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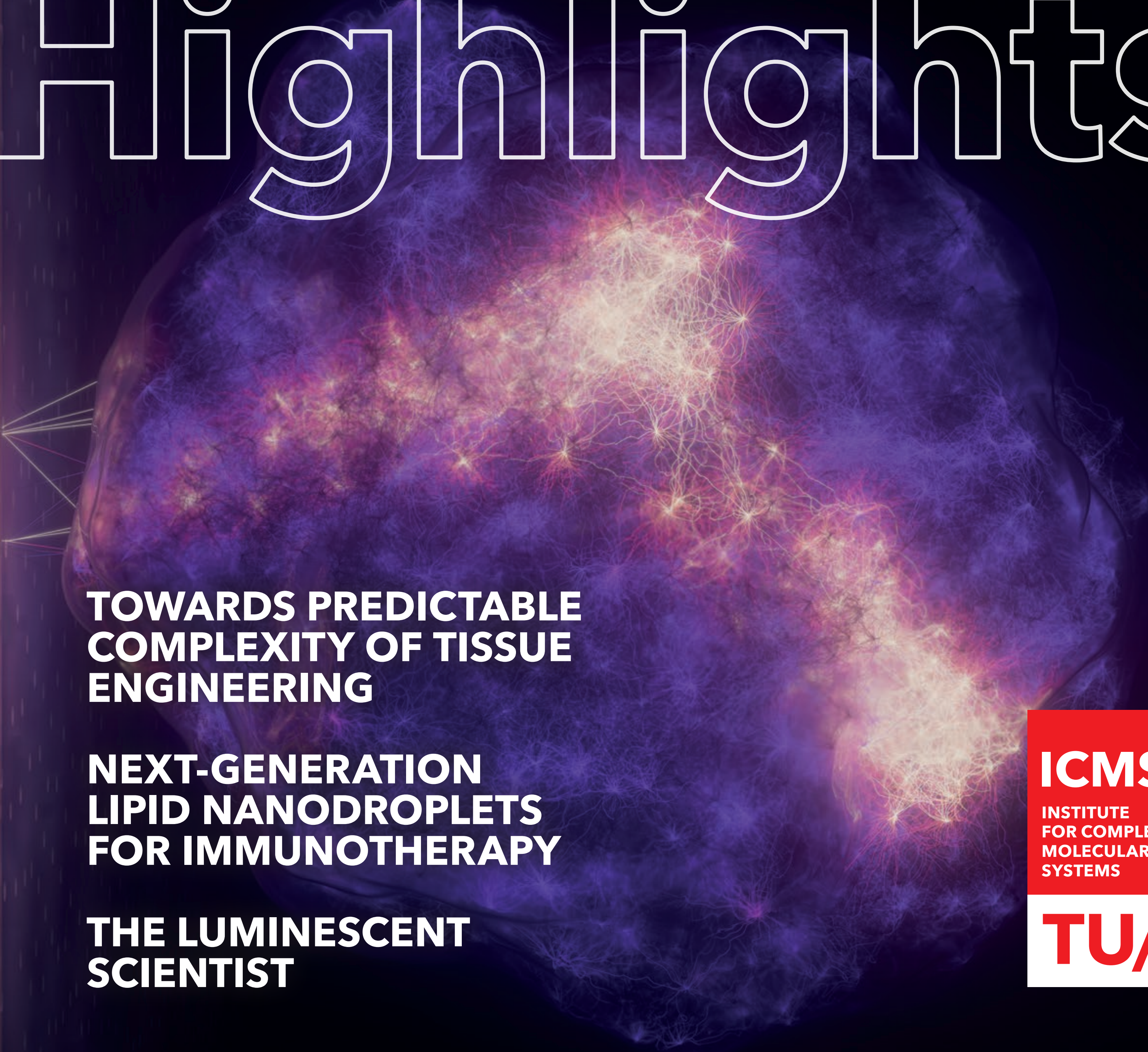
ICMS Highlights



TOWARDS PREDICTABLE COMPLEXITY OF TISSUE ENGINEERING

NEXT-GENERATION LIPID NANODROPLETS FOR IMMUNOTHERAPY

THE LUMINESCENT SCIENTIST

ICMS
INSTITUTE FOR COMPLEX MOLECULAR SYSTEMS
TU/e

INTRODUCTION

ICMS Highlights

Next year we will celebrate the 15th anniversary of ICMS. Over the years, ICMS scientists have generated a wealth of fundamental knowledge about phenomena associated with complex molecular systems. We hope that this knowledge will continue to be a springboard for science, industry and society. In that regard, we take our anniversary as a great opportunity to discuss exciting ICMS science in monthly meetings with our community members. Soon, you will find an overview of events on our website.

