Arian Visser and guest performer Erik Min took their audience on a trip into the future of energy and built up a model fusion reactor using household equipment in less than an hour. The event is the culmination of a lessons module about nuclear fusion and has reached tens of thousands of students in its five editions. The Fusion Road Show was conceived in 1999 with regular upgrades in collaboration with experts from research and theater. The show is consistently rated 4-5 out of 5 by the students and teachers and has helped inspire many students to a science career and fusion research projects at DIFFER.

Education

DIFFER is proud to help train the next generation of energy scientists. PhD students at DIFFER are an integral part of our research groups, as are higher education students performing their Bachelor or Master research at the institute. By teaching courses at Dutch universities, our staff help attract top students to the institute *(see page 28)*.

25 PhD students

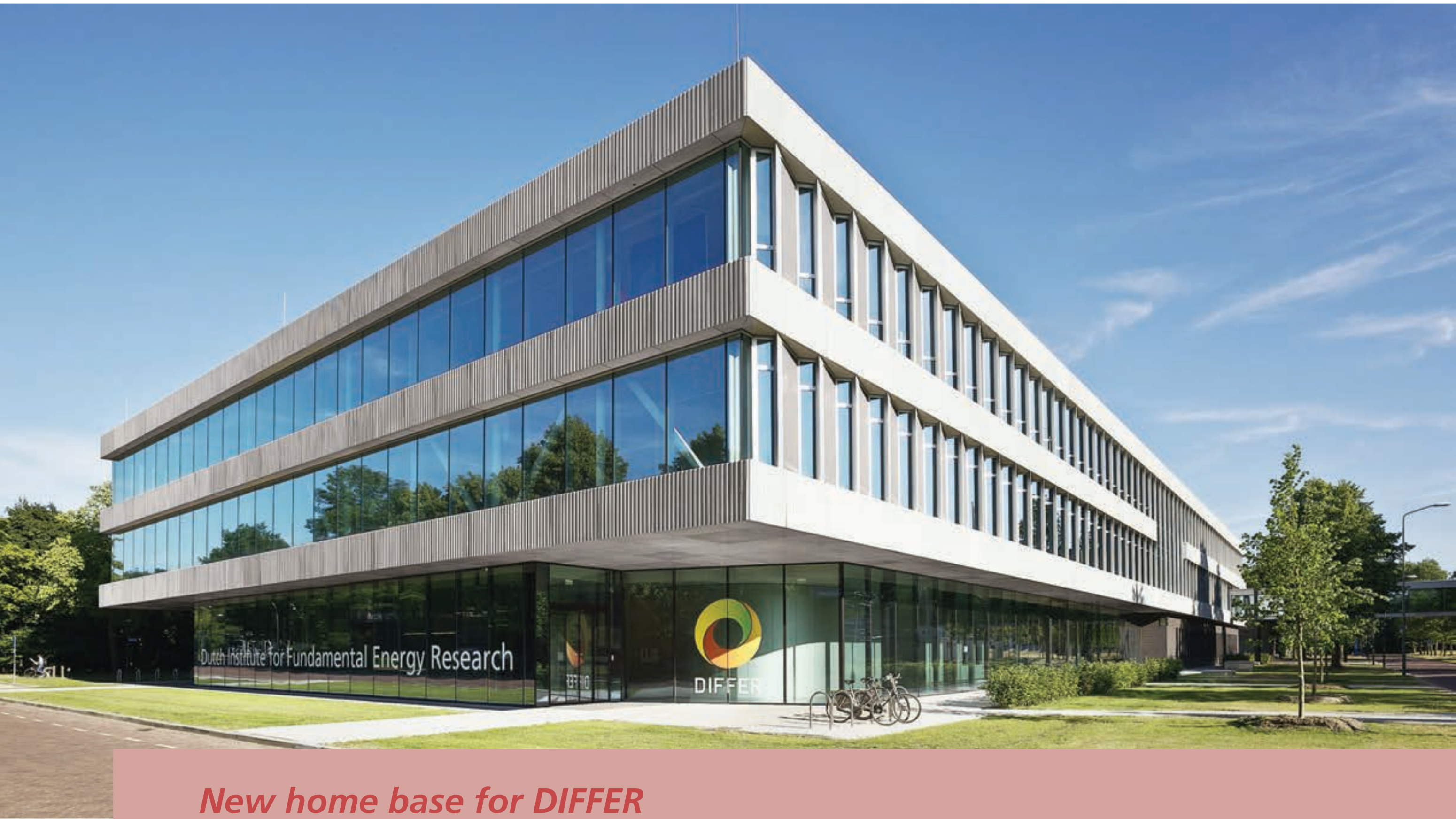
12 Master & BSc students

4 Staff w. university professorship

8 University courses taught

Energy discussion during the DIFFER open day in October 2015

5 New home base



New home base for DIFFER

When DIFFER started its mission of fundamental energy research in 2011, it was clear that it would need a new home base for its work. This would give the institute the space to grow with new research groups and facilities, but also a closer connection to the research, education and high-tech industry. After an open procedure involving all science faculties at Dutch universities, it was decided to relocate DIFFER to a brand new building on the campus of Eindhoven University of Technology.

Grow and diversify

With room for 200 people, the new DIFFER building offers ample space to expand the institute's research groups. This process is already underway, with the solar fuels theme now counting ten research groups of physicists, chemists, materials researchers and engineers. This growth will continue in 2016 with the expansion of the fusion energy theme and the relocation of the offices and laboratories of Syngaschem BV to DIFFER (page 22).

Ion-beam facili

Facilities

In the two halls at the core of the building and in smaller labs in the outer shell, experimental facilities for fusion and solar fuels research are being set up. This includes new chemical, optics, material deposition and plasma laboratories, as well as DIFFER's unique facility for plasma-surface interactions Magnum-PSI. Bridging the two research themes is a 3.5 MV ion accelerator, which DIFFER is installing in the hall next to Magnum-PSI. The new Ion Beam Facility will allow researchers to follow surface and subsurface properties and processes in materials for fusion and for solar fuels (page 14).

