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Advanced Materials

News and backgrounds on advanced materials at the University of Groningen

From the editor

The world of advanced materials is a dynamic one. Not only are the materials we are developing in Groningen more and more dynamic or adaptable, the people that discover them are also quite a dynamic group. In this edition of the Advanced Materials magazine, we have plenty of examples of both that we are proud to share with you.

We welcome some new faces to the UG Advanced Materials team (Richard Hildner, Marleen Kamperman and Marcos Guimarães) and celebrate the achievements of our current and previous staff in moving forward: Petra Rudolf was elected as president of the European Physics Society and Moniek Tromp is now on the board of the national network of female professors as well as the NWO Science domain. We also hear from alumna Alina Veligura (Philips) and emeritus prof. Jeff De Hosson who was knighted before retiring from active duty.

In an update on the latest scientific developments, we see, among others, how Sijbren Otto tries to coax materials to undergo evolution, and how Wouter Roos team makes movies of cells transmitting information in real time.

Finally, we take a moment to celebrate the renewed accreditation for our Top Master Nanoscience, and our successful 2019 Vlieland meeting. As a bonus, you can also use the back of this issue as a nice reminder of the Zernike colloquium dates for next academic year!

Caspar van der Wal

Scientific director Zernike Institute for Advanced Materials

Sijbren Otto

Cell synthesis in a jar

Molecules that form a cell themselves. That is what professor Sijbren Otto of the Stratingh Institute is dealing with. The recipe seems very simple: throw a few molecules in a jar and wait how they will interact. “I have the feeling that life processes could also arise with other molecules.” Because that is special about his research: he does not put body molecules in the jar, such as proteins and fats, but molecules that do not occur in living nature.

You can see a cell as a group of molecules that together form an operational system.This system can function thanks to three properties: it can copy itself (replication), it can grow by absorbing substances from the environment (metabolism) and the molecules can keep themselves apart (compartmentalisation). Because the molecules in our cells can, they can form a stable unit.

Stable whole

“I am a chemist. I like to make new things. It has already been known for a while how we can make simple molecules. That is why I am dealing with the next step: what can you do to make molecules do with each other? That is ultimately what this research is all about: a few substances that may not be able to do much independently of one another are capable of much more. Then 1 + 1 = 3. That is currently an important focus of research in chemistry.“

The limits of our capacities

In his research, Otto hits the limits of the possibilities of science. “We use molecules that form a ring structure of carbon and have sulphur groups. We can roughly predict and measure what happens, but it is difficult to see in detail what structures are created at the molecular level. That is why we collaborate with Wouter Roos, for example, who can scan the surface of molecules with atomic force microscopy (AFM) and with Siewert-Jan Marrink, who can predict the reactions of molecules with computer models. So in the end, it doesn’t go beyond mainly indirect measurement and simulation. You can’t see what exactly is happening.“

Promising results

It seems that Otto can achieve cell synthesis with its ring structures. “We have already observed all three properties: we have made a molecule that can divide itself and is therefore capable of replication. We have also seen how one molecule breaks down another and thus makes its own building blocks available (metabolism). The molecules also appear to be able to organise themselves into larger structures (compartmentalisation). So far, we have not seen this together in one system, but the different systems are compatible, so I think that is a matter of time.”

Evolution

Although Otto himself is mainly interested in the chemical side of the research, he acknowledges that there is also an interesting aspect to it in the field of evolution theory. Complex molecules play an important role in almost all forms of life. For a long time it was thought that these molecules only emerged later in evolution. “Now that we have demonstrated that such molecules can automatically form themselves from simple molecules, the idea is more likely that those complex substances originated much earlier in evolution. Moreover, it is interesting to know whether the emergence of life is also possible with other molecules. And to see how evolution will take place if stable “cells” are formed with other substances.“

Other applications

Molecular folding also plays a role in medicine. In neurodegenerative diseases, such as Alzheimer’s and Parkinson’s, proteins fold incorrectly, causing you to accumulate proteins. “We saw by chance that folding and replication of molecules are close together A molecule seems to choose whether to fold or replicate, but seems capable of both. If we understand how that choice is made, we could influence it and thus prevent the wrong folding of proteins.“

Petra Rudolf

New President of the European Physical Society

Training physicists to talk better with politicians and teaching researchers to write better grant applications. These are two new activities Petra Rudolf wants to introduce in the two years of her mandate as president of the European Physical Society (EPS). "In addition to my research, I think it's great to enthuse and motivate researchers. I want to help the next generation of European physicists to gain a solid position in both science and society." Rudolf is president since April 2019.

Rudolf is professor of Experimental Solid State Physics at the Zernike Institute for Advanced Materials. In addition to her research into molecular motors, organic/inorganic hybrid thin films and two dimensional solids, she is also involved in management around research and scientific education. For example, in the past four years, she was director of the Graduate School of Science and Engineering at the RUG and in 2000/2001 president of the Belgian Physical Society. "I like to inspire people to do things better. In the end, I get as much energy from making people happy and satisfied as from doing research."

Train the trainer

As chair of the EPS, Rudolf is engaged for 42 member societies representing 130 000 physicists. "I have two big goals. First of all, I want to set up a 'train the trainer' program. Physicists often find it difficult to talk to policy makers. The financial support for physics research is decreasing, also because politicians do not realise how important it is what we do. Research in physics has an important economic impact, for example in developing new technologies. With the 'train the trainer' programme we want to train delegates from 42 physics associations in Europe so that they in turn can train their fellow physicists to start this conversation with policy makers."

Eastern Europe

A second goal is aimed in particular at Eastern Europe. "There are plenty of talented researchers in Eastern Europe, but all the countries in Eastern Europe together receive just as many ERC grants as the Netherlands. That needs to be more balanced, so that the scientists there, too, get a fair share," Rudolf believes. "For them, too, we want to organise a train the trainer event, aimed at talent development of young people, and to teach them how to apply for funding effectively."

Young physicists

Rudolf also wants to work on the skills of European physicists. "Through Young Minds, EPS wants to stimulate European young scientists, namely master's students, PhD students and post-docs, to do outreach and communicate with the general public and, for example, schools - and in their own mutual networking. To support member societies, attention is paid to the exchange of best practices and questions such as: how can education and research improve cooperation? How do you attract a more diverse group of researchers and make physics a more inclusive working environment? How do you prevent brain drain of talented PhD students? How do you prepare PhD students for their job choices?" Rudolf considers this attention to young people essential.

"I like to mentor young people. It is nice to give them strength and to encourage them. So that they can get and keep pleasure in their work. That gives me energy."

Current affairs

Of course, Rudolf also wants to continue with current affairs. "I've walked the road with the chairman for a year now, so I know what the current issues are. EPS organises conferences, publishes scientific journals, lobbies for physics research and we also work for example on historic sites; identifying places where important events in physics have taken place and making these visible. That is a fun and interesting project, which we, of course, will continue."

Research

Her duties as EPS president do not interfere with Rudolf's research. Together with her group of 11 PhD students, a postdoc and a project engineer, she is involved in three directions in research to which also bachelor's and master's students regularly contribute.