We are surrounded by talent at every level. The efforts and achievements of our researchers do not go unnoticed. Here, we want to mention a few of those in no particular order. We are proud of Sandra Loerakker and Roy van der Meel who both received a Vidi grant from the Dutch Research Council. Lorenzo Albertazzi received an ERC proof-of-concept grant. Bert Meijer has been awarded the 2022 Hermann Staudinger Prize. Mert Astam has received a PhD thesis award organized by and for PhD students. The iGEM student team achieved an incredible victory at the iGEM Giant Jamboree in Paris, the international competition for innovations in synthetic biology. With their new ideas for treating autoimmune diseases, they finished first in a competition involving more than 180 teams. Finally, we are happy to announce the substantial support of the National Growth Fund for research in Self-Thinking Molecular Systems, and PharmaNL. These initiatives focus on revolutionary digital approaches in chemistry, to design and manufacture complex formulations that can be applied in a wide variety of fields, from medicine to materials science.

We want to wish you happy holidays and we hope you enjoy reading this edition of the ICMS Highlights.

You can keep up to date with ICMS by following us on LinkedIn.

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Scientific director

Monique Bruining
Managing director

Colophon

Please check our website
for our upcoming events.
www.tue.nl/icms

EDITORIAL
ICMS Highlights is the half-yearly magazine of ICMS for ICMS members, colleagues, collaboration partners, policy makers and affiliated companies.

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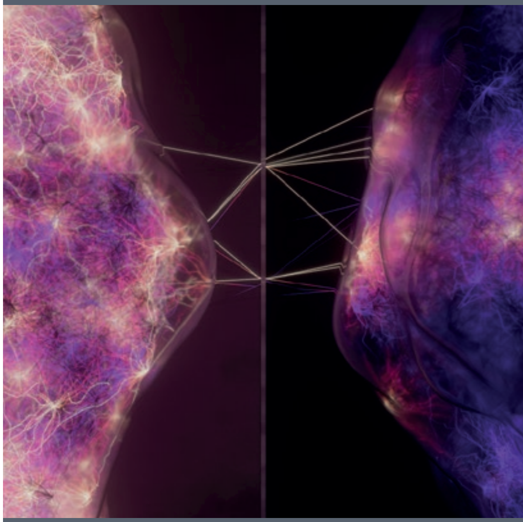

COVER "Mini brains connecting through a membrane"

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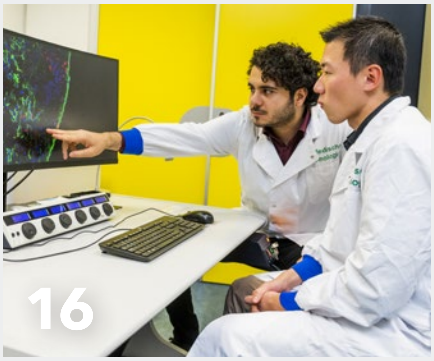
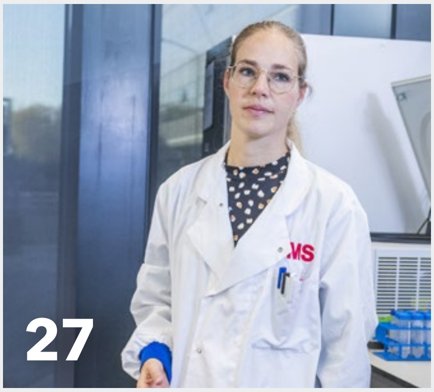




Pim van der Hoorn (left) and Roderick Tas (right)

Counting dots to find the interface

When a mathematician and molecular scientist look at the same image, they may perceive different things. At ICMS, mathematician Pim van der Hoorn spotted a point process where molecular scientist Roderick Tas saw a liquid-liquid interface. It led to a faster, more precise and more fundamental method to image soft matter interfaces at nanometer level.

"In principle, we took an off-the-shelf solution," says Pim van der Hoorn, assistant professor in mathematics at the research group Statistics, Probability and Operations Research. "It was a mathematical approach published in the 1960s. So it was not about applying revolutionary mathematics, we just wanted to find out if the problem indeed could be abstracted to the mathematical issue we thought it was." The problem he refers to concerns the precise localization of a liquid-liquid interface after visualizing it with microscopy at near-nanometer level. Liquid-liquid interfaces play an essential role in emulsions – tiny oil-drops neatly dispersed in water, or the reverse, water-drops dispersed in oil. They are found in foods (e.g. mayonnaise or milk), in cosmetics and in medicines. At ICMS, the fundamentals of such quasi-stable systems are studied with the main aim to create new self-assembling, functional materials. These can be self-repairing, or may regenerate a damaged heart.

"TO STUDY EMULSIONS YOU NEED TO KNOW THE EXACT LOCATION OF THE SOFT INTERFACE"

Particles at the liquid-liquid interface often play a crucial role in stabilizing emulsions. They prevent their segregation into two separate layers of water and oil. The size and concentration of the particles affects the size of the tiny droplets and can also determine if an emulsion consists of tiny oil drops in water or the reverse. "To study the influence of particular particles, it's important to know their exact position and orientation at the interface," says post-doc Roderick Tas, a microscopy expert working at the Laboratory of Self-Organizing Soft Matter. "However, to establish that, you first need to know the exact location of the soft interface itself." Since 2014, the research group uses iPAINT to do so: interface Point Accumulation for Imaging in Nanoscale Topography. It is a minimal-invasive imaging technology with nanometer resolution, based on fluorescence. Tas: "We use small amounts of water-soluble fluorescent probes, which show up as dots in the images." As the probes are hydrophilic, the water phase has many more of these dots than the oil phase. Therefore, a liquid-liquid interface reveals itself as the line where a low dot-density changes to a high dot-density.

GRIP ON COMPLEXITY

Until recently, that line was determined by means of image analysis applying density-based thresholds. Master student chemical engineering Danny van der Haven, however, wondered if he could develop an alternative method by applying statistical analysis. After all, the distribution of the dots depends on chemistry and thus on "statistical entropy." This appealed to Tas, who supervised Van der Havens Master's project. Via the ICMS Grip-on-Complexity-group, where Tas and Van der Hoorn regularly meet, he asked the mathematician to have a look. "Like most mathematicians who look at dots, I immediately thought: point processes," says Van der Hoorn. "If the points are indeed distributed stochastically, the interface presents the meeting or switching of two point processes, and that can be described as a Poisson process." Van der Hoorn dug in the literature and discovered that such problems were already solved in the late 1960s. "Then it was a matter of finding out if we indeed could apply the algorithm to the problem. And not only on my computer, but in the real world." Van der Hoorn and Van der Haven quickly wrote some code for a first test, which looked promising. They proceeded to develop a software tool, so that Van der Haven could test the algorithm in large-scale simulations. "The method worked faster and is way more elegant," he says. "You don't need to set a baseline before you can analyse your data, and so you don't have to perform a series of similar measurements to determine this baseline and filter out any background signals. The method is solely dependent on counting the points."

"THE METHOD WORKS FASTER AND IS WAY MORE ELEGANT"

OVERLAPPING KNOWLEDGE

This striking result is a good example of how people from different disciplines may solve complex problems, emphasize Tas and Van der Hoorn. "In this field it is necessary to share problems, to discuss them with other scientists," says Tas. "You may have overlapping or additional knowledge you're not aware of." The tool is open source, any scientist may use it. A next step at ICMS will be to use it for studying particles at the interface. Where and how are they positioned? And do they deform the interface? Tas and Van der Hoorn combine forces on at least one other complex topic: antifreeze proteins and their influence on ice crystal formation. Meanwhile, Van der Haven has moved to the Centre for Scientific Computing at Cambridge University for a PhD on simulating powder compaction. Does he find computing to be more fun than wet chemistry? Van der Haven: "In simulations you can obtain fundamental insights that experiments cannot provide, because in a chemical lab it is often not possible to change just one parameter. However, I will and want to keep working together with experimentalists, they are your anchor to reality."

D.L.H. van der Haven, *et al.*, "Parameterless detection of liquid–liquid interfaces with sub-micron resolution in single-molecule localization microscopy," *J. Colloid Interface Sci.* 620, 356–364 (2022). DOI: 10.1016/j.jcis.2022.03.116

A closer look at 3D-printing

Patrick Anderson

Additive manufacturing, more commonly known as 3D-printing, has gained momentum in recent years. You can buy a 3D-printer for just 150 euros. And the technique is becoming relevant for on-demand production in industrial applications. However, the quality of 3D-printed objects often lags behind that of more conventional production techniques. To improve this, professor Patrick Anderson and his colleagues Ruth Cardinaels and Lambèrt van Breemen at the Processing and Performance of Materials group study the complex interplay between temperature, flow and crystallization in the industrial 3D-printing process of selective laser sintering (SLS).

"IT IS