Watch the DIFFER opening ceremony and symposium on YouTube: http://tinyurl.com/jcdvft6

Shaping future energy

Ellen Williams (director of the US energy research agency ARPA-E, left) and Sander Dekker (State Secretary for Education, Culture and Science, middle) officially opened the new DIFFER building on Thursday 19 November 2015.

Together with the visiting dignitaries, our 300 guests and staff celebrated the opportunities that DIFFER's new home base is providing. The key message of the Shaping Future Energy-day was the need for close, cross-disciplinary collaboration to realise future energy technologies. "Researchers here are working on clean energy for the future. With its unique facilities, this institute is a magnet for scientific talent to come do their work here in Eindhoven." State Secretary Sander Dekker (Ministry of Education, Culture and Science).

"The best findings result from a collaboration between different disciplines", says State Secretary Dekker. His message was well received by the diverse list of participants from the worlds of research, higher education, industry and government. In a scientific symposium they explored multidisciplinary approaches to the energy transition. Laboratory visits to innovative research in fusion and solar fuels and a reception rounded out the opening event.

Rector Magnificus Frank Baaijens of TU/e: "It is a pleasure to welcome the institute to this dynamic campus environment, with ambitious and entrepeneurial students. TU/e and DIFFER are already working together and the coming years, the number of joint appointments will only grow further. I see many opportunities for us to make the difference in energy research."

Ellen Williams, director of the US government's agency for energy research ARPA-E, sees a large role for government-sponsored research. "Fundamental research into technology that can solve the climate and energy challenges will not happen spontaneously in the private sector. There must be a first impulse to build on. I cannot imagine a worthier goal for our greatest minds and our public resources."

Most sustainable Dutch research building

Working on a sustainable future was not enough for DIFFER; with our new building we already wanted to set a record in sustainability today. On 19 November 2015, DIFFER became the first research building in the Netherlands with an Excellent certificate from the BREEAM-NL sustainable building code.

Responsible energy use is the first measure which comes to mind and the new building has a lot to offer here: triple glazing, a connection to the campus thermal storage, and 922 solar panels of the roof, good for at least 189.000 kWh annually. But there is more to sustainability than energy use; BREEAM-NL ranks a building's sustainability in nine different categories from energy and materials use to ecology, public information and wellbeing.