Molecular switches and motors

By changing the top layer of molecules on a surface you can change the properties of that surface considerably. Rudolf compares it with ice. "You can skate well on Dutch ice, because the topmost layer of molecules is water instead of ice. In Antarctica most of the year you cannot skate, because the top layer is not liquid but frozen as well. Then the ice behaves like sand and is not slippery at all. With molecular switches or motors as the top surface layer, properties can be changed by light. With this we can switch from a surface that can be wetted by water to a surface that behaves like a Teflon pan, where water droplets rolls off, and back to a wettable surface."

Micro- and nanoporous materials

Another area of research is combining layers of atoms with molecules as pillars between them as to create a material that is porous on a very small scale. Such a material can be used to store gases in the pores, for example greenhouse gases like CO_2, or to filter herbicides from drinking water.

Electrical and chemical properties change

A third direction of research is more fundamental. Rudolf is particularly interested in what happens when you make a material very thin, just one or a few atomic layers. "We try to understand how these very thin solids respond when heated by laser light. We can visualise what is happening with millions of images per second. And that lead to surprises: materials react differently to what we thought they did, instead of just expanding when heated we saw that they strongly contracted before expanding. Or we observe that in a very thin solid, where electrons are confined and cannot move in every direction, the temperature at which the material becomes superconductive changes."

Nanoscience student wins Shell Award

On Monday, November 26, UG researcher Anouk Goossens receives the Shell Award. This prize is awarded annually to three (former) physics students. Goossens receives the prize for her investigation into using the material Nb-doped $SrTiO_3$ for imitating elements of our brain. She graduated with honors from the Master's program in Nanoscience, and continues her research in a PhD program at the UG.

The nominees for the Shell Award are judged on the basis of academic achievements, graduation thesis, and a letter of nomination from the mention. "Anouk is a very responsible researcher," explains supervisor Tamalika Banerjee. "In a responsible manner she developed a new line of research in the group. She is a careful and critical investigator and able to organise well, from the installation of new devices to the collection of data and the writing of a publication. The combination of involvement, responsibility, and thoroughness make her an outstanding scientist." The professor is glad that Goossens will continue her work as PhD student.

Top Master Programme in Nanoscience

Nanoscience is an interdisciplinary field at the border between physics, chemistry and biochemistry. The manipulation of matter on the nanoscale offers new opportunities to solve scientific challenges in the modern world.

The Nanoscience Master is a selective master's programme in Groningen. The programme works with small groups of very talented and motivated students from all over the world (with a Bachelor in Physics, Chemistry or Material Sciences) training them to perform cutting edge research in this highly challenging field. The application of Nanoscience to solve problems in today's society requires the fundamental understanding of the interplay between physical, chemical, and sometimes biological processes. Questions that can be addressed include: Can we build 100x cheaper solar cells? Can we make a computer working similarly to the brain? Can we control quantum properties on the nanoscale for useful applications? Can we make computers using spin instead of electrons?

Excellent

The Top Master Programme in Nanoscience has been assessed as excellent for the third time. This assessment is performed by an international peer review committee, organized by QANU, and their report has been published and confirmed by the NVAO (Accreditation Organisation of the Netherlands and Flanders). On three of the four standards that have to be assessed, the committee has awarded the Top Master Programme the highest possible distinction of "excellent". The overall summary assessment is also "excellent". The meaning of this epithet is, according to the NVAO rules: "The programme systematically well surpasses the generic quality standards across its entire spectrum and is regarded as an (inter)national example". This is the third time that the Nanoscience programme has received this distinction of "excellent". The committee writes: 'The students of the master's programme convincingly show that they systematically far exceed the expected level for graduates of a master's programme.' and 'Overall, the panel was very impressed by the programme's design and focus, and considers it an internationally unique master's programme.' The Top Master Programme in Nanoscience started in 2003. The sixteenth cohort of students started in September 2018. So far, more than 110 students have graduated from this Programme, of whom almost everyone continued towards a PhD.

Group picture cohort 2016-2018

The Topmaster Best Teacher Award presented to Graeme Blake

"Graeme Blake will help his students every way he can. He dedicates lots of personal attention." This is one of the reasons dr. Graeme Blake has won the Topmaster Best Teaching Award. The best teacher is elected every single year by Nanoscience Topmaster students.

Blake has been leading an investigation group dedicated to Nanostructures of Functional Oxides at the Zernike Institute (RUG). He also lectures masters, and is a member of the selection committee for masters, guiding students during their investigative internships and while writing review articles.

Pleasantly surprised

Blake was pleasantly surprised to find out he had been elected 'best teacher of the year'. "I believe students particularly appreciate the fact that I am available as much as I can to answer any questions they might have." He is right about that. "Also they enjoy my practical lessons a lot. For a subject called Crystallography, they are doing lab tests using X-ray diffraction. This is definitely state-of-the-art material, entirely new to them. We make investigation as realistic as possible, which makes everything great fun."

Well-organised and practical

But Blake has much more to offer. "He is one of the most organised professors I have ever had," one of the students says. "All the course material was in perfect sequence. Everything made sense from start to finish." His practical lessons are valued as well, not only because using good material is highly interesting, but also because Blake shares experiments that failed big time. He allows students to experience how problems are dealt with during real investigation projects.

Interaction at a high level

Enthusiasm goes both ways. "I love working with Nanoscience Topmaster students. It's a small group, with very good students. It allows us to interact at a very high level. It's like talking to colleagues, really. Students will come up with solutions to problems we are still figuring out." Students seem to notice. "Basically, being one of Graeme's student has made me richer in my scientific experience and knowledge."

Annual award

The Topmaster Best Teacher Award is presented every summer towards the end of the academic year. The Best Teacher is elected by Topmaster Nanoscience students. In fall, the teacher is recommended for the faculty's Teacher of the Year. The winner is announced in late November.

NEWS

Moniek Tromp: role model for Dutch girls

Moniek Tromp features in Barbie

Zernike member Prof. Dr. Moniek Tromp is presented as a role model for Dutch girls and women by no other than Barbie in honour of 60 years of the toy. In two pages she tells why she became a chemist, shares her dreams and give a message for all girls on earth: 'Do whatever you like and where your heart is. Don't let anyone tell you what you can do.'
Tromp tells this story also in other ways: she teaches at various primary schools. You have to tell children at a very young age that girls can also become firefighters or chemists, Tromp knows: gender stereotyping starts at the age of 5 or 6. Not approaching girls until they are in high school is therefore much too late. Initiatives such as 'Image Breakers' bring new thoughts to both girls and their parents.
The Zernike institute is proud of Tromp's efforts to promote diversity even from a young age, in addition to her scientific accomplishments. You can find Tromp's feature in the Barbie book here:

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https://www.rug.nl/research/zernike/news/newsitems/20190313-tromp-dive

Cover of the VNCI Chemie Magazine

Tromp is also featured on the cover of the VNCI Chemie Magazine. In the feature article, she and two colleagues share their experiences with diversity on the workfloor.

