DIFFER
Dutch Institute for Fundamental Energy Research
Edisonbaan 14
3439 MN Nieuwegein
The Netherlands

PO Box 1207
3430 BE Nieuwegein
The Netherlands

www.differ.nl

New address per April 2015:
Dutch Institute for Fundamental Energy Research
De Zaale 20
5612 AJ Eindhoven
The Netherlands

PO Box 6336
5600 HH Eindhoven
The Netherlands

www.differ.nl

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).

Annual Report 2014

Dutch Institute for Fundamental Energy Research

Index

Various images in this report link to online movies or animations via QR-code and web address.
The full list of the institute's output and an overview of the DIFFER staff is given in the online appendix:
www.differ.nl/annual_reports

Colophon

Editor in chief — Wim Koppers
Editor & coordination — Gieljan de Vries
Layout editor & design — Melanie van der Vlis
Reading committee — Richard van de Sanden, Wim Koppers, Marco de Baar, Arian Visser, Egbert Westerhof, Erik Langereis
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Cover image — Last plasma event Magnum-PSI in Nieuwegein, on 31 October 2014.

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We are ready

Preface

The Dutch *Energieakkoord* outlines the ambition to reach a fully climate neutral energy system by 2050. The transition is well under way already, for instance in our German neighbors' *Energiewende*, and demands the highest of our ingenuity. At DIFFER, we are inspired by the promise of future energy technologies. Our approach to realising them is fundamental research in close collaboration with the entire knowledge chain of sustainable energy, from university research groups and technology institutes to industrial partners.

Ever higher device efficiencies, clean production processes, use of abundant materials - these topics transcend the scientific mono-disciplines. With our workshop series *Science and the Energy Challenge*, we invite Dutch science to organise itself across disciplines and develop novel applications for sustainable energy.

In our solar fuels theme, we aim to tackle supply and demand mismatches in sustainable energy, by converting sustainable energy (e.g. solar and wind energy) into high energy density fuels. From the original line on plasmolysis the group is now diversifying and attracting new talent. External funding for the research projects has been secured from FOM and NWO-Chemical Sciences. This has lead to the appointment of two tenure trackers at DIFFER with a photo-electrochemical approach to solar fuels. In preparation for the relocation to our new laboratory, their first experiments are already set up on the TU/e science park. Our collaboration with TU/e is taking further shape with the formation of a new research group that the university will contribute to DIFFER and which will focus on converting light to fuels. Lastly, first results from our Industrial Partnership Programme with Fujifilm Research show the clear potential of atmospheric plasma processing in producing functional foils with sustainability applications.

DIFFER's fusion department has proven the potential of our linear plasma generators such as Magnum-PSI with studies on wall materials for fusion reactors. Together with international partners we investigated tungsten as wall material for the ITER fusion project, and started research on liquid metals as an advanced concept for fusion reactor walls. International interest in our PSI experiments is so high that we decided to keep Pilot-PSI operational until October 2015, while its big brother Magnum-PSI is being installed in Eindhoven. We are also expanding our research in understanding and control over fusion plasmas. Two personal grant winners are gearing up to study the fundamentals of steady state and dynamic heat exhaust at the edge of fusion plasmas.

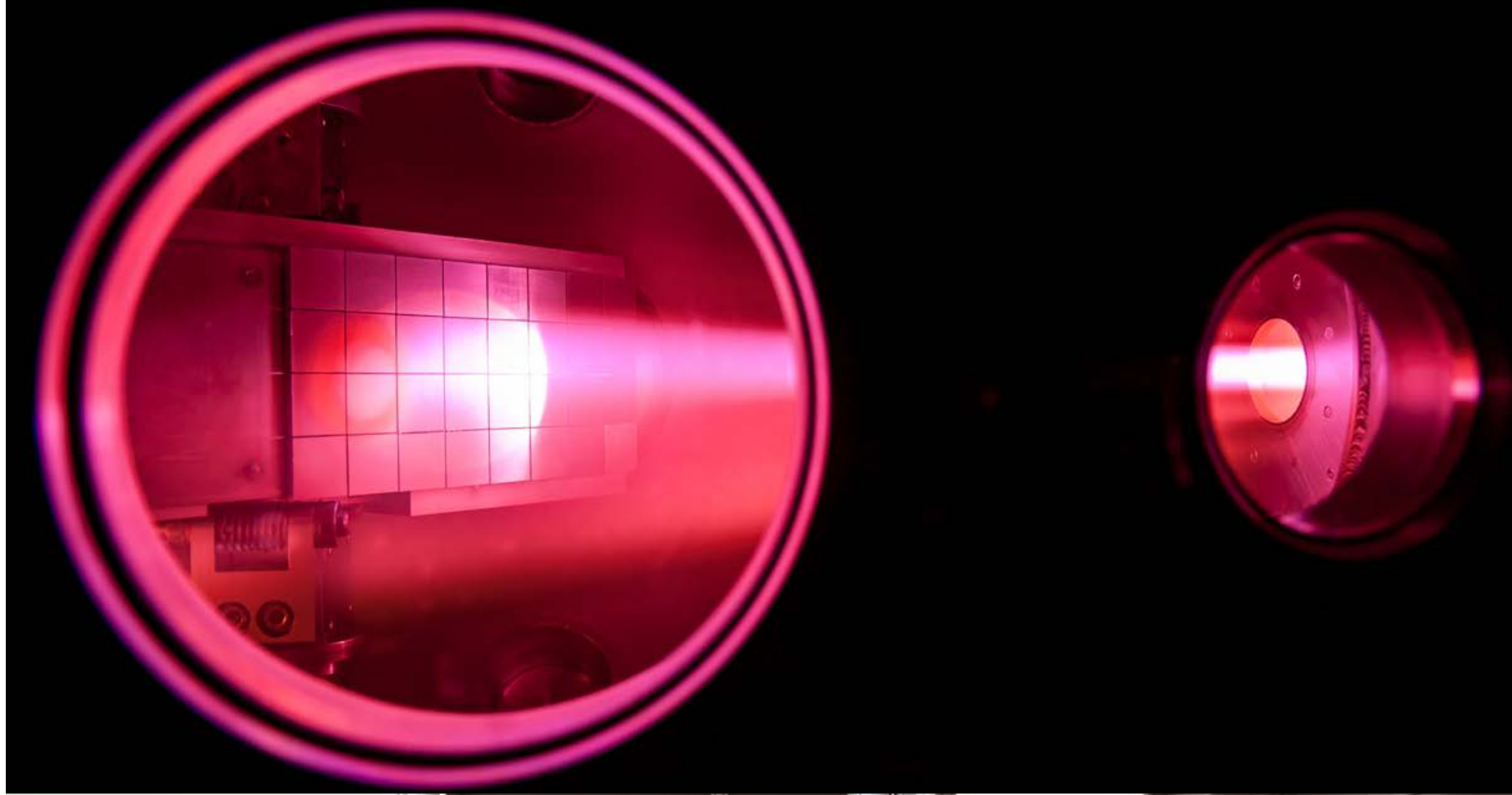
In a few months' time, DIFFER will move to a highly sustainable new building at the heart of the TU/e Science Park. Preparations are on-going throughout the institute. Experiments are dismantled and scheduled for transport, operations teams are planning upgrades and expansions of equipment, offices and storage spaces are inventoried - the impact on our staff is great, and I am proud to see the energy with which they are rising to the challenge. Of course, we have the good example of the efficient way our nSI division already completed its own relocation to Twente University at the start of 2014.

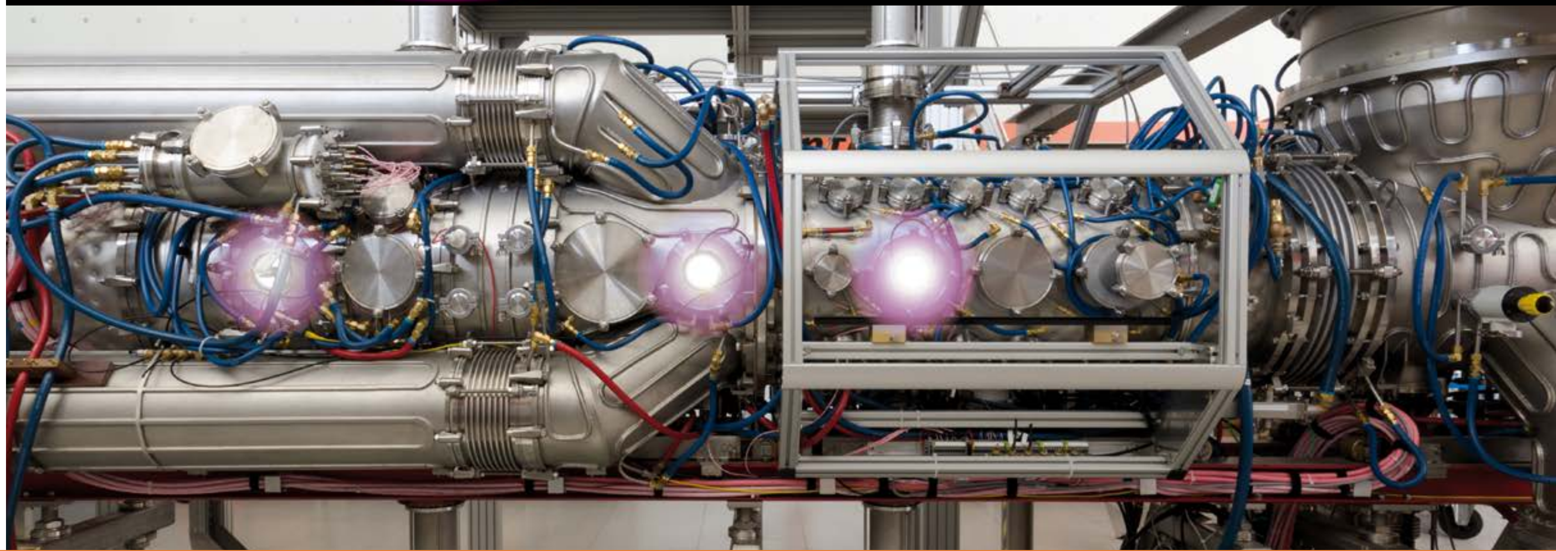
What will 2015 bring? Building up research facilities and connecting to our neighbors on the TU/e campus. An energizing prospect.

Richard van de Sanden,
Director

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

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 in close partnership with academia and industry. To successfully transfer fundamental insights to society at large, we are actively building a national community for energy research.

Science for Future Energy

To tackle the issues of the energy challenge and climate change, we need to develop sustainable energy on a global scale. By the end of the century, our current fossil-dominated infrastructure must be replaced by a fully sustainable system. This transition is one of mankind's biggest challenges of this century. As national institute for fundamental energy research, we seek to build the interdisciplinary networks capable of solving the myriad of scientific questions involved. Our own research efforts are focussed on two themes: solar fuels for sustainable energy storage and transport, and fusion as a clean, safe and inexhaustible power source.

Fusion has the potential to provide concentrated, safe and clean energy from the process which powers the sun and stars. DIFFER's two fusion research programs both address 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 future fusion reactor conditions. Our program on control in burning plasma 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.