Nowhere is this broad definition of sustainability more visible than in the sawtooth facade. The angle of the long and short windows in the sawtooth, extended by aluminum fins, is calculated so that the north-facing short windows never face direct sunlight during work hours. Designer Koen Klijn (Ector Hoogstad Architects): "The facade ensures daylight entry even when the sun screens on the large window panes are down. This reduces the need for artificial lightning and also results in more comfortable working conditions."

Birds and bats

When the DIFFER site was prepared for construction, a series of Tilia trees housing local populations of common pipostrelle bats and common swifts had to be relocated to the north side of the campus. To provide a home for the bats and birds living in the trees, nesting sites were built into the building facade. A line of trees was planted back after construction and will in time provide more nesting space.

Sawtooth facade

Traveling to and from DIFFER

DIFFER encourages the use of public transport by its employees and our visitors. This is aided by the dedicated 104 bus service to the TU/e campus running during rush hours, and there are information screens about public transport services at the main exit and walkway.

On 19 November 2015 Guido Slokkers (Dutch Green Building Council) awarded the BREEAM-Excellent certificate to Wim van Saarloos, programme director of the transition of NWO (Netherlands' Organisation for Scientific Research) and chairman of the steering group for DIFFER's new building.

Change of scenery

"A new building shakes up the way you work and work together", say DIFFER's head of HR Henk Tamsma and communications advisor Arian Visser. Together they reflect on the way the institute is reinventing itself.

Henk Tamsma loves the many windows into DIFFER's offices and laboratories. "I can see the institute growing. Labs taking shape, visitors meeting our staff, discussions in the central coffee corner - there is a lot of energy going around." Arian Visser agrees: "You can feel the focus shift. The really hard part was the personal impact of having your place of work move 82km. FOM helped ease the transition with a solid plan for work-from-home solutions, travel costs, and so on. People are finding their new rhythm now."

Tamsma: "What I appreciated was the programme to introduce people to our new environment when we were still in Nieuwegein. Take the idea of visiting both the building site and future colleagues on the TU/e campus - it showed people the possibilities."
"The real change came from people themselves, not from some communications agenda", says Visser. Right from the start of DIFFER's new mission, he saw people step up who saw opportunities: "'Who in my network can I tap for expertise? When can I have my first experiment up and running in Eindhoven?' You need these frontrunners to clear the way for their colleagues."

Boosting the impact of these pioneers is DIFFER's shift to smaller, more flexible research groups. Tamsma: "I see many young people coming in, eager to make a name for themselves in energy research." Tamsma laughs: "And of course each has their own wish list which requires custom work by the support facilities! Change the primary process, change the way you need to support it. We're right in the middle of that process." Visser is confident of the outcome. "I see an enduring love for the job and great flexibility. People here want to help create things that matter for society."