Moniek Tromp

Young Academy Europe and NOW Domain Science

Tromp also contributes in several ways to the scientific community. For instance, she was elected to become a member of the Young Academy Europe (YAE), a bottom-up, pan-European initiative of a dynamic and innovative group of recognized European early career scientists and scholars with outspoken views about science and science policy.

She is also appointed by the NWO Executive Board as new board member for the NWO Domain Science, from 1 May 2019, together with Ilja Arts (Maastricht University). They will succeed Ineke Braakman en Titia Sixma.

Royal Decoration for Prof. Jeff De Hosson

On Friday 29 March 2019, Prof. J.Th.M. De Hosson has been awarded the Royal Decoration of Knight of the Order of the Dutch Lion. He was presented with this decoration by acting Mayor Koos Wiersma of the Westerkwartier municipality directly after his valedictory lecture in the Aula of the Academy Building.

Jeff De Hosson

Jeff Th.M. De Hosson (Utrecht, 1950) is professor of Applied Physics at the UG, specializing in Materials Science. For four decades, he has performed excellent, innovative technical-scientific research and teaching as well as management duties. De Hosson was appointed Professor at the extraordinarily young age of 27. Throughout his highly productive career, his scientific achievements in the field of physical materials science have resulted in many societally relevant breakthroughs.

After his retirement in 2015, De Hosson has continued working as leader of his research group at the UG. He is still conducting his groundbreaking research, with the same energy and passion as during his early years as a professor.

Defects promise quantum communication through standard optical fiber

An international team of scientists led by the University of Groningen's Zernike Institute for Advanced Materials has identified a way to create quantum bits that emit photons that describe their state at wavelengths close to those used by telecom providers. These qubits are based on silicon carbide in which molybdenum impurities create color centers. The results were published in the journal npj Quantum Information on 1 October.
By using phenomena like superposition and entanglement, quantum computing and quantum communication promise superior computing powers and unbreakable cryptography. Several successes in transmitting these quantum phenomena through optical fibers have been reported, but this is typically at wavelengths that are incompatible with the standard fibers currently used in worldwide data transmission.
Physicists from the University of Groningen in the Netherlands together with colleagues from Linköping University and semiconductor company Norstel AB, both in Sweden, have now published the construction of a qubit that transmits information on its status at a wavelength of 1,100 nanometers. Furthermore, the mechanism involved can likely be tuned to wavelengths near those used in data transmission (around 1,300 or 1,500 nanometers).

Source: www.rug.nl/sciencelinx

More than 3 million euros for research into new materials

The NWO Science Domain Board has awarded more than 3 million euros to a consortium of four companies and eight knowledge institutions active in materials research. The multidisciplinary consortium led by Katja Loos (University of Groningen) will develop new and improved sustainable materials in a project named Soft Advanced Materials. Dutch material researchers from all disciplines will join forces with leading industrial partners to make this transition possible. The companies will jointly contribute one million euros to this project within the Top Sector Chemistry.

Katja Loos

Members of the consortium: ALTANA, BASF, Corbion, DSM, AMOLF, Eindhoven University of Technology, Leiden University, University of Amsterdam, University of Groningen, University of Twente, Utrecht University, VU Amsterdam

Source: NWO

Nanosized ferroelectrics become a reality

Using ferroelectricity instead of magnetism in computer memory saves energy. If ferroelectric bits were nanosized, this would also save space. But conventional wisdom dictates that ferroelectric properties disappear when the bits are made smaller. Reports that hafnium oxide can be used to make a nanoscale ferroelectric have not yet convinced the field. University of Groningen physicists have now gathered evidence that hafnium oxide can be used to make a nanoscale ferroelectric. They published this evidence in Nature Materials.

In the opinion of one of the researchers, Beatriz Noheda, the results are conclusive: hafnium oxide is ferroelectric at the nanoscale. This means that very small bits can be constructed from this material, with the added advantage that they switch at low voltage. Furthermore, the particular substrate used in this study is magnetic, and this combination of magnetic and ferroelectric bits brings an extra degree of freedom, allowing each bit to store double the information. Now that the mechanism of nanosized ferroelectricity is clear, it seems likely that other simple oxides could have similar properties. Noheda expects that together, this will spark a lot of new research.

Source: www.rug.nl/sciencelinx

Graphene bilayer provides efficient transport and control of spins

University of Groningen physicists in collaboration with a theoretical physics group from Universität Regensburg have built an optimized bilayer graphene device which displays both long spin lifetimes and electrically controllable spin-lifetime anisotropy. The work provides insight into the fundamental properties of spin-orbit coupling in bilayer graphene. It has the potential for practical applications such as spin-based logic devices. And furthermore, the findings open up new avenues for the efficient electrical control of spins in high-quality graphene, a milestone for graphene. The results were published in Physical Review Letters on 20 September.

Source: www.rug.nl/sciencelinx

oLife granted, PostDocs available

The European Union has awarded a COFUND grant to a consortium of researchers from the universities of Groningen, Leiden and Eindhoven for a collective fellowship programme called 'oLife'. The 6 M € programme, which is co-financed by the participating universities, will recruit and train 18 post-doctoral fellows to conduct world-leading research on the origin and nature of life and its distribution in the universe. The Call for Proposals has opened on April 1st, 2019.
The oLife Fellowship Programme is a joint initiative by seven world-leading research institutes: TU/e Institute for Complex Molecular Systems, Groningen Biomolecular Sciences & Biotechnology Institute (GBB), Groningen Institute for Evolutionary Life Sciences (GELIFES), Kapteyn Astronomical Institute, Leiden Institute of Chemistry, Stratingh Institute for Chemistry and Zernike Institute for Advanced Materials (ZIAM). The scientific coordinators of the programme are prof. dr. Wouter Roos (ZIAM) and prof. dr. Floris van der Tak (SRON/Kapteyn). The programme manager is Ms. Vanessa van Hest (ZIAM).

oLife thinks about the origin and evolution of life in the universe

The 2019 Vlieland meeting: excursion on the facets of nanoscience

Between May 19th and 21st more than 170 members of the Zernike Institute National Research Centre visited the beautiful island of Vlieland. During a three-day symposium, organised by Giuseppe Portale, Justin Ye, Shirin Faraji, Clemens Mayer and Jeannette de Boer, mainly the junior staff presented the beauty of nanoscience during oral and poster presentations. Besides our own team, we were happy to welcome Prof. Monica F. Craciun (University of Exeter, UK), who presented the keynote lecture entitled "2D Materials for Emerging Technologies".

The Vlieland conference has a long-standing tradition in the Zernike Institute National Research Centre (NRC), which is running the advanced materials research program of the Zernike Institute for Advanced Materials, the Stratingh Institute for Chemistry and the Groningen Biomolecular Sciences and Biotechnology Institute. The meeting in the dunes of Vlieland combines the presentation of the latest results, discussing options for collaborative projects and a big portion of fun. This year we were happy and grateful to welcome Prof. Petra Reinke (University of Virginia, guest in the group of Petra Rudolf) and Prof. Christoph Brabec (honorary professor at the Zernike Institute) who very actively joined the scientific discussions at Vlieland.