Our division on Nanolayer surfaces and interfaces completed its relocation to the University of Twente in 2014. The focus group XUV Optics will continue its pioneering work on multilayer mirrors for Extreme Ultraviolet wavelength photolithography and other applications. As a prime example of the 'Topsectoren' philosophy, the group includes both scientific and industrial partners so that new innovations can be developed right from the very initial stages of know-how.

Science & politics

On 25 February 2014, Member of Parliament Stientje van Veldhoven (D66) visited DIFFER. She had a discussion with our team on the roles of research and industry in achieving the energy transition, and toured our solar fuels and plasma surface interactions experiments.

30 months of fusion exhaust

Our main experiment Magnum-PSI started experiments in January 2012 and is the only laboratory setup in the world that can expose materials to the intense plasmas expected near the exhaust of future fusion reactors. This has allowed the team to make clear contributions to solving issues for ITER, such as the effect of transient heat loads on materials. For highlights of the research, see pages 12 and 13.

Magnum-PSI produced its last plasma beam at its current location in Nieuwegein on 31 October 2014. The team is now preparing the set-up for its relocation and upgrade to continuous plasma production with a superconducting magnet at our new Eindhoven location (see pages 28 and 29).

http://goo.gl/1lyQ2J

People

Plasma wall interactions at ITER

In 2014, Greg De Temmerman joined the international ITER project as coordinating scientist for the plasma edge and plasma wall interactions. From 2010 to 2014, De Temmerman headed DIFFER's research on plasma surface interactions. He successfully positioned the institute's facilities Magnum-PSI and Pilot-PSI at the front of materials research under the extreme conditions in a fusion reactor.

Richard Pitts (ITER, left) and Greg De Temmerman (right) at the Magnum-PSI opening ceremony in 2012

Tony Donné (second left) at the EUROfusion launch event in at the Solvay Library in Brussels. Director-General of DG Research & Innovation Robert-Jan Smits and Sybille Günter, Chair of the EUROfusion General Assembly, signed the grant agreement between EUROfusion and the European Commission.

EUROfusion program manager

DIFFER's head of fusion research Tony Donné was appointed as EUROfusion program manager in 2014. This new Horizon2020 consortium EUROfusion was launched to realize the ambitious Fusion Roadmap: fusion electricity on the grid by 2050. The consortium brings together 29 fusion research institutes in one of Europe's largest scientific collaborations.

"EUROfusion helps us share knowledge and focus the European fusion research efforts", Donné explains. "For instance, by financing joint programs or ensuring that scientists have access to international research facilities. I think DIFFER is in an outstanding position to benefit from the new framework. The institute's fusion research lines are well aligned with the EUROfusion Roadmap and DIFFER boasts an excellent network of national and international research partners." As a EUROfusion partner, DIFFER wants to join with Dutch universities and companies in a coherent program to optimally connect to the European research agenda.

News clippings

PhD theses in 2014

Nine PhD students at DIFFER completed their research and successfully defended their PhD thesis at a Dutch university in 2014. Of these nine, one worked in the nSI theme and eight in the fusion theme, on plasma surface interactions (3 PhDs) and on control of burning plasma (5 PhDs).

Personal grants for advanced fusion diagnostics

Two DIFFER scientists received prestigious *Vernieuwingsimpuls* Grants from the Netherlands Organisation for Scientific Research (NWO).

Wouter Vijvers (right) won one of NWO's Veni scholarships for post-doc researchers with a research proposal for a novel plasma diagnostic. This will allow him to tackle the challenges of determining the state of the plasma near the reactor exhaust (divertor) in real-time. The long-term goal is to extend the lifetime of the reactor walls in future fusion energy plants. This information will then be used to actively control advanced shapes of the divertor plasma.

In addition to the Veni grant, Ivo Classen was granted an NWO Vidi scholarschip. For more information about the research in this project, see page 17.

NWO

Veni grant for Wouter Vijvers

Research 2

Fusion

2.1 *Plasma surface interactions*

The plasma surface interactions group investigates how materials behave under extreme plasma loading conditions. Finding and designing materials able to withstand such conditions in fusion reactors, is a large challenge in itself, and understanding and controlling the interaction of a fusion plasma with the reactor wall is vital. Conversely, the far from equilibrium conditions caused by the bombardment of huge numbers of low energy ions, also offer new opportunities. The team will exploit these for the synthesis of advanced nanostructured materials.

The plasma surface interactions program actively studies:

- Surface evolution under extremely high ion fluxes
- Ion species retention and diffusion in materials
- Synergistic effects of transient and steady heat and particle loads
- Use of liquid metals as a plasma facing material in future fusion reactors
- Novel plasma processing techniques for material synthesis and modification

The DIFFER-based high flux linear plasma generators Magnum-PSI and Pilot-PSI provide access to regimes that are otherwise unavailable in today's fusion research devices. They also give ample diagnostic access and sample manipulation under controlled conditions. Both machines can reach enormously high heat (over 30 MW/m^2) and particle fluxes (over 10^{25}/m^{2}s), which can even exceed those expected in the ITER divertor at a similarly low electron temperature. The machines can replicate transient events known as Edge Localised Modes (ELMs) which expel bursts of ~1 GW/m^2 of energy and particles from the fusion plasma onto the material wall.

A smaller device nano-PSI permits comparison of material modification effects at lower fluxes than in Magnum-PSI and Pilot-PSI, and has been used to investigate nanostructuring of metal surfaces under ion bombardment as well as the growth of carbon nanowalls and structures.

Experiments are supported by simulations of erosion and transport using the ERO code, while a kinetic model for the neutral particle species in the plasma vessels (EUNOMIA) has been created in-house and coupled to the fluid model code B2. This is currently being converted to tokamak (toroidal) geometry which allows a stronger coupling between linear machine results and those of future fusion reactors.

Program leaders

Greg De Temmerman, Hans van Eck, Wim Goedheer

Funding

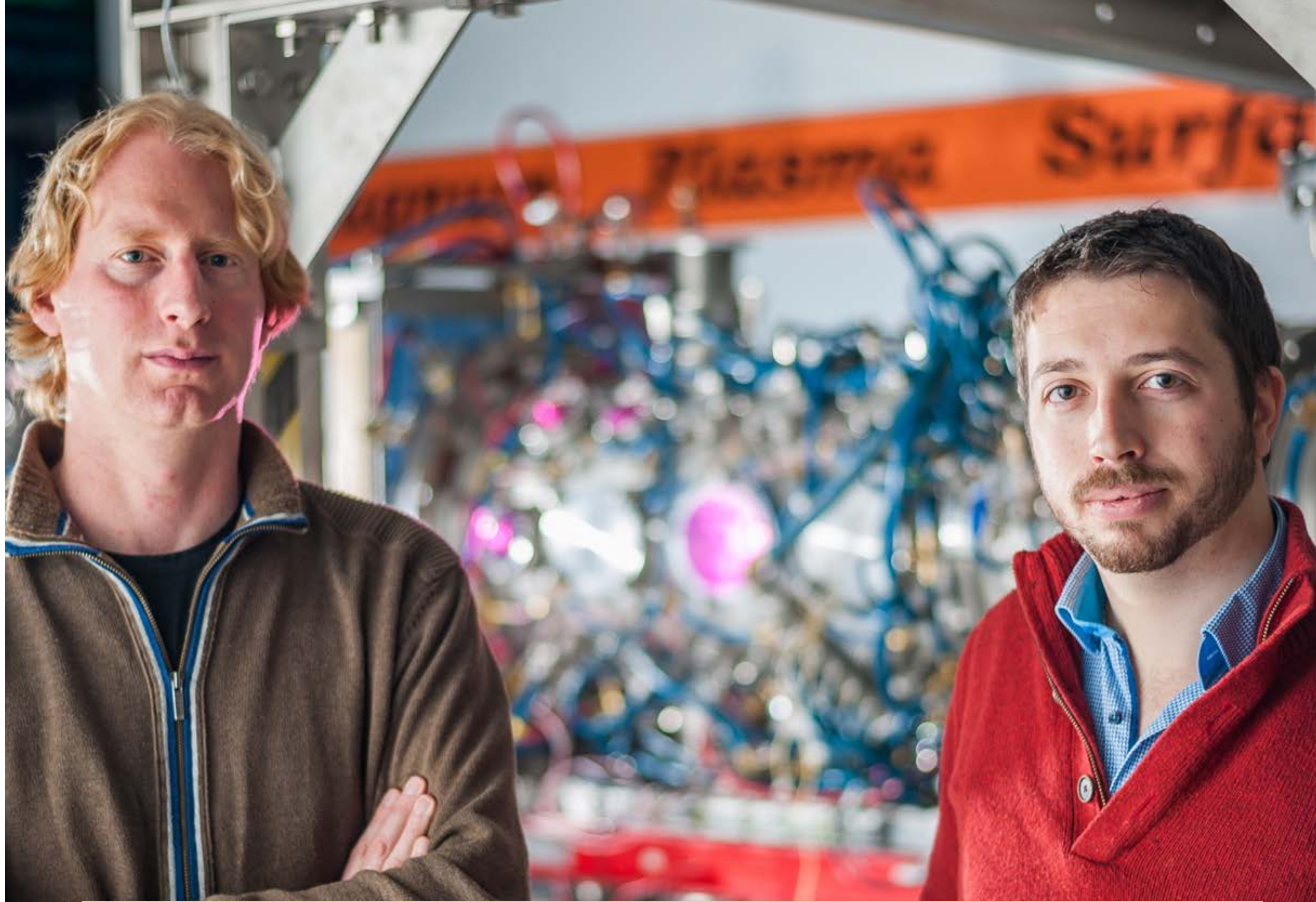
FP-75 - PSI-lab; FP-148 - Magnum-PSI; FOM-TU/e Impulse program; EUROfusion consortium, ITER Organisation service contract, Erasmus Mundus Fusion DC

Grants

Sebastien Bardin – EUROfusion Researcher Fellowship

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; IFP-CNR, Milan, Italy; IOFFE Institute, St Petersburg, Russia; IPP Garching, Germany; ITER IO divertor section, 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; VTT, Finland; 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



Exploring the surface of the Sun on Earth

Heat spikes of a gigawatt per square meter, a 10.000 degree abrasive blast of charged particles - the exhaust of future fusion reactors faces extreme challenges. Tenure track researcher Thomas Morgan (right) and facility manager Hans van Eck (left) explore materials under reactor-relevant conditions with DIFFER's worldwide unique experiment Magnum-PSI.

Morgan: The interplay of plasma and reactor wall has a big influence on the reactor performance. Understanding and controlling this interplay will be a crucial topic for the ITER fusion project. To explore the range of conditions that are relevant to ITER and beyond we exploit the unique Magnum-PSI and Pilot-PSI devices.

Van Eck: In Magnum-PSI we can create ITER-relevant plasmas with an ease of operation and diagnostics access you do not find in a tokamak. To operate a machine like this you really need a "large facilities" culture. DIFFER has a very high-level technical support and a dedicated facilities and instrumentation team. Together they allow a very high level of research to continue while also working towards steady-state operation with a superconducting magnet.

Morgan: The continuous magnetic field allows us to maintain the plasma beam for as long as we want, so we can explore how materials respond to extremely long-term exposure to ITER-like plasmas. We want to help design a system which can stand up to the even more intense conditions in a fusion power plant. Ideas we will explore in my new group are a flowing liquid wall to quickly replace eroded material, or self-healing materials in which cracks draw in mobile atoms and repair themselves.