6 Facts & Figures

Output

33 PhD students

12 Master & BSc students

3 Technical interns

8 University courses taught

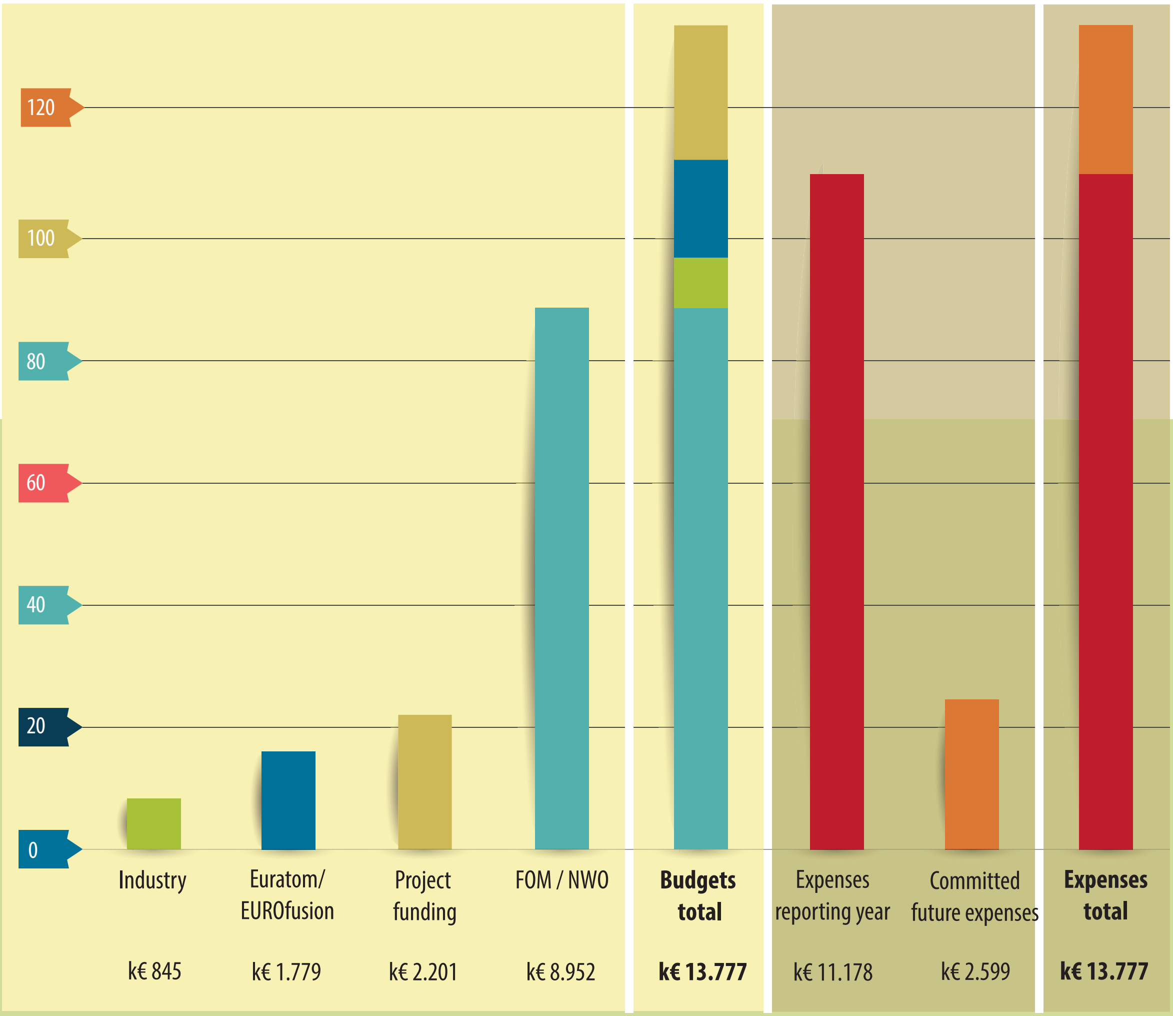
6 PhD theses

106 Publications

41 Invited talks

2 Book chapters

Funding and expenses 2015



Organisational chart

THEME LEADER FUSION
M.R. de Baar

DIRECTOR
M.C.M van de Sanden

INSTITUTE MANAGER
W.R. Koppers

THEME FUSION ENERGY

- Computational Plasma Physics High Temperature — *E.G. Westerhof*
- Computational Plasma Physics Low Temperature — *E.G. Westerhof a.i.*
- Plasma Diagnostics — *M.R. de Baar*
- Tokamak Physics — *M.R. de Baar*
- Plasma Surface Interactions Engineering — *vacancy*
- Plasma Surface Interactions Facilities & Instrumentation — *H.J.N. van Eck*