Ferroelectrics, virus assembly, spintronics and polymers

This year's scientific program kicked-off with talks of Loredana Protesescu (Zernike), Clemens Mayer (Stratingh) and Danny Incarnato (GBB) who all recently started their tenure track in Groningen. The 24 oral presentations of PhD students and Postdocs presented once more the full breadth of the institute: With topics covering the whole chain from synthesizing materials, building devices, characterizing materials and devices, and investigating the theoretical foundation of their properties, all attendees had the chance to broaden their scientific horizon and to get inspired by each other. In addition to the oral sessions, 120 posters reflected on the latest results of the PhD students and Postdocs and gave a lot of room for in depth discussion.

Fun part

During the packed scientific program the organizers scheduled some time to take a breath and digest the information while taking a walk at the beach or during the early morning running activity.
This years evening program included bowling, discussing and dancing in the bar and a hilarious pub quiz on (fun) facts of the advanced materials research in Groningen and the involved people.

A highlight was the keynote by Prof. Monica F. Craciun from the University of Exeter. Her inspiring talk on the many different application prospects of layered 2D materials, gave a glimpse on the transfer of fundamental science into applications such as flexible electronics or lightweight solar cells.

No scientific meeting without awards

In good tradition of almost all scientific meetings, we closed the event withawarding the best poster with the Bert de Boer Prize (Sanne Berg), the best oral presentations (Talieh Ghiasi, Carmem Maia Gilardoni, and Dina Maniar), the best flash-presenters (Si Chen, Pascal Freyer, Jan Hidding, Mart Salverda, Atreya Majumdar and Jordi Antoja-Lleonnart) and, after establishing the best dancing professor award in 2017, the Wouter Roos Dance Award (winner chooses to remain anonymous).

Alumnus

Alina Veligura
Promoted: November 2012
Subject: Quantum transport in two- and one-dimensional graphene
Promotor: Bart van Wees
Employer: Philips
Education: Bachelor and Master of Science in Medical Radiophysics at the National Tara Schevchenko University of Kyiv, Top Master in Nanotechnology at RUG.

How did you become a PhD student with Bart van Wees?
'In the second year of the Top Master Nanoscience, I did a research project with professor Bart van Wees. At the time, graphene just started to gain a lot of attention. The group had just had a publication in Nature on this topic. A lot was happening, it was an exciting environment to be a part of. At the same time, Bart suggested applying for an NWO grant for top students, for which the university can only nominate a limited number of people per year. I was selected as a nominee by the university and further coached by Bart and professor Petra Rudolf to give a winning presentation at the NWO. I think what helped me to get the grant is not only my personal skills and knowledge but convincing the NWO that these skills would be a winning match in combination with unique equipment RUG has to offer for the research.'

What is the most important thing you learnt?
'Applying vastness of the gained technical and scientific knowledge in the most efficient way in a professional and private life: embrace any complex problem and dissect it in solvable pieces.'

What made the work in the Van Wees Group enjoyable?
'A plurality of sophisticated tools in Bart's lab. You could really do many things, which most of the PhDs in applied physics can only imagine. That made the research extra attractive. I also greatly appreciated the collaboration with other groups, such the Ben Feringa's Group, which trained me approaching any scientific problems using different points of view.'

How did you end up with your new employer, and what work do you do?
'Bart's former PhDs are contributing substantially to a "patent" profession (I don't think any other professor can say this). One of those PhDs (currently my colleague) introduced me to a "patent" world.
I work at Philips the in Intellectual Property & Standards department that deals with all company's patents. I draft and defend patents and support Philips researchers in the area of healthcare.'

The best memories
'Sometimes we had to cool down samples, which often would last through the weekends. Once you are "cooling" there is a set of rules one needs to follow: first liquid nitrogen, then helium. The cooling speed and sample placement has to be precise: fast, but not too fast, because then you might get too much evaporation and helium alarm will go on. We really worked together as a synchronized team. Those were fun weekends.

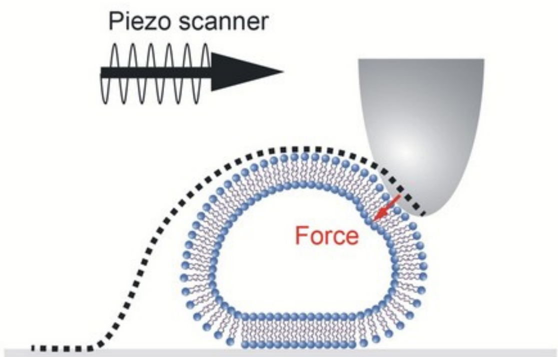
Enthusiastic about Groningen
'Groningen is a bustling city, where there is always something to experience. If you wanted, you could always go into town after work (no matter how late you finish cooling the samples). I found that to be special about Groningen. In addition, Groningen has a very good University Library and excellent sports facilities. I have tried many different sports courses at the ACLO, even pole dancing. Thanks to those courses at the ACLO, I still exercise regularly now. RUG and Groningen will always take a big place in my heart, because here I also met my future husband.'

Wouter Roos: A closer look at the communication packages of cells

Cells in our body communicate with each other by sending little balls with protein to one another. Wouter Roos, professor of Molecular Biophysics at the RUG, described as first with colleagues from Amsterdam and Utrecht the mechanical properties of these exosomes from red blood cells, and compared them to exosomes from cells with a blood condition. 'It appears that they have very different properties,' concludes Roos. 'That offers new possibilities to develop treatments.' The results have been published in de scientific journal Nature Communications on 23 February.

That cells send little balls with proteins in and out of the cell has been known for a long time. Cells compose those balls using a small part of the cell membrane, the outer wall of the cell. For a long time it was thought that in this way cells mainly cleaned up waste from the cell. But for about fifteen years we know that these exosomes are important for the communication between cells. 'So far we have only studied them in groups to discover their properties. But thanks to a special microscope, we could now study and describe one single exosome,' says Roos.

Needle
Roos started the research a few years ago in Amsterdam together with professor in physics and life processes Gijs Wuite and finished it after his arrival in Groningen, where he is now part of the Zernike Institute for Advanced Materials. 'We have first looked at the red blood exosomes with a touch microscope, the atomic force microscope' says Roos. 'This microscope feels over the surface with a needle, so that we discover what the surface looks like.' A bit like a blind person feels braille letters. 'We then tested the properties by pressing the small balls with proteins. You then get an idea of the firmness and flexibility of the exosome.' This way the researchers were the first to map the properties of exosomes from red blood cells.



Use of the Atomic Force Microscope to investigate exosomes
Illustration ZiAM/University of Groningen

Surprise
'Then we looked at red blood cells of people with spherocytosis. People with this condition have far too round and stiff red blood cells. We expected that their vesicles would be harder too. But to our surprise they turned out to be softer.' That observation led to the insight that especially the soft parts of the cell can form the vesicles. 'We knew that people with spherocytosis make more vesicles, but that they would show such unexpected behavior, we did not suspect. That insight leads to a lot of new questions, which might help to understand the genesis of the stiff red blood cells in sferocytosis and maybe leads to new therapies.' There are still many mysteries left. 'What exactly is there in such a exosome, for example? What information do they transfer? And how do they know at which cell the information should arrive? Once we know that for healthy cells, we can also better understand how the communication in several diseases. And then we can also develop techniques to better detect those exosomes and make medicines that influence their communication.'

Puzzle
There is an important reason that Roos and others dive into the properties of exosomes. 'Not only healthy cells communicate with exosomes, but also tumor cells. If we understand them better, we may be able to discover differences between exosomes of healthy cells and exosomes of tumor cells. Then we can use them for diagnostics and to make medicines against cancer,' explains Roos. In the Netherlands only there are already nine research groups that work on this subject, organised in the Cancer-ID partnership.

Appointed professor

Marcos Guimarães: Optics and Magnetism in Two Dimensions

Marcos Guimarães has been appointed on the first of February as Assistant Professor at the Zernike Institute of the RUG. In this capacity he will be dealing with two-dimensional materials and magnetism. "The purpose of my research is to better understand how the optical and magnetic properties of materials behave in two dimensions. This allows us to engineer new materials with specific properties. To build better computer memory, for example."

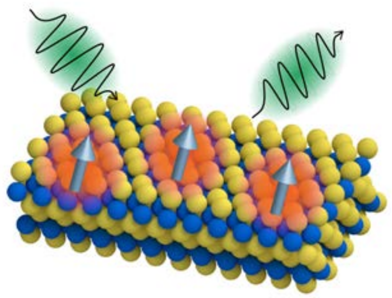
Guimarães is no stranger to Groningen. After his master's at the Federal University of Minas Gerais in his hometown in Brazil, he worked as a PhD student with Bart van Wees from 2010 to 2014. He then received a NWO Rubicon and a Kavli Institute fellowship to work as a postdoctoral researcher at Cornell University in the United States. In the last two years Guimarães worked as a researcher at Eindhoven University of Technology, funded by a NWO Veni grant. "At Cornell I familiarized myself with electrical methods to manipulate magnets (spin-orbit torque) and in Eindhoven with time-dependent magneto-optics, where we can measure the magnetization with time resolution. I will now combine the knowledge I gained in both places for my research here in Groningen."

Cake stacking

For his research, Guimarães combines different two-dimensional materials; materials that consist of a single layer of atoms and thus have special properties. He does not only look at these layers separately, but stacks several layers on top of each other. Guimaraes compares it to a cake. "A cake consists of multiple layers: a layer of cake, a layer of whipped cream, another layer of cake, then a layer of chocolate, a layer of fruit and another layer of whipped cream, for example. Although individual layers taste differently when you combine them. And the beauty of it is that this allows you to make endless combinations. There are many different material 'flavours', which can have new unique features when they are put together. This is what makes working with two-dimensional materials so incredibly beautiful."

Two angles

Guimarães' research has two directions. "First and foremost, I'm interested in magneto-optics: where we study how the intrinsic angular momentum of electrons (the spin) and magnetism behave using lasers. I am interested in the dynamics of these systems: how do they behave, how long these spins live in these materials, and how does magnetism behave in 2D? This gives us the opportunity to get to know the properties of two-dimensional materials better and better." The other direction is a more applied direction. "For this purpose, we use a 'cake' made of two-dimensional materials. On top of that cake we place a magnet. By running current through the layers, the outer layer of these materials can accumulate spins. They, in turn, can change the magnetization direction of the magnet on top. This change is permanent. These systems are therefore suitable for a new generation of memory devices, for example to improve the memory of computers."



Industry

Guimarães enjoys working with two-dimensional materials because there are so many 'flavours'. "There are a lot of possible combinations which can lead to the discovering of interesting materials and different effects. But for the industry, it is difficult to manufacture these materials. On a small-scale level, we investigate which flavours are needed to yield interesting effects, and then we can attempt to make other materials which are industry-compatible but with the same characteristics."

Appointed professor

Richard Hildner: Watching photoluminescent molecules

We have known for a long time molecules which, under certain conditions, will emit light. OLED lamps and devices, used for instance in displays of the new Samsung smartphones, are based on these molecules. However, we know less about how exactly this is done at the molecular level. Professor Richard Hildner has dedicated himself to studying these photoluminescent molecules. On October 1st, he and some members of his research group will be joining the Zernike Institute (RUG), to continue with this research in cooperation with other groups within this institute.

Messy spaghetti

OLEDS are used in e.g.lamps, telephone displays, TV and computer screens. Hildner explains: "The molecules used for OLEDs are often like a pan of cooked spaghetti. Until now, we used to study the entire pan; you can see long molecules intertwined inside it. You can see their shapes, bending in different ways, but other than that, it's chaos basically." Hildner and his group have been trying to understand this chaos. "We remove all but one strand of spaghetti, which means keeping a single molecule only, to have a closer look. We test how this molecule responds under specific circumstances, how their photoluminescent properties, particularly their emission colour, change with shape and bending, etcetera.

Other molecules

Hildner is not only interested in organic light emitting diodes, which is how OLEDS are actually referred to. He is also interested in molecules which can be used to make organic solar cells, i.e., which can be used to convert sunlight into electrical power. "It's about us wanting to better understand how these molecules actually work, how they are able to absorb sunlight, transport the resulting energy, and finally convert this energy into an electrical current. Once we do, perhaps we might be able to improve performance of solar cells. "Some of the substances he has been working on include poly-(3-hexylthiophene) (P_3HT) and carbonyl-bridged triarylamine. The interesting thing about carbonyl-bridged triarylamine is that it is capable of forming long nanowires by self-assembly. These nanowires are well capable of transporting energy over unprecedented distances (> 1 µm). I really want to find out how they do that, and how we could potentially further improve it."

Better understanding

The purpose of Hildner's research is to develop a better understanding of the optical properties of molecules and how new function, such as energy transport, emerges if molecules arrange themselves into larger structures. "We are no engineers, and this is not about building better machines. Basically, we want to know how the molecule works." Once they do, Hildner and his colleagues will team up with chemical experts. "Our knowledge will help chemists come up with a solution as to how we might be able to adjust the chemical structure of those molecules to make even better ones, which transport energy or charges more efficiently or which are even more sensitive to light." Hildner is also hoping other research groups at the Zernike Institute will start cooperating. "We all have great knowledge to offer, and we certainly can learn a lot from one another."

Resumé

Since 2011, Richard Hildner has been researcher and group leader at the Bayreuth University in Germany, where he also studied and obtained his doctoral degree in 2008. From 2008 to 2011 he was postdoctoral researcher in Castelldefels (Barcelona), at the Institute of Photonic Sciences (ICFO). On October 1st, he became professor for Optical Spectroscopy of Functional Nanosystems at the Zernike Institute (RUG).

A closer look at the Huntington-protein

Solid-state Nuclear Magnetic Resonance (ssNMR) enables the study of the structure of the mutated Huntington-protein – the cause of Huntington's Disease. This has been reported by the group of professor Van der Wel from the Zernike Institute (at the time professor in Pittsburgh) and a research group led by professor De Paëpe in Grenoble in France in the scientific journal Journal of the American Chemical Society. 'If we can better understand that structure, we might be able to develop smarter drugs that target the cause of the disease, rather than just treating the symptoms.'

Huntington's Disease is a so-called neurodegenerative disease, such as Parkinson's Disease and Alzheimer's Disease. Many neuronal cells in the central nervous system die over time in neurodegenerative diseases. The outcome, amongst other things, is deterioration of the motor skills and the memory and eventually leads to a premature death.

Protein aggregates

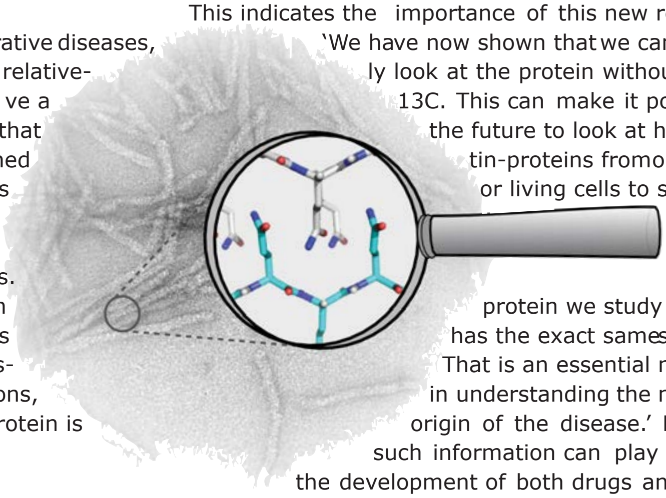
In contrast to many other neurodegenerative diseases, the cause of Huntington's Disease is relatively clear and predictable: patients have a special kind of mutation in their DNA that is responsible for the before mentioned huntingtin-protein. The mutation leads to misfolding of this protein and consequently the formation of protein aggregates, a type of cluster of proteins. Such protein clusters are also seen in other neurodegenerative diseases. It is not known if and how these protein clusters contribute to the death of the neurons, partially because the structure of the protein is not known yet.

In the heart of the protein

It is not easy to image the protein. That is not possible yet with commonly used techniques based on X-ray diffraction and high-resolution electron microscopy. 'If you look at the structure of the clustered protein, you can understand why this is such a challenge,' explains Van der Wel. 'It forms kind of a long wire from thousands of proteins, of which no crystals can be made. In addition, these wires do not dissolve easily and are disordered and dynamic.' Two years ago, the Van der Wel group managed for the first time to look into the heart of the protein, in the mutated part. This was possible via a special form of spectroscopy, based on the detection of nuclear magnetic resonance, which is also used in MRI scanners. 'However, that was only possible when we made the protein ourselves in the laboratory with extra 13C-atoms in it. We needed these atoms to get a good look at the protein. 13C-atoms are rare in nature: naturally only one in a hundred carbon-atoms is 13C. Thus, that is also the situation you find in proteins of natural sources, which makes it difficult to study protein clusters from humans and animals with our technique.'

Natural proteins

This indicates the importance of this new research. 'We have now shown that we can carefully look at the protein without adding 13C. This can make it possible in the future to look at huntingtin-proteins from organisms or living cells to see if the protein we study in the lab has the exact same structure. That is an essential next step in understanding the molecular origin of the disease.' Hopefully such information can play a role in the development of both drugs and signaling molecules that recognize and detect the misfolded proteins (for the benefit of diagnosis and prognosis).



Other proteins

A better understanding of Huntington's Disease might also help in understanding (and targeting) other neurodegenerative diseases. "Unfortunately, it is not easy to apply this technique directly on other proteins. To also look at proteins from Parkinson's Disease and Alzheimer's Disease more research has to be done. But our French colleagues will definitely continue with developing this research method."

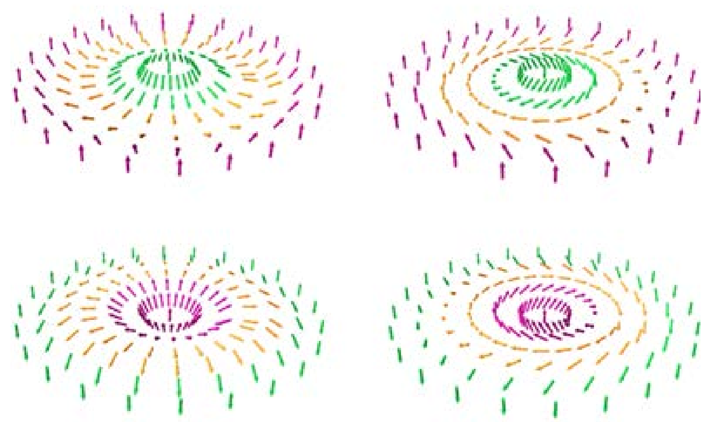
Smith A.N., Märker K., Piretra T., Boatz J.C., Matlahov I., Kodali R., Hediger S., van der Wel P.C.A., De Paëpe G. Structural fingerprinting of protein aggregates by DNP-enhanced solid-state NMR at natural isotopic abundance. J Am Chem Soc. 2018;140(44):14576-80.

Marie Curie Fellowship for research into skyrmion-friendly materials

Thanks to a two-year Marie Sklodowska-Curie fellowship, Dr. Liliia Kulish can continue her research into the field of magnetic skyrmions at the Zernike Institute for Advanced Materials of the University of Groningen. With her research, she increases the understanding of materials that could possibly play a role in a new generation of memory and logic devices. "Magnetic skyrmions are promising, but we still know very little about their practical use. We are looking for new materials in which skyrmions occur and are trying to understand their properties better."

Nanoscale tornadoes

Skyrmions look a little like very tiny tornadoes in materials. All elementary particles that make up the matter in the Universe have a property related to their spinning direction ("spin"). Skyrmions are collections of spins in a material that are confined to a space just a few nanometers large. Just like real-life tornadoes have an overall wind direction and different internal air flows, the outer edge of a skyrmion has a different magnetic direction than the centre. "The outer direction is easy to detect, while the internal structure of the vortices can be switched using low electric voltages. This means a skyrmion can act similar to a 0 or 1 bit in a computer, but with a lower energy cost."



Synthesis and investigation of new materials

The problem lies in finding materials that can hold stable and sufficiently small skyrmions. In 2009, the first skyrmions were found in chiral magnets, but these were too large to be useful. Other materials have been elusive so far, but recent theoretical work predicts that more compact skyrmions can be found in so-called frustrated magnets. Thanks to the Marie Curie project of Dr. Kulish, she can proceed to put this theory to the test. "I hope we can make the frustrated compounds with magnetic skyrmions. It is not easy to find compounds with suitable crystal structures and chemical compositions, but guidance from our collaborators in theoretical physics gives us a number of new approaches to pursue."
Dr. Kulish is investigating a group of materials that potentially meet the required structural criteria, based on the alkali chromites and manganites ABO_2 (A = Na, K, Rb or Cs; B = Cr or Mn). "Little research has been done so far on these compounds, but theoretically they are promising for the existence of skyrmions. We can tune the structure and composition of these compounds by exchanging one ion for another, which allows us to create interesting features. I am planning to do a full investigation of the ABO_2 family, using cutting-edge methods of synthesis and modern analysis techniques such as Lorenz transmission electron microscopy, neutron and resonant X-ray scattering."

Collaboration

Dr. Liliia Kulish previously worked in the field of solid state chemistry in St. Petersburg, Russia. Since February 2018, she works at the Zernike Institute for Advanced Materials in the group of Dr. Graeme Blake. "The great thing about this research is that I can collaborate with experts from different fields. For example, our group works with Prof. Maxim Mostovoy from the Theory of Condensed Matter group and with other experts in materials science. We also work with the group of Prof. Catherine Pappas from Delft University of Technology, who is expert in neutron scattering techniques that can detect skyrmions directly." Dr. Kulish is therefore extremely pleased the EU recognized the importance of her research by awarding the highly competitive fellowship to continue her research for another two years.

Patrick Onck
Using waves to move droplets

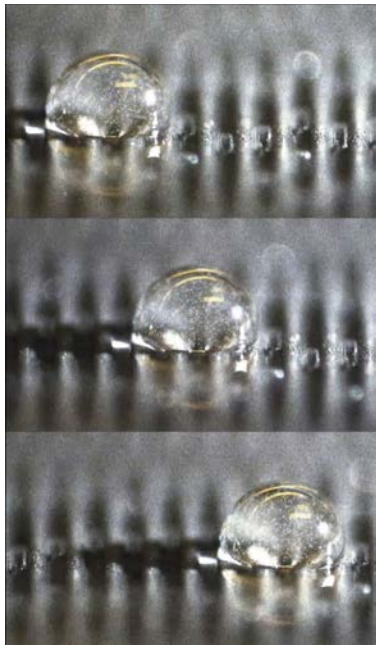
Self-cleaning surfaces and laboratories on a chip become even more efficient if we are able to control individual droplets. University of Groningen professor Patrick Onck, together with colleagues from Eindhoven University of Technology, have shown that this is possible by using a technique named mechanowetting. 'We have come up with a way of transporting droplets by using transverse surface waves. This even works on inclined or vertical surfaces'. The research was published in Science Advances on 14 June.

The idea of mechanowetting is basically very simple: put a droplet on a transverse surface wave, and the droplet will move with the wave. 'One of the properties of water droplets is that they always try to stay on top of a wave. If that top runs ahead, the droplet will run with it', Onck explains. It is possible to move the droplets by using mechanical deformation to create surface waves. 'The remarkable thing about this is that it also works on inclined or vertical surfaces: drops can even move upwards against gravity.'

Theory

Edwin de Jong, PhD candidate in Onck's group and first author of the paper, tested the concept of mechanowetting by means of a computer model. 'When it seemed to work in theory, our colleagues from Eindhoven University of Technology devised an experiment to test it. Our model turned out to be right: in practice, the drops moved exactly as we had imagined.'

One of the applications of mechanowetting is in lab-on-a-chip systems, complete laboratories the size of a credit card, which are used to analyze biological fluids such as blood or saliva. This allows the samples to be tested outside the lab, e.g. directly at the bedside, with a much faster response rate. 'If we are able to direct each drop separately, it is possible to perform a lot of different tests at high speed with a very small volume of fluid', says Onck. Transporting droplets separately was already possible by means of electrowetting. 'Electrowetting is able to transport droplets by applying electric fields. However, these fields can change the biochemical properties of the sample, and that is something you don't want when doing blood tests.' In the meantime, Onck's group is exploring new possibilities. 'We have performed computer simulations that show that mechanowetting also works by using light-responsive materials to create waves. Light is especially interesting because of its precision and its ability to control the movement of drops remotely.' In addition to lab-on-a-chip systems, mechanowetting has several other interesting applications, such as self-cleaning surfaces, where water droplets actively absorb and remove the dirt. It also offers opportunities for harvesting moisture from the air, by collecting dew drops for use as drinking water.



A glycerol droplet travels along with the wave. Small particles in the droplet visualize the internal fluid flow. | Illustration De Jong et al., Sci. Adv. 2019;5: eaaw0914

Marleen kamperman starts as new professor of polymer science
Imitating natural superglue

A gecko seems to have superglue on its feet: it can detach its feet and attach them again, over and over without the glue losing its strength. Likewise, mussels also have special glue: they can stick under water. This fascinates Marleen Kamperman. As professor of Polymer Science she attempts to reproduce such special glue.

Kamperman is currently working at the Wageningen University (WUR), but will continue her research as professor at the Zernike Institute in Groningen, starting in September. The substances animals use as glue are polymers, a kind of plastic. "In Groningen I can work together with other polymer chemists. They have experience with bio-based materials: polymers synthesized from plant materials instead of petroleum."

Medical glue

Imitating the super glue of geckos, mussels, and other animals is not only fun but also useful. "Glue that also works on a wet surface is interesting for the medical world. After all, the human body is also wet. This kind of glue would make it much easier to attach materials inside the body." Kamperman is eager to look for opportunities to collaborate with UMC Groningen. "It would be wonderful if our research of these materials eventually leads to practical applications."

Glue on robot hands

The glue from a gecko could be of interest for robotics, another active field of research in Groningen. "Robots can do many things, but they have difficulty handling fragile objects. If your grip on a tomato is too weak, it drops, but if you squeeze too hard, it gets damaged. If the robot had the abilities of a gecko, it could glue a tomato to its hands and simply release it when necessary."

Multidisciplinary

Kamperman was trained as a chemist, but is excited about this research because it combines multiple fields of study. "I learn much from biologists. In our lab we do not actually work with animals, but we utilize the knowledge from biologists to understand how that glue works." Physics also plays an important role for understanding how substances stick and let go. "I find that combination attractive, especially together with the wide range of possible practical applications."

Curriculum Vitae

Marleen Kamperman (1979) received her PhD in 2008 from Cornell University in Ithaca, New York. She then worked for two years as post-doc researcher at the Leibniz Institute for New Materials in Saarland (Germany). Since 2010 she works at the Wageningen University, first as Assistant Professor, and since 2016 as Associate Professor. In September 2018 she will take up her new position as professor of Polymer Science at the Zernike Institute for Advanced Materials at the University of Groningen.

The glue from a gecko could be of interest for robotics

Storing data on a nanoscale using light

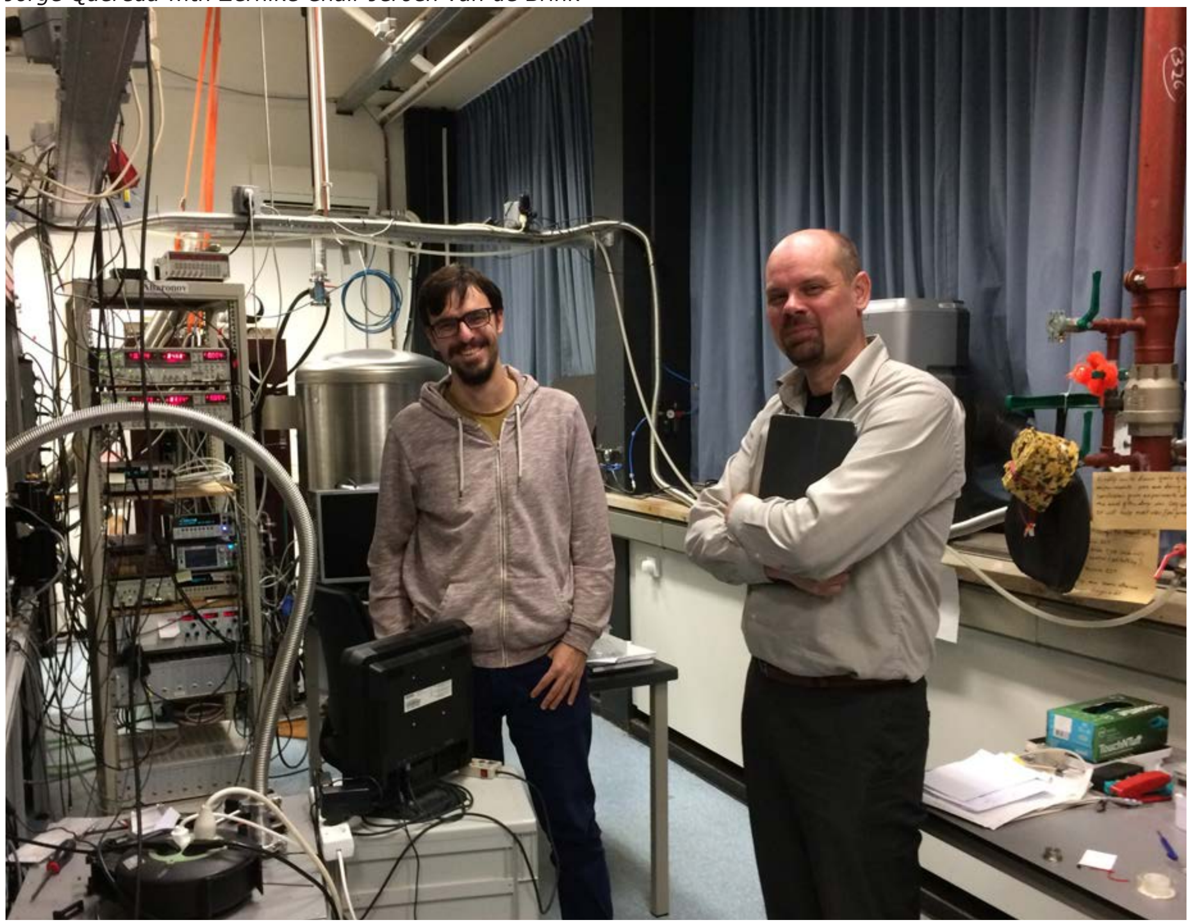
It is possible to store data with the help of light without further electricity being required. Last Summer, postdoc Jorge Quereda and professor Caspar van der Wal wrote this in Nature Communications. For the research they used the two-dimensional material molybdenum diselenide ($MoSe_2$), in which electrospinning occurs. "This research can potentially contribute to the development of faster, better, smaller and more sustainable computers," says Caspar van der Wal. "This kind of nanomaterial can make things possible in the future far beyond our current limitations."

The idea of using electron spin for storing data isn't new. "There are electrons in atoms. They rotate on their own axis, such as a coin that you can turn upright on the table. Then there are two options: clockwise or anti-clockwise," explains Quereda. The investigation into this is also referred to as spintronics. "If you can influence the direction of that spin and measure that direction, you can use that to store data. Just like now in computers, you get a code with two values, 1 or 0. A whole series of ones and zeros can together form a code."

Good angle

The discovery that $MoSe_2$ had these special properties started during an experiment by PhD student Jorge Quereda for another research. "I knew that $MoSe_2$ has certain properties, which might turn in it into a potential candidate to set the direction of the electron spin using light, if that light falls on it at a certain angle. So when I shone light straight on the material for another experiment, it took little effort to see what would happen if I dropped light at a different angle." Quereda saw unexpected responses to that light, more than he had expected. "I quickly gathered this might be a good point of view for further research."

Jorge Quereda with Zernike Chair Jeroen van de Brink



Zernike Chair

At the time that Quereda discovered this, professor Jeroen van de Brink was as a guest at the Zernike Institute for a month as a Zernike Chair. During lunch, he spoke with Quereda and Van der Wal about Quereda's observations. He visited their lab and was immediately intrigued. That resulted in a longer collaboration. "This publication is the direct result of a fruitful collaboration with him, thanks to the Zernike Chair."

Sherlock Holmes

Yet it still has taken a lot of doing before the publication finally came to be. "If you only see an effect, you haven't reached the finish line yet," Quereda knows from experience. "It was hard to explain the effects we saw. We initially expected that those effects in response to light were caused by an effect we call Berry curvature. However, after calculating and testing again and more calculating, we concluded that we actually had correct evidence that that effect was not caused by Berry Curvature. What it is caused by, is still a puzzle. It was really a theoretical puzzle, I felt like a Sherlock Holmes. Combining clues over and over again, looking for new clues and test ideas, until I got closer to the solution."

More features

Research on two-dimensional materials has not been done for very long. "The field started around 2007 with the discovery of spintronics in graphene. Since then, more two-dimensional substances have been discovered, but the properties have not yet been discovered and described in detail. That makes this type of research special, because it helps to understand the properties of the materials." As far as Van der Wal is concerned, the research is by no means finished. "We saw many more reactions to light in the material than we thought. The properties $MoSe_2$ seems to have means that the material may also be used to make very specific detectors and sensors. But then further research is needed first."

Current through light

Until now, electrical current was also needed to influence the electron spin. "In this study, we influenced that spin with only light, so without adding any further electricity," Quereda proudly says. "In this material, the current is established by the light." Van der Wal is enthusiastic about that, too. "In this way, spintronics can not only provide more computer power, but can also do so with considerably less energy. That is important, because at the moment, ten percent of the energy used worldwide is used by computers, and the use of computers is only increasing."

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ZERNIKE INSTITUTE COLLOQUIUM CALENDER 2019 / 2020

10 Oct 2019	New ZIAM faculty & research lines
7 Nov 2019	Jennifer Ogilvie, University of Michigan
12 Dec 2019	Lukas Eng, Technische Universität Dresden
9 Jan 2020	New ZIAM faculty & research lines
6 Feb 2020	Mircea Dinca, Massachusetts Institute of Technology
5 Mar 2020	Charlotte Williams, University of Oxford
2 Apr 2020	To be announced
7 May 2020	To be announced
4 Jun 2020	To be announced

Colofon

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