Van Eck: This year our team worked hard to both support such new research and prepare for the relocation. Everybody is committed to relocating Magnum-PSI to Eindhoven as soon as possible and expand our capabilities with the new magnet and ion beam materials diagnostic (page 12).

Morgan: We want to explore a regime which is highly relevant to ITER. It is a big question mark right now: how do materials behave under these intense conditions on very long time scales? This regime hasn't been reachable anywhere else. With the new capabilities, we can position Magnum-PSI as the world's premier facility for replicating and exploring ITER-divertor relevant conditions.

Long term performance of fusion reactor wall material

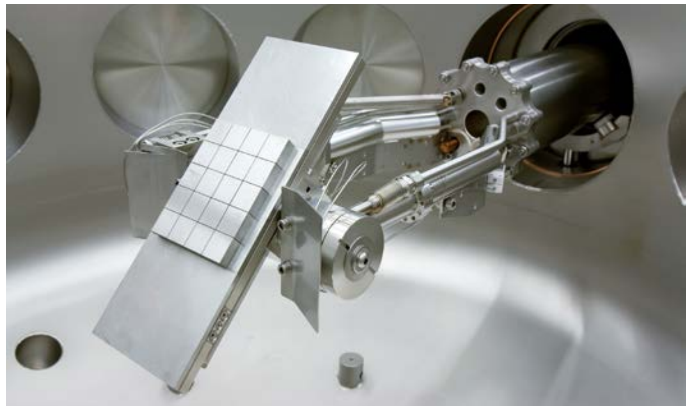
Under contract by the ITER Organization, our experiments Magnum-PSI and Pilot-PSI investigate the long-term performance of ITER's planned wall material tungsten. Our two experiments are uniquely capable of exposing materials to the extreme conditions expected near the ITER exhaust. While no surface modifications were found, the results indicate a progressive change in the thermal response of the tungsten which merits further research.

Wall materials in future fusion reactors will be exposed to intense heat and particle loads, on top of which trains of so-called Edge-Localized Modes (ELMs) will strongly increase heat and particle fluxes on a very short timescale. Wall material resilience under the combination of these thermal shock loads, thermal fatigue and steady state plasma operation is a top research priority for fusion.

ITER will be outfitted from the start of operations with a full tungsten divertor. One of the highest risks with this system is that the tungsten surface could melt shortly during an ELM. Over time, repetitive shallow melting is then expected to cause gross surface topological deformation. Presently, it is unclear how such strong material modifications may affect the long term behavior of these components.

During our experiments we exposed a tungsten target to 1400 seconds of plasma and over 9000 ELM-like energy bursts, after first melting it transiently in Pilot-PSI. We saw no apparent evolution or modification of the surface, but we did see evidence that the temperature response of the surface to identical ELMs rose by 40% over the series. This indicates a progressive change in the thermal response of the tungsten target, which could be of concern for the divertor long term performance.

Sebastién Bardin et al: Evolution of transiently melt damaged tungsten under ITER relevant divertor plasma heat loading, J. Nucl. Mater. (2014)



Tungsten monoblocks mounted on the target holder in Magnum-PSI. This target holder can tilt and turn to expose a surface to the intense plasma beam.

Ion accelerator to probe surface modifications

A modern 3.5 MV particle accelerator acquired in 2014 from Acctec B.V. allows DIFFER to expand its materials analysis arsenal with an ion beam facility. This facility will open up unique research opportunities for experiments in fusion and solar fuels, and will also be accessible for external groups from academia and industry. With the new diagnostic a plethora of analytical techniques for depth resolved chemical characterization of materials comes available. These are based on various interactions between MeV ions and solids, such as scattering, nuclear reactions, and excitation and ionization processes.

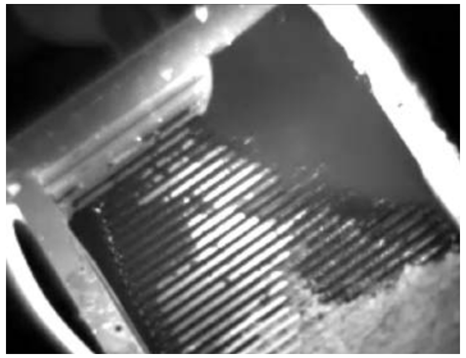
Flowing liquid lithium as a fusion reactor wall

The exhaust region or divertor of future fusion power plants will have to withstand extremely large heat and particle fluxes continuously for hours or days at a time. DIFFER and the TU/e explore such conditions in their joint Extreme Materials progamme.

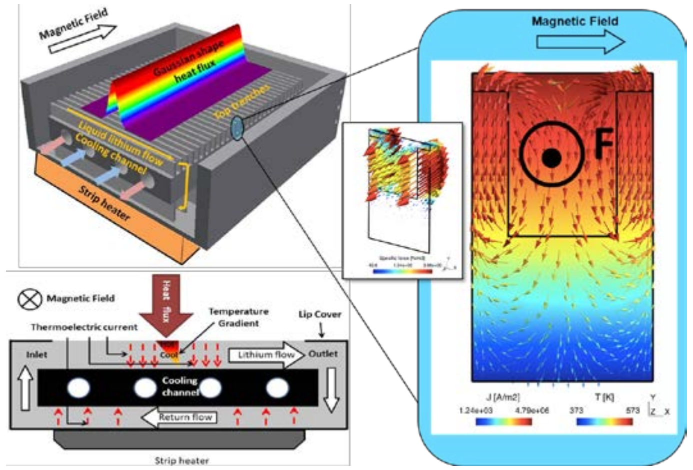
A constantly replenishing wall made of flowing liquid metal would avoid erosion, irreversible damage or even melting in a solid wall. Together with the University of Illinois, we explore the concept of the flowing liquid lithium divertor concept (LiMIT).

Lithium in LiMIT uses Lorentz forces from naturally occuring temperature gradients and the magnetic field in the reactor to pump itself through a series of trenches. We tested the cooling properties and stability of the component under the high heat fluxes and long timescales reachable in Magnum-PSI and found encouraging results. For instance, measured flow velocities agree well with theoretical predictions, and can successfully convect heat away from the plasma beam. The trenches can also harness surface tension to produce far less droplets than an open pool concept, and many droplets were returned to the surface after being entrained by the plasma beam. This will help keeping the core plasma clean in a real reactor.

Peter Fiflis et al: Performance of the Lithium Metal Infused Trenches in the Magnum PSI Linear Plasma Simulator - in preparation



Still from video of LiMIT in the Magnum-PSI plasma beam (http://goo.gl/770UJi)



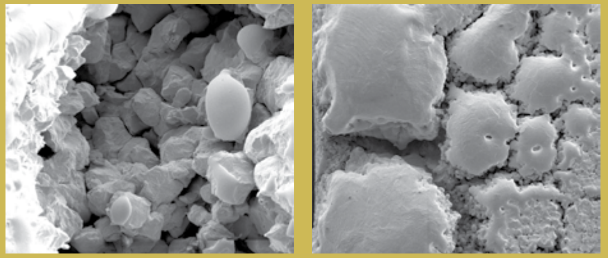
Heating of one side of the trenches combined with cooling of the other side (top left) gives rise to thermoelectric currents in the lithium and trench walls (right). In a magnetic field this promotes lithium flow (bottom left).

Simulating the transport of eroded impurities in fusion plasma

How does hot plasma in a fusion reactor erode the wall, and how is the eroded material transported through the plasma? At the exhaust of a fusion reactor, impurities and the fusion product helium are removed from the reactor. However, the high heat and particle loads on this designated part of the wall can erode its surface. Gijs van Swaaij investigated this process in his PhD thesis.

Model calculations with the numerical code ERO simulate this erosion of a carbon reactor wall. The study shows how eroded material enters the plasma, which processes can spread such impurities through the reactor, and where they are redeposited.

Gijs van Swaaij, Studies of impurity transport in high density, low temperature plasma with the ERO code (2014), PhD thesis at Eindhoven University of Technology



Detail of melted targets

Fusion

2.2 Control in burning plasma

Fusion research aims to develop a clean, safe and sustainable energy source based on the process that powers the sun and stars. With the construction of the ITER experiment in Cadarache in France, a global effort is underway to build the first ever fusion reactor to produce more power from fusion than the device requires: a so-called burning plasma.

ITER will be the first fusion reactor to produce a plasma dominated by fusion heating. The fusion heating power is transferred to the plasma by collisions between alpha particles and the bulk plasma. Thermalized alpha particles are referred to as helium-ash. At fusion relevant conditions, the plasma is prone to a variety of magnetohydrodynamic (MHD) instabilities.

The research program Control in burning plasmas aims at understanding the strongly coupled systems of MHD instabilities and energetic particles. We strive to develop active control of the instabilities, which is a prerequisite for successful ITER operation with the planned tenfold multiplication of power input.

The research groups in the program are directly involved in the design of ITER components. The development of high resolution multi-channel diagnostics allows the measurement of small scale structures in hot magnetized plasmas. These novel diagnostics concepts lead to new insights in plasma physics, which feed into the development of sensors, actuators, and models for the control of MHD instabilities. The diagnostics and control work are supported and inspired by mathematical and numerical modelling of MHD instabilities and their real-time control.

Physics and control oriented models have been developed, and high end diagnostics, sensors, and controllers have been installed on various experiments such as the ASDEX-Upgrade tokamak in Garching (Germany), the Joint European Torus (UK), TCV (Switzerland), MAST (UK), Tore Supra (France), and LHD (Japan).

The instrumental work for ITER is organized within the framework of ITER-NL, a consortium consisting of four Dutch research institutes: TNO, DIFFER, NRG and Eindhoven University of Technology (TU/e). ITER-NL aims to facilitate front-line participation of Dutch researchers in the scientific exploitation of ITER and to enable Dutch companies to have strong participation in ITER. Together with HIT and Dutch Space, DIFFER exploits a state of the art virtual reality simulation of ITER to validate remote handling maintenance procedures.

Program leaders

Tony Donné, Marco de Baar, Egbert Westerhof

Grants

NWO Vidi - Ivo classen
NWO Veni - Wouter Vijvers

Funding

FP-120 - Advanced Control of Magnetohydrodynamic Modes in Burning Plasmas, ITER-NL2, EURATOM, EFDA, EFP, NWO, NWO-RFBR CoE, TU/e, US-DOE

Collaborations

ASIPP, Hefei, China; CCFE, Culham, UK; CEA, Cadarache, France; CWI, Amsterdam, NL; DTU, Risø, Denmark; EPFL CRPP, Lausanne, Switzerland, ERM-KMS, Brussels, Belgium; FZJ, Jülich, Germany; IAP, Nizhny Novgorod, Russia; Ioffe St., Petersburg, Russia; IPP Garching, Germany; IPF Stuttgart, Germany; ITER IO, Cadarache, France; KIT, Karlsruhe, Germany; Kurchatov Institute, Moscow, Russia; NFRI, Daejon, Korea; NIFS, Toki, Japan; NRG, Petten, NL; SWIP, Chengdu, China; TNO, Delft, NL; TU/e, Eindhoven, NL; UC-Davis, USA; University of Pohang, Korea, Utrecht University, NL

Controlling a fusion plasma via contaminants

Fusion researcher Ivo Classen will use a NWO Vidi grant to build up a research line on the interplay between ELM-outbursts from the fusion plasma and impurities from the reactor wall. PhD student Branka Vanovac will use Classen's new diagnostic at the ASDEX Upgrade tokamak (see page 17) to study the nature of ELMs. Then the team explores how they cause impurities to be released from the reactor wall in DIFFER's experiment Magnum-PSI.

Classen: At the edge of a fusion plasma, you have to cope with repeating outbursts of energy - ELMs. They leak a lot of power from the plasma to the wall - very bad for the wall, of course. In the experimental reactor ITER we will have ELMs of such a magnitude that it becomes an issue for the wall lifetime.

One idea we have to tackle this problem, is deliberately using the impurities which the ELMs can release from the wall. For instance, experiments have shown that puffing nitrogen gas into the plasma leads to smaller ELMs. We want to study how ELMs trigger impurity release. Magnum-PSI is ideal for this - it has good access for measurements, and switching target materials is much easier here than in a tokamak. In a tokamak you would need to replace the entire divertor, which costs months and millions.

Vanovac: Before we can bring Magnum-PSI into play, we need to really know the details of how ELMs are built up. This is not yet known! The new 3D diagnostic at the ASDEX Upgrade tokamak allows us to get a detailed picture of the structure of ELMs, how long they last, their temperature and density. That's my topic. My fellow PhD student will take those characteristics and feed them to Magnum-PSI.

Classen: In the end, fusion research is about getting the most efficient fusion power station. After ITER, we will have the knowledge to design the first demonstration power plant, DEMO. The 3D diagnostic we are using now is aimed at exploring plasma physics, it will not itself end up in DEMO. What it hopefully will do is teach us how the plasma responds to contaminants from the reactor wall, so we can dampen or maybe even suppress the ELM discharges.

NWO

Predictive controller optimizes tokamak performance

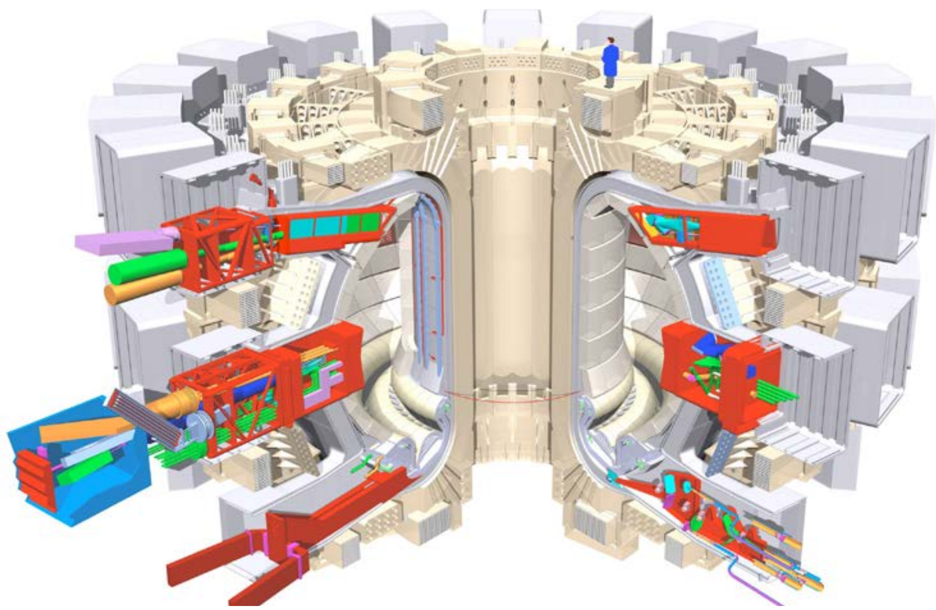
A newly developed predictive controller will allow fusion energy researchers to further improve the performance of their tokamak reactors. The Model Predictive Controller is designed to anticipate and optimize the plasma conditions, while steering clear of unwanted physics or operational limits.

To produce energy from a fusion plasma, the tokamak reactor simultaneously requires plasma stability at high pressure and long energy confinement times. Both are associated with the distribution of the current density in the plasma. The Model Predictive Controller charts a path to the optimal current density distribution using the various actuators in the reactor.

Tests for ITER-relevant scenarios with the nonlinear plasma transport code RAPTOR confirm that the controller can successfully predict the plasma state and formulate appropriate responses. Because the controller takes real-time varying operational and physics limits into account, it can respond to sudden changes such as unpredictable loss of available actuator power. This enables the system to suppress a rapidly developing instability in the plasma by diverting one of its microwave systems for overall plasma shaping. The controller can then reconfigure the use of its remaining actuators to maintain the general plasma conditions until the microwave system is available again.

In follow-up research, the controller will be extended and implemented in existing fusion reactors.

Bert Maljaars et al.: Control of the tokamak safety factor profile with time-varying constraints using MPC. Nuclear Fusion 55 (1), 2015.

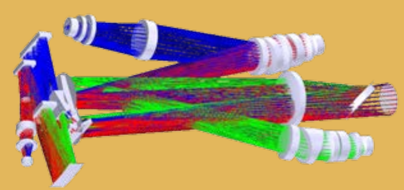


About 50 individual measurement systems will help to control, evaluate, and optimize plasma performance in ITER

Charge Exchange Recombination Spectroscopy

The helium produced in fusion reactors is very energetic, and transfers its energy to the bulk plasma via collisions. The thermalized helium is referred to as the 'ash' of the reactor, and needs to be exhausted. The efficiency of the thermalization and the exhaust determines the reactor performance. Funded by ITER-NL, and as part of a consortium lead by Forschungszentrum Jülich, TNO, TU/e and FOM developed an advanced Charge Exchange Recombination Spectrometer (CXRS) for ITER which is able to track the thermalisation of helium and the radial transport of the ash.

Experimental physicist Athina Kappatou developed experimental methods and theoretical models to improve the analysis of the CXRS instrument on the German tokamak ASDEX Upgrade. Dr. Athina Kappatou successfully defended her PhD thesis on helium transport in fusion reactors at Eindhoven University of Technology on 23 October 2014.



Optics and light paths in CXRS

New diagnostic to resolve ELM structure

Ivo Classen and his PhD student Branka Vanovac want to shed light on one of the biggest unsolved problems in fusion plasmas. ELM instabilities can leak large amounts of energy from the plasma and expose the reactor wall to extreme heat loads. Despite their importance, the structure of ELMs is still not perfectly understood. A new diagnostic system on the ASDEX Upgrade tokamak can help unravel the underlying physics and hint how to control these energy pulses.

ELMs or Edge Localized Modes develop at the plasma edge and extend along a magnetic field line to the wall of the reactor exhaust. The common view is that ELMs are essentially 2D; rapid heat transport along field lines causes them to quickly extend over the full length of the field line. Recent advanced modelling indicates that ELMs might have a different structure, with a length of only part of the field line. Because of the short timescales involved and the limited access to the plasma, present diagnostics cannot resolve the structure of ELMs.

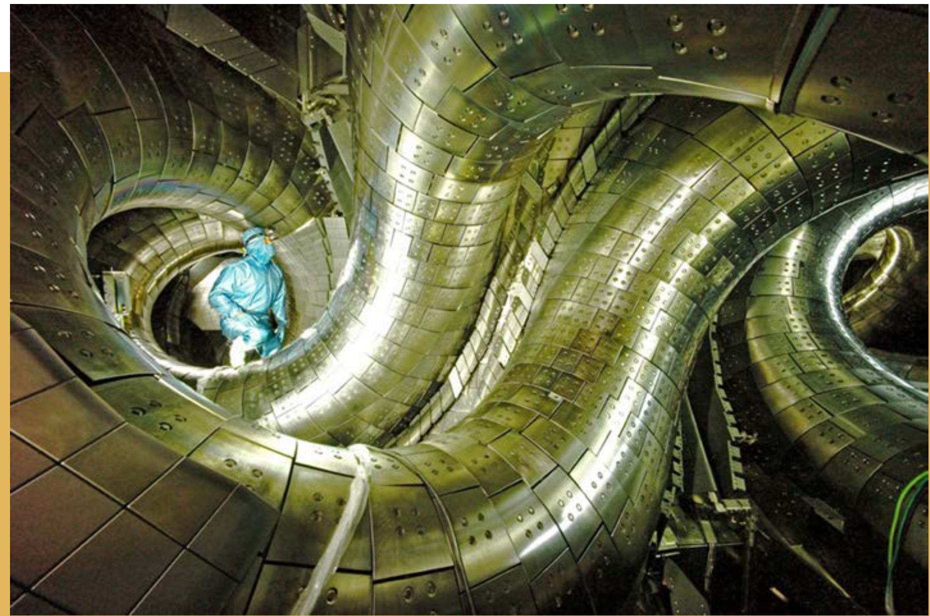
Ivo Classen has made a major addition to an existing DIFFER diagnostic for the electron temperature at ASDEX Upgrade. With the upgrade, the Electron Cyclotron Emission Imaging (ECEI) system can simultaneously observe in great detail two 2D slabs of plasma which are separated by 40 cm toroidally. These quasi-3D measurements of plasma instabilities enable for the first time a full characterization of the 3D nature of ELMs and the associated heat transport towards the wall.

Estimating heat transport in real-time

Optimal performance of the burning plasma in a fusion energy plant will require detailed knowledge of the plasma parameters. PhD researcher Matthijs van Berkel has demonstrated new techniques to identify the spatial distribution of heat transport in a fusion reactor. This is one of the factors influencing the overall reactor performance. Van Berkel combines optimized measurements and models of the plasma to determine the heat transport. Using system identification methods, he can estimate the diffusivity, convectivity and damping of a fusion plasma.

As part of his research, Van Berkel performed experiments at the Japanese fusion reactor LHD under a grant by the Japan Society for the Promotion of Science (JSPS).

Matthijs van Berkel et al.: Explicit approximations to estimate the perturbative diffusivity in the presence of convectivity and damping, Phys. Plasmas 21 (2014) 112507, 112508, 112509



The Large Helical Device (LHD), a large superconducting stellarator (a type of fusion reactor) which can create long duration plasma discharges at temperatures of tens of millions degrees
Photo: NIFS

Solar fuels
2.3

Sustainable energy storage

Large scale implementation of renewable energy sources in our current energy infrastructure involves balancing the differences in time and place of energy generation and consumption. In particular for wind and solar energy, efficient storage and distribution are essential to overcome these supply-demand mismatches. Solar fuels offer an attractive solution by creating a fuel without carbon foorprint via energy storage in chemical bonds.

The DIFFER solar fuels research and development program is driven by the need for cost-effective production of solar fuels and the use of abundantly available materials. The central theme is to achieve 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 of choice. The concrete research areas are materials synthesis for photocatalysis, materials for photo-electrochemical water splitting, membranes for fuel conversion applications, and plasma for efficient CO_2 conversion.

Two new research lines

Most of the worldwide research efforts in solar fuels are directed at the splitting of water into hydrogen and oxygen. However, no efficient catalytic or traditional chemical alternative catalyst is yet available. DIFFER has installed two new groups to initiate research in this area.

One group is led by Anja Bieberle and studies the electrode-electrolyte interfaces of photo-electrochemical systems. By combining experiments on different materials chemistries, micro- and nanostructures, and 3D structures with state-space modeling and simulations of the photo-electrochemical interface, she wants to uncover the limiting features in today's photoelectrodes.

The other group is led by Mihalis Tsampas and studies photo-electrochemical promotion of solar fuel conversion in solid electrolytes. Co-catalysts are developed for utilizing light induced species to drive electrocatalytic reactions. Emphasis is given on the catalytic formation of fuels from streams of CO_2 and H_2, produced by water splitting in a previous step.

TU/e Technische Universiteit Eindhoven University of Technology

Program leaders

Anja Bieberle, René Janssen, Mihalis Tsampas, Hindrik de Vries, Gerard van Rooij, Michael Gleeson, Waldo Bongers

Funding

NWO program CO_2-neutral fuels; NWO program New Chemical Innovations; STW-Alliander plasma conversion of CO_2; TKI Gas; Topsector Chemistry NCI; STW-Alliander plasma conversion of CO_2, Topsector Energy.

Collaborations

Fujifilm Research, Tilburg, NL; IPP Stuttgart, Germany; Radboud University Nijmegen, NL; TU/e, Eindhoven, NL; University of Antwerp, Belgium; University of Leiden, NL; University of Twente, Enschede, NL; Sichuan University, Chengdu, China; Alliander, NL.

Distilling sunlight into fuel

Tenure trackers Anja Bieberle and Mihalis Tsampas each explore an artificial leaf approach to DIFFER's solar fuels theme. In their five year programs, they are working on direct conversion of solar energy into chemical bonds.

Bieberle: Take a walk outside: sunshine, wind - all that energy is available, and we are not using it. Yet! When you get electricity from a solar cell, you either need to use it immediately or you have to store it in a battery. Direct conversion of sunlight into a storable fuel would be much better, right?

Tsampas: The goal with solar fuels is to offer an alternative to fossil fuels. Fundamental research is essential to develop these sustainable technologies. Both our approaches are electrochemical in nature: we directly use sunlight in a device to convert water and CO_2 into hydrogen or hydrocarbons.

Bieberle: In my group, we want to design better photoelectrodes for photoconversion. To reach that goal we investigate the interface where solid electrode meets liquid electrolyte in solar fuel devices. By combining experiments with modeling and simulations, we can investigate the fundamental processes and limitations at the interface..

Tsampas: Together with my group, I want to use electrocatalysis to enhance an artificial leaf-type cell. We will develop novel materials and methods for solar fuels production in solid photoelectrochemical cells. The main idea is to use electrochemistry to tune the selectivity of a reaction towards a desired product, i.e. specific fuel.

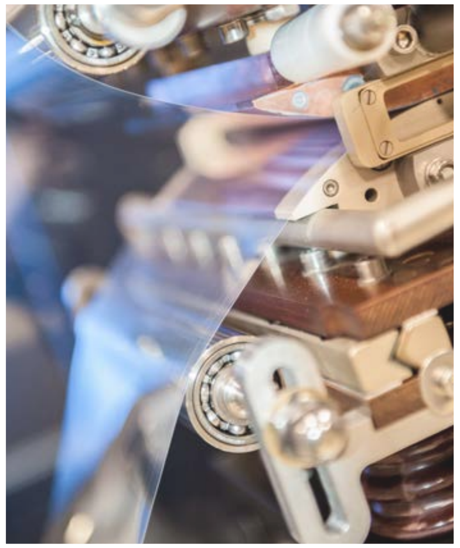
Bieberle: This is one of the things that I like at DIFFER: working together with people from diverse disciplines. I am collaborating with different researchers from the fusion group on nanostructuring surfaces with plasma and on modelling and simulation of interfaces. Although our fields are different, the shared focus on energy makes it easy to connect.

Tsampas: In our groups and in energy research in general, we draw on many different disciplines to realize a breakthrough: chemistry, materials science, engineering, physics... I think that over the next years, when we're all in the same building, the current research groups will find more and more synergy and inspire each other to even more innovative approaches.

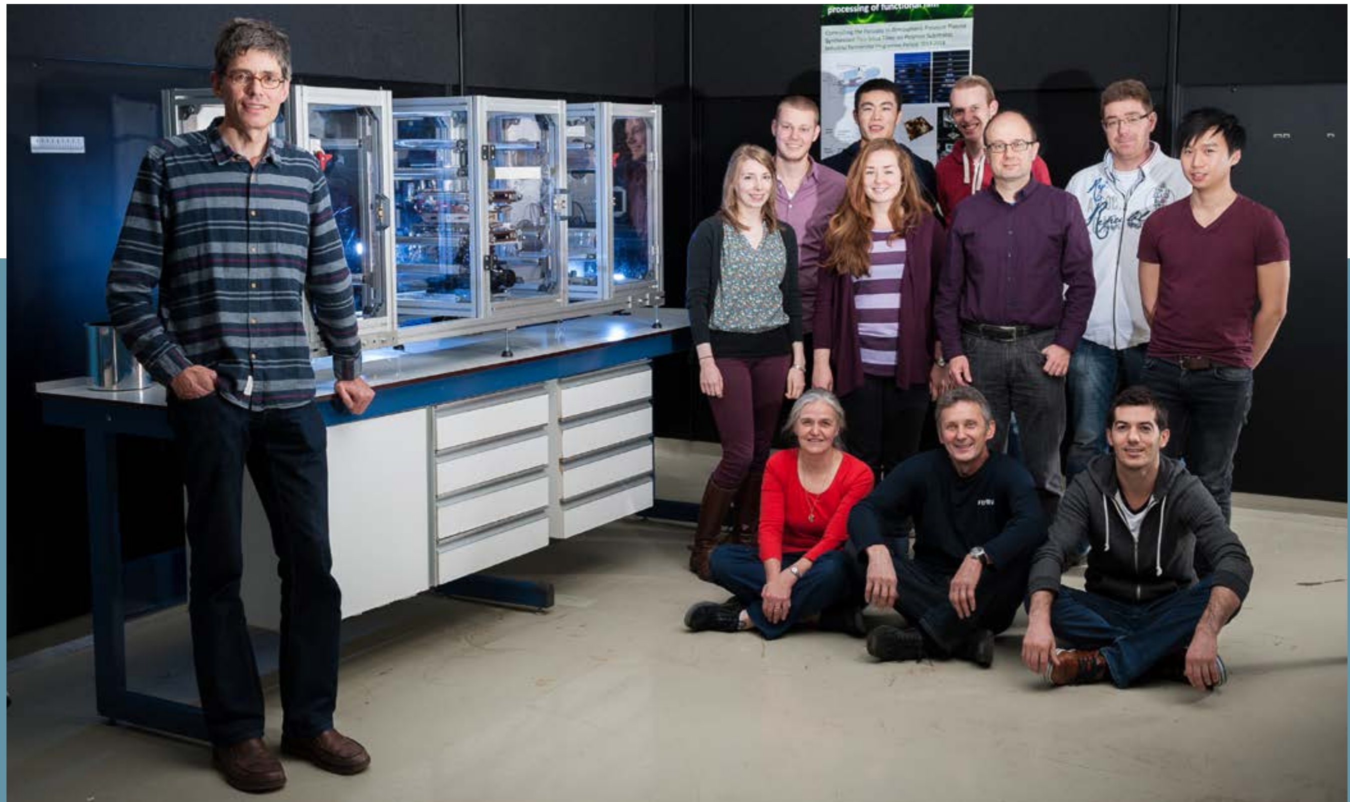
Atmospheric plasmas for roll-to-roll thin film processing

Together with our industrial partner Fujifilm we have produced competitive moisture resistant foils in an atmospheric discharge roll-to-roll set-up. These foils can find application as a top layer for flexible thin film PV cells. The result is part of the wider FOM Industrial Partnership Program on functional foils with Fujifilm. In this program we investigate atmospheric pressure plasma deposition as a faster, and equal or better quality alternative for the existing low pressure PECVD-technique. By obtaining a better understanding of the governing permeation mechanisms, we aim to control permeation in both moisture barriers and membrane applications.

Sergey Sarostin et al.: Towards Roll-to-Roll Deposition of High Quality Moisture Barrier Films on Polymers by Atmospheric Pressure Plasma Assisted Process, Plasma Processes and Polymers, DOI 10.1002 / ppap.201400194



Roll-to-roll setup designed and built in-house at DIFFER, with the dielectric barrier discharge connected to the novel dual frequency power supply



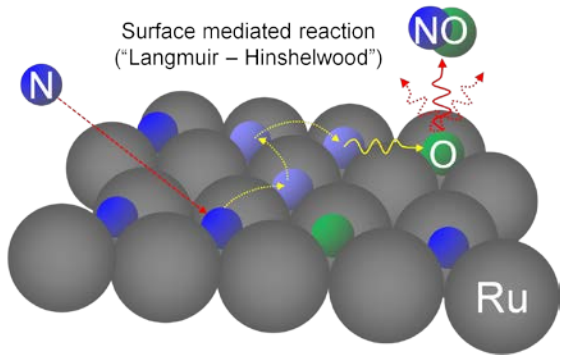
The group Atmospheric Plasma Processing for Functional Foils-group works in-house at Fujifilm Research in Tilburg in the framework of an FOM Industrial Partnership Program

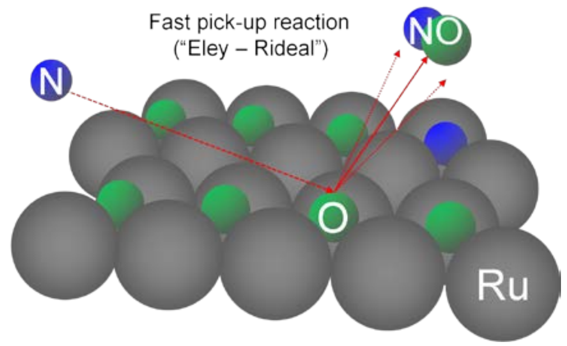
Probing fast reactions

To effectively use a plasma to dissociate CO_2 into the building blocks for solar fuels, we are investigating the use of a nearby surface to introduce or remove reagents. Of particular interest is the Eley-Rideal reaction, in which an incoming atom reacts directly with an atom adsorbed at the surface. This reaction is effectively instantaneous and proceeds independent of the surface temperature. This promises a substantially more efficient conversion than is achievable by standard temperature-driven reactions.

Eley-Rideal reactions were previously only observed experimentally for reactions involving at least one hydrogen atom. In our Harpoen set-up, we have now conclusively demonstrated direct removal of an oxygen atom from a metal surface by an incident nitrogen atoms. Being able to observe the process in isolation allows for in-depth study of the mechanisms involved.

Teodor Zaharia et al.: Eley-Rideal Reactions with N Atoms at Ru(0001): Formation of NO and N_2, Physical Review Letters 2014, 113(5): p.053201





Measuring hydrogen uptake in individual palladium nanocrystals

The uptake of small atoms into a solid matrix is an important process for energy storage processes, such as hydrogen storage in metals and lithium uptake in Li-ion battery electrodes. With respect to their bulk counterpart, nanostructured materials offer the advantage of faster charging/discharging kinetics, longer life cycles and size-tunable thermodynamics. Ensemble studies of nanomaterials, however, are limited by the distribution in size, shape and crystallinity of the sample, and can therefore only provide an average picture. On the other hand, single nanoparticle studies, especially in a reactive environment, are extremely challenging.

A novel approach involving in situ transmission electron microscopy at Stanford University succeeded in measuring the absorption of hydrogen by individual palladium nanocrystals exposed to varying pressures of hydrogen gas. The results support the view that the charging mechanism is regulated by swelling of the nanoparticle's surface. Since the surface is the first to absorb hydrogen atoms, it is the first to swell up and 'pull open' the bulk of the nanoparticle. This effect leads to smaller nanoparticles absorbing hydrogen first, because they have larger surface-to-volume ratios. Andrea Baldi (Stanford University and DIFFER): "The breakthrough is that we can now measure and potentially predict how an individual particle's size, shape, and crystal structure determine its mechanism of hydrogen uptake and release."

Andrea Baldi et al.: In situ detection of hydrogen-induced phase transitions in individual palladium nanocrystals, Nature Materials 13, 1143-1148 (2014)

Andrea Baldi

Nanolayer surfaces and interfaces

2.4 *Transition to University of Twente*

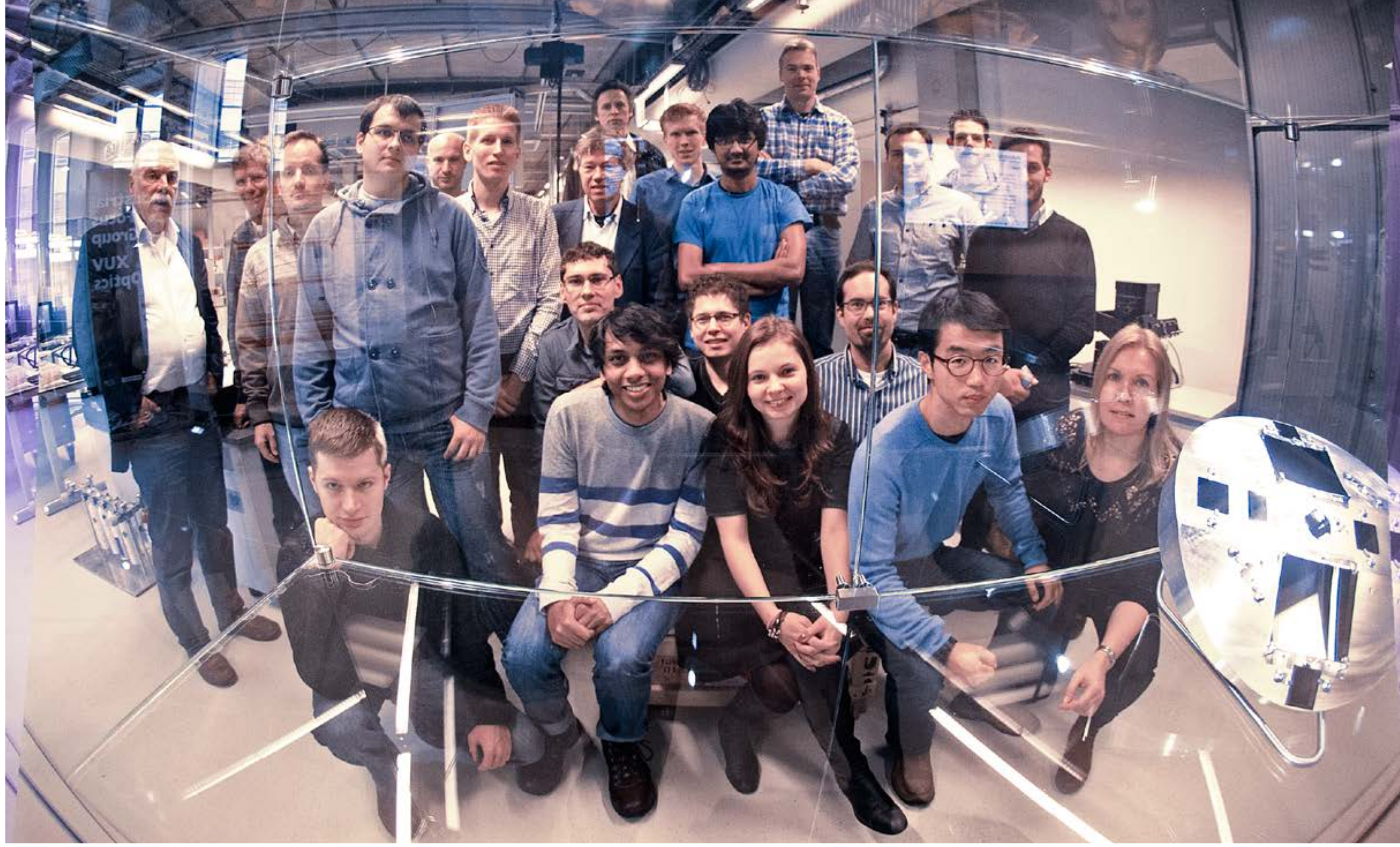
The nSI division aims to perform high-quality scientific research in the fields of surface science, and thin film and interface physics. The research includes photo-chemical phenomena, photo-conversion processes, and the solid state and interface physics of short-wavelength optics. The latter primarily concerns multilayered reflective coatings relevant for the 'XUV wavelength band' ranging from the soft X-ray to the VUV. In particular, the division studies the boundary areas between these topics: the use of XUV optics, for instance, generates exciting research questions in the field of photo-induced surface chemistry, as in Extreme UV-induced optics contamination.

The industrial relevance of their research allowed the nSI division to grow into a new public-private research constellation at the University of Twente's MESA+ Institute for Nanotechnology. This new 'Industrial Focus Group XUV Optics' is directly linked to the new governmental 'Topsectoren' innovation policy. The focus group brings together experts from industry and academia in order to accelerate the application of fundamental insights in innovative designs. XUV Optics maintains its successful extra-mural research activity within ASML Research (Veldhoven). Here, six PhD students, two part-time postdocs and a full-time group leader focus on nonlinear photochemistry processes at surfaces under EUV illumination.

Relocation process completed

The Industrial Focus Group XUV Optics was established by late 2012, and the nSI division completed its relocation to MESA+ at Twente by early 2014. The permanent staff moved to this nationally leading institute, and already is experiencing the benefits of a well-fitting environment for thin film research. Running PhD projects were continued with minimal interruption and new staff has been appointed to reinforce the XUV Optics group. The 500 m² laboratory includes an over 4 M€ investment in new, state-of-the-art equipment. Much of the existing thin film instrumentation was transported from Nieuwegein to Enschede and arranged in the new laboratory. The full move was completed 4 months in advance of the formal transition date of 1 July 2014.

The Focus Group is funded by a consortium of industrial participants, the regional government, and the MESA+ Institute for Nanotechnology. Industrial parties include ASML, Carl Zeiss SMT, PANalytical, DEMCON, SolMateS, and TNO.



Members of the XUV Optics Group, headed by Fred Bijkerk (top, 7th from left)

Together they raised the 20 M€ funding for an eight year research program. In return, the industrial participants have aquired a right in the intellectual property developed in the focus group. The parties are selected based on their complementary industrial competence so that new innovations can be developed right from the very initial stages of know-how.

The themes in the focus group are selected on basic physics aspects of thin film and multilayer systems within the areas of the applications. Clever choices allow for both fundamental research and high quality scientific output, as well as a high probability of industrial spin-off. The development of physics and technology for XUV and soft X-ray multilayer optics for various applications builds on this basic research.

Division leader

Fred Bijkerk

Program leaders

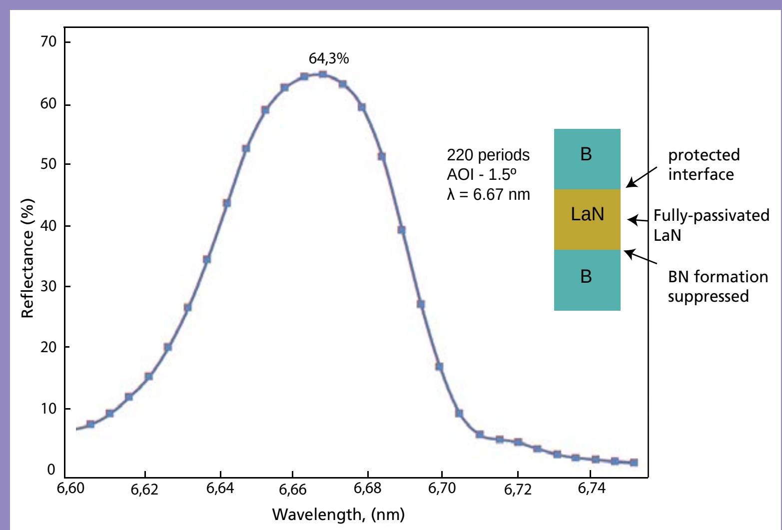
Chris Lee, Eric Louis, Andrey Yakshin

Funding

FOM Industrial Partnership Programs FP-I10 and FP-I23, AgentschapNL, ASML, Carl Zeiss SMT, CATRENE program of the EC, FOM, M2i, NanoNext, STW

Collaborations

ASML Research, Veldhoven, the Netherlands; Carl Zeiss SMT GmbH, Germany; Delft University of Technology, the Netherlands; DEMCON, Enschede, the Netherlands; Eindhoven University of Technology, the Netherlands; Institute for Plasma Physics, Warsaw, Poland; Institute for Spectroscopy, Troitsk, Russia; Institute of Crystallography, Moscow, Russia; Lawrence Berkeley National Laboratory, USA; Lebedev Physical Institute, Russia; MESA+ Institute for Nanotechnology, University of Twente, the Netherlands; Moscow State University, Russia; PANalytical, Almelo, the Netherlands; Physikalisch Technische Bundesanstalt Berlin, Germany; SolMateS, Enschede, the Netherlands; SRON Space Research, Utrecht, the Netherlands; TPD/TNO, Delft, the Netherlands



Measured at Physikalischer Bundes Anstalt

Progress on mirror reflectivity

The new XUV group has set a new world record of normal incidence reflectivity. This record, now 64.3%, is important because it may lead to a reconsideration of the application perspective of such optics for the next generation photolithography (moving from 13.5 to 6.8 nm). The result was obtained by applying a multi-step layer growth process based on passivation of interdiffusion processes in LaN/B multilayer mirrors. Of major relevance was an improved analysis performance of X-ray Reflectivity diagnostics. On a routine basis, full scale analysis became possible down to the Angstrom level layer thicknesses, revealing critical layer formation processes.

3 Community building

Network on energy research

To accelerate technology innovation in the energy sector, an active and well connected research community is a prerequisite. DIFFER is investing in a multidisciplinary network, convinced that it is a promising soil for scientific collaboration and breakthroughs. This well-connected network has the ability to strengthen the Netherlands position in European and international energy initiatives. We contribute by organizing workshops and participating in (inter)national consortia and networks.

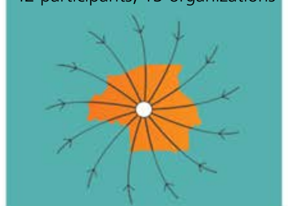
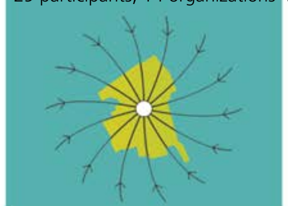
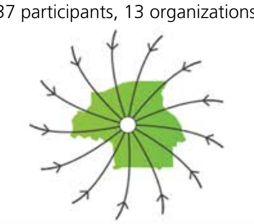
Workshops

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

This year five workshops were organized together with universities and institutes striving to connecting scientists from different disciplines. Each workshop focused on identification of the (fundamental) challenges in a scientific element of the energy challenge. Typically each workshop brought together a dedicated group of 30-40 scientists. Experts from the field introduced their views and relative outsiders to the topic kick-started an in-depth discussion for which ample time was reserved. These workshops had a predominant contribution from academic scientists, although some companies were represented. For the coming year we will co-organize energy workshops with partners like ECN and TNO, to focus on use-inspired research challenges bridging to the entrepreneurial perspective.

Students

We strive to involve students and PhD candidates in the global energy challenge. DIFFER helps organize the TU/e Energy Days, which inform young scientists about various energy and climate related topics. In May 2014, DIFFER organized a masterclass on energy storage for students at the multidisciplinary Groningen Energy Academy.

Where no material dares to go	Solar fuels	Offshore wind	Energy system integration	Plasma-facing components
January 2014, Leiden	April 2014, Eindhoven	May 2014, Amsterdam	November 2014, Delft	December 2014, Eindhoven
56 participants, 28 organizations	42 participants, 13 organizations	50 participants, 16 organizations	29 participants, 14 organizations	37 participants, 13 organizations
				

Collaboration in networks and consortia

DIFFER is an active member in several national and international consortia and networks. Numerous scientific collaborations and connections have been built-up over the years, both in fields of nuclear fusion and solar fuels. Here, we like to highlight some of the initiatives of the last year.

NERA

In parallel to DIFFER's activities, the Netherlands Energy Research Alliance (www.nera.nl) has become active in connecting energy researchers on a national level, but also to align and coordinate activities to and from the European Energy Research Alliance (EERA) and others. The NERA was initiated by FOM, 3TU, ECN and TNO but is recently joined by University of Groningen. We contribute to NERA as member of the working group. In November, NERA organized their first event by adopting the DIFFER workshop format to focus on scientific challenges in relation to energy systems integration.

EUROfusion

In the EUROfusion consortium (www.euro-fusion.eu), DIFFER represents the Netherlands research on nuclear fusion. This consortium, consisting of 29 institutes from 27 EU countries, is the EFDA's successor. The EUROfusion "Roadmap to the realization of fusion energy" specifies the milestones of the EUROfusion program.

The scientific work is assigned in open competition, making it relevant for DIFFER and its national network to operate strongly by finding synergies between the different scientific disciplines and to develop novel expertise.

SOFI

DIFFER joined the novel international Solar Fuels Institute (SOFI, www.solar-fuels.org) bringing together academia, research institutes, and industrial partners world-wide on sharing knowledge and expertise on direct and indirect conversion of solar light into chemical fuels. In addition, SOFI is hosting a campaign to demonstrate a lab-scale demonstration project to convert solar light into methanol in order to show the potential of chemical energy storage to the general public.

FOM focus groups

FOM maintains two focus groups at the University of Groningen and the FOM institute AMOLF, to strengthen the position of the Netherlands in the international field of energy research. The focus groups are positioned to address fundamental aspects in the global energy challenge under the guidance of a renowned researcher.

Light management

Solar cells which capture all impinging light and convert the full color spectrum into electricity are the core of research for the FOM focus group "Light management in new photovoltaic materials". The group develops novel materials combined with new geometries to realize efficient and inexpensive solar cells. The researchers pioneer to control the capture, guidance, concentration, and conversion of light on the nanoscale.

Head of research: Prof.Dr. Albert Polman
Parent organisation: FOM institute AMOLF, Amsterdam
Collaborations: Utrecht University, Dutch Energy Research Institute (ECN)
Online: www.erbium.nl

Next generation organic PV

Large-scale, inexpensive and sustainable energy generation in 2020 is the objective of the FOM focus group "Next generation organic photovoltaics". This multidisciplinary group of physicists and chemists develops plastic solar cells based on a new class of molecular semiconductors. These novel electronic materials also have relevance beyond the field of energy, such as in medical imaging technology or as building blocks for molecular computers.

Head of research: Prof.Dr. Kees Hummelen
Parent organisation: University of Groningen, Zernike Institute for Advanced Materials
Online: www.groningensolar.nl

4 Outreach

Knowledge transfer to society

One of DIFFER's goals is to transfer knowledge to society at large. Our triple focus is on strong ties with high-tech SME's and industry, education to secondary and higher level students, and general outreach on solar fuels and fusion.

Connecting to industry

DIFFER strongly pursues contact with industry, both as an inspiration for research questions and as a pathway to translate our fundamental research into practical applications.

In the solar fuels theme, we are connecting with industrial partners to develop and apply technological solutions for large-scale conversion of sustainable energy into fuels. One example is the Dutch Topsector project 'Hyplasma' on efficient hydrogen production together with Alliander, Gasunie and Groningen Energy Valley. The successful collaboration on functional foils together with Fujifilm Research is detailed on page 20.

DIFFER is an active partner in the ITER-NL consortium, which aims to better connect Dutch SME and industry to the international fusion project ITER. An active website and ongoing news feed inform high-tech companies about ITER-related opportunities.

Right: State Secretary Sander Dekker visiting the DIFFER stand at the Hannover Messe 2014.

As a networking opportunity, we organized a representation by Dutch companies at the 2014 SOFT Symposium for Fusion Technology in San Sebastian, Spain. A delegation from the European Spallation Source (ESS) visited DIFFER's public-private Remote Handling Study Centre to explore possible collaboration.

Finally, the nSI division's public-private collaboration on multilayer XUV optics is of high industrial relevance. In 2014, this activity left DIFFER and became part of Twente University as the core of the new industrial focus group on XUV Optics (page 22).

Hannover Messe 2014

From 6 to 11 April 2014, DIFFER and our fellow NWO institutes presented themselves at the Hannover Messe, the world's leading trading fair for industrial technology. Together with visitors from industry and research, we discussed use-inspired research into sustainable energy generation and storage.

In 2014, the Netherlands were the Hannover Messe's partner country, with the international spotlight on Dutch high-tech knowledge and products. The Messe had the warm attention of the Dutch government. Sander Dekker, the State Secretary for Education, Culture and Science, visited the stand of the NWO institutes and discussed the increasing interaction between fundamental research and industry.

Broadcast

Dutch TV program *Altijd Wat* focused one edition on future society on the energy transition. What technology do we need in order to switch to a fully sustainable energy system? DIFFER's director Richard van de Sanden acted as tour guide and introduced the viewers to various projects such as local energy storage in batteries and solar fuels, and large-scale sustainable power production, where Marco de Baar introduced fusion energy. *(http://goo.gl/KxQ3w1)*

Education

DIFFER is proud to help train the next generation of energy scientists. The 25 PhD students active at DIFFER in 2014 are an integral part of our research efforts. This year, 9 PhD candidates successfully defended their thesis at a Dutch university. Conversely, DIFFER's researchers have been proud to serve on thesis defense committees at home and abroad.

Our research groups welcomed 12 BSc and MSc students for three to twelve month internships, and 4 technical apprentices joined our mechanical and electronics groups. For many students, the introduction to our institute is one of the 9 university courses on plasma physics, fusion, control theory and plasma surface interaction that our staff teach at Dutch universities. In 2014, eight members of our staff (co-)taught courses in the university curricula, six of whom held a part-time university professorship.

For secondary schools in particular, we support an elective lessons module in which final year students explore design steps leading to their own fusion reactor. During the year, 6 groups of 28 secondary school students in total participated in our dedicated Paschen curve plasma experiment as part of their course work.

Media and general public

Energy research was a big media theme in 2014, with frequent media appearances by DIFFER staff. By providing the media with expert views on the energy challenge, we both underline the importance of fundamental research to the energy transition and aim to strengthen our own reputation as nationally leading research institute.

In our media outreach, we strive to make the connection between specialized research and the broader relevance for society. This mix portrays energy research as both valuable and exciting, and manages to engage an audience of diverse specialists and general public.

The solar fuels groups featured in both general news items, for instance on solar fuels as an alternative to natural gas, and in more specialized items on research results from the institute. In relation to fusion, DIFFER's researchers commented on stories about the ITER project, the laser fusion facility NIF, and the compact fusion system announced by Lockheed Martin.

Lastly, our annual open days for students and general public drew a five year record of 950 visitors to the institute.

Open day 2014

5 New home base

Hans van Duijn (TU/e, left) and Wim van Saarloos (FOM, right) sign collaboration contract at the 2014 Hannover Messe

Strengthening ties with Eindhoven

At our new home base in Eindhoven, we will work closely with higher education and research on the university campus. To strengthen the ties between DIFFER and the university, our parent organisation FOM and Eindhoven University of Technology (TU/e) signed a collaboration contract at the 2014 Hannover Messe. FOM and TU/e also made agreements about intellectual property and the joint use of large-scale facilities.

TU/e Rector Magnificus Hans van Duijn: "With this collaboration we are giving a powerful boost to fundamental energy research in the Netherlands."

A key aspect of the collaboration is a new research group that TU/e will contribute to DIFFER. TU/e professor René Janssen will head this group on solar fuels and sustainable energy storage. The group will be part of DIFFER and will eventually consist of about twenty senior researchers, PhDs and postdocs.

"This new group both brings extra focus and mass to DIFFER's scientific mission, and strengthens the link between the research institute and university education", says FOM director Wim van Saarloos.

On June 30th 2014, the cornerstone of the new DIFFER building was placed by Van de Sanden and Van Duijn


DIFFER staff visiting the construction site

Building excitement

Our new building on the TU/e Science Park went from basic structure to nearly completed in 2014. It will be completed on schedule, and the relocation will start in March 2015.
To better prepare our staff for the relocation of people and facilities, a series of information meetings on the new building and on the campus environment in general was organized. In this way, we actively informed our staff about the construction progress, and built excitement for the possibilities at the new home base.

Key part in these efforts were several visits to the construction site and to the labs and facilities of our future colleagues on the campus of the Technical University of Eindhoven.

"They will not even notice the transition"

"We want a network so seamless that users cannot tell when we move their data or phone extension." Head of ICT Andries Broekema (at right) and IT architect Fred Wijnoltz designed the data and communication solutions for DIFFER's new building.

Broekema: Our big goal in this relocation is moving all the institute's ICT services while they are in use, without users or experiments noticing. During the move, people at both sites can access all their data via the same network and can be reached via their familiar phone number.

Wijnoltz: We've prepared this for two, three years now. The idea is to stretch our computer network over a 10 GB/s SURFnet light path between Nieuwegein and Eindhoven. In effect, the new building in Eindhoven is treated the same as any other floor in the current building. That way we can set up a new server core and move data to it while it's being used.

Broekema: Because our new telephone solution runs over the network, users can be reached at either site via one and the same connection. We will also use this to connect more efficiently with our researchers stationed at for instance Fujifilm in Tilburg, or the fusion reactor JET in the UK.

Wijnoltz: We chose Lync as an anywhere, anytime, any device telephone solution. As an example, colleagues can see immediately if you are available, in a meeting on or off-site, or working at home, and opt for chat, voicemail, phone or other contact options. All from the same device and without switching applications or devices.

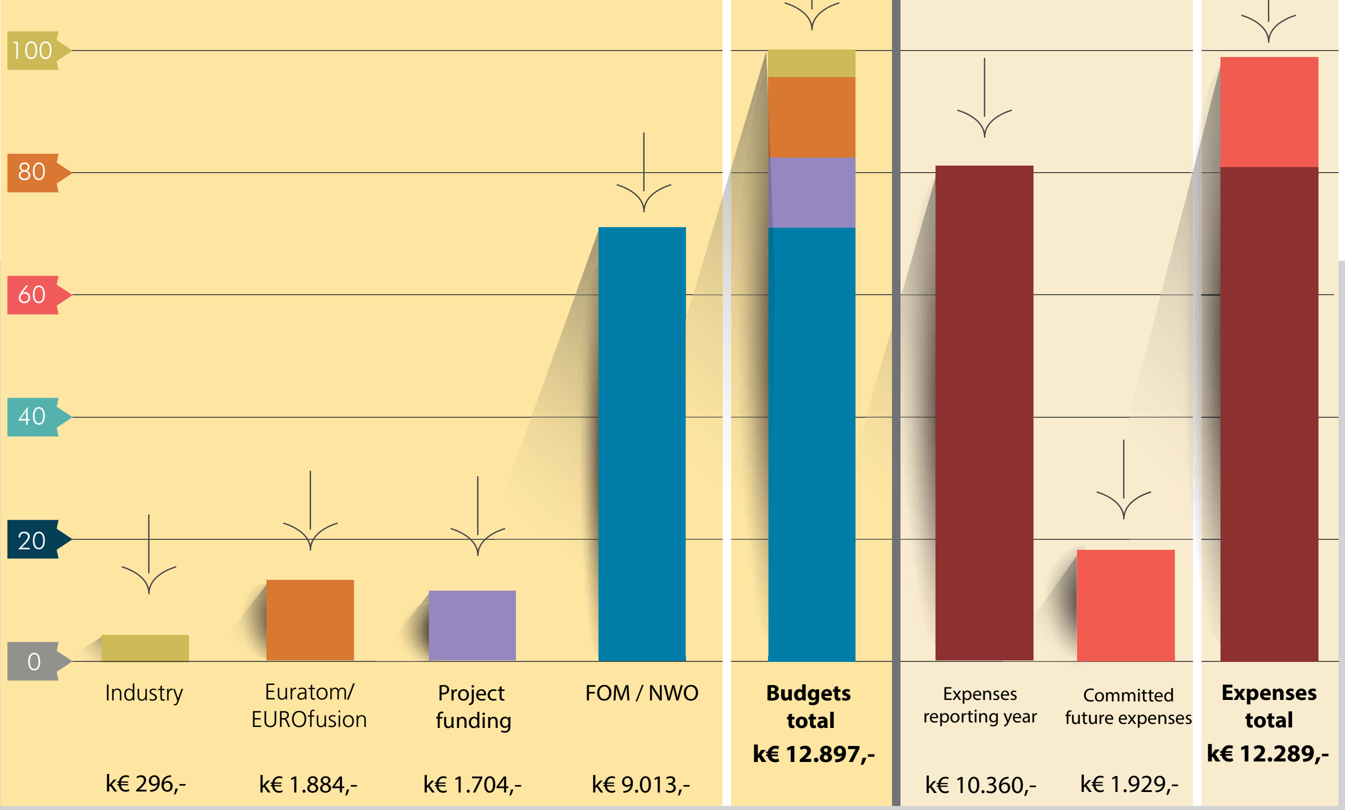
Broekema: Our new building will also feature some very visible ICT technology. I am thinking of the audio-visual system in our seminar room, where one press of the button prepares the entire system for a video conference or a presentation, with the microphone and laptop input automatically routed to the right place.

Wijnoltz: Touch pads outside the smaller meeting rooms will show or book the room's availability. Inside the rooms, digiboards will allow you to use a powerpoint presentation as a white board: new notes are exported to all meeting participants on the fly. You won't even notice the technology helping you.

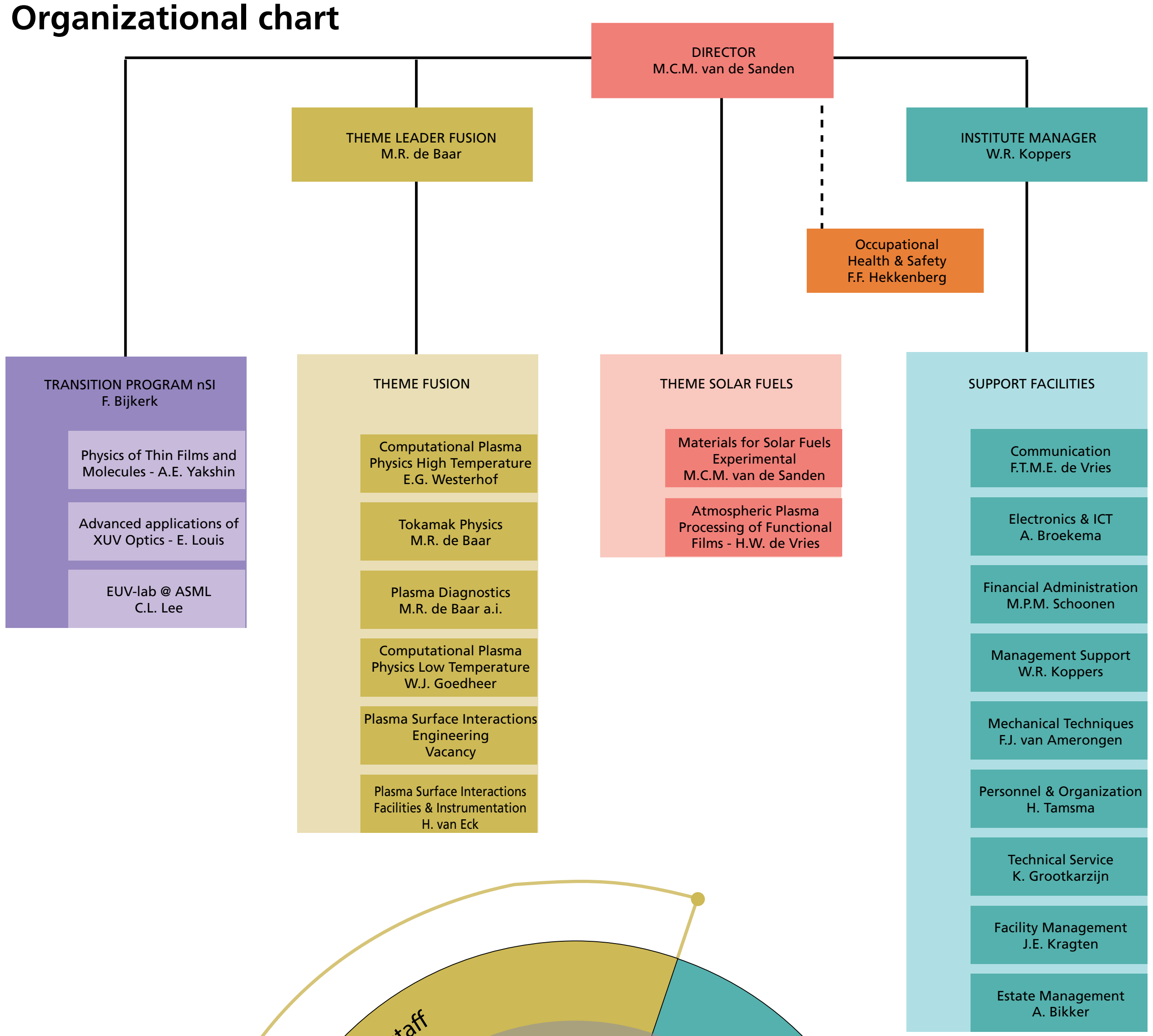
Facts & Figures 6

Output

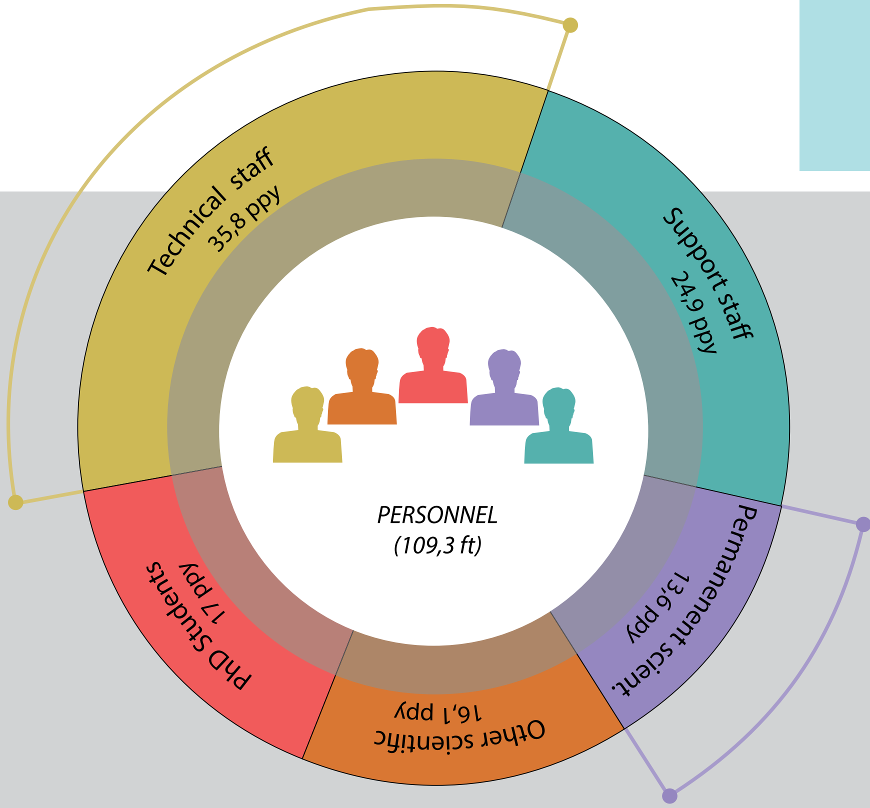
Funding and expenses in 2014



Organizational chart



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)

Scientific Advisory Committee

G. van der Steenhoven (University of Twente; chairman)
D.J. Campbell (ITER)
A. von Keudell (Ruhr-University Bochum)
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J.W. Genuit
E. Langereis
F.J. van Amerongen
E. Westerhof

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DIFFER
Dutch Institute for Fundamental Energy Research
Edisonbaan 14
3439 MN Nieuwegein
The Netherlands

PO Box 1207
3430 BE Nieuwegein
The Netherlands

www.differ.nl

New address per April 2015:
Dutch Institute for Fundamental Energy Research
De Zaale 20
5612 AJ Eindhoven
The Netherlands

PO Box 6336
5600 HH Eindhoven
The Netherlands

www.differ.nl

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