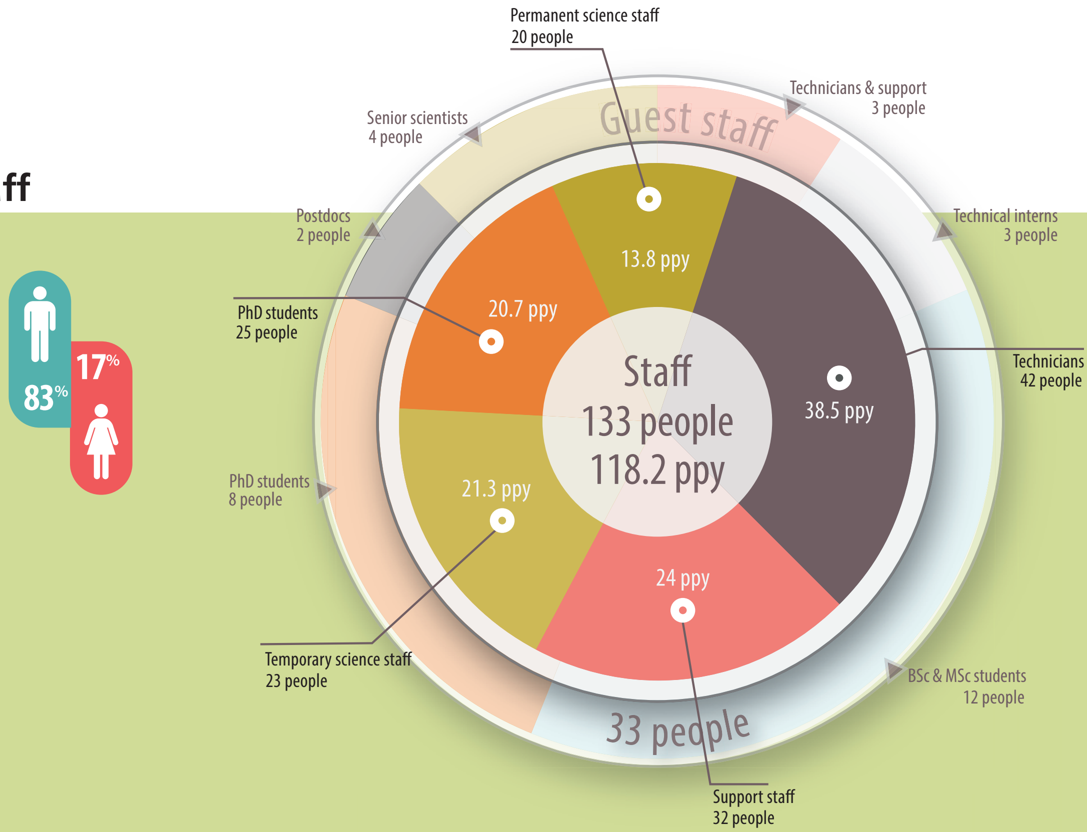
THEME SOLAR FUELS

- Atmospheric Plasma Processing of Functional Films — *H.W. de Vries*
- Photo-electrochemical Materials and Interfaces — *A. Bieberle*
- Photoelectrocatalysis for Solar Fuels — *M. Tsampas*
- Materials and Surface Science — *M.A. Gleeson*
- Nonequilibrium Fuel Conversion — *G.J. van Rooij*
- Nanomaterials for Energy Applications — *A. Baldi*
- Plasma Solar Fuels Devices — *W.A. Bongers*
- Molecular Solar Energy (Tu/e) — *R. Janssen*
- Solar Fuels Facilities & Instrumentation — *S. Welzel*
- Photonics for Energy — *J. Gómez Rivas*

SUPPORT FACILITIES

- Occupational Health & Safety — *F.F. Hekkenberg*, *A.M.M. Arends*
- Communication — *F.T.M.E. de Vries*
- Electronics & ICT — *A. Broekema*
- Financial Administration — *M.P.M. Schoonen*
- Management Support — *W.R. Koppers*
- Mechanical Techniques — *F.J. van Amerongen*
- Personnel & Organization — *H. Tamsma*
- Technical Service — *K. Grootkarzijn*
- Facility Management — J.E. Kragten
- Estate Management — *A. Bikker*

Staff



Committees

Management Team

M.C.M. van de Sanden (institute director; theme leader solar fuels)
W.R. Koppers (institute manager)
M.R. de Baar (theme leader fusion energy)

Scientific Advisory Committee

G. van der Steenhoven (University of Twente; chairman)
D.J. Campbell (ITER)
A. von Keudell (Ruhr-University Bochum)
D. Lincot (Institut de Recherche et Développement sur l'Energie)
E.B. Stechel (Arizona State University)
Y. Ueda (Osaka University)
H. Werij (TNO)

Employees Council

E. Langereis (chairman)
B. Elzendoorn
H. Genuit
J. Stroet
A. Tamminga
T. Verhoeven
W. Bongers
M. J. van Veenendaal *(official secretary)*

For a full list of employees per group, please see the online appendix at: http://www.differ.nl/about-us/annual_reports

Below: DIFFER staff in front of the new building in April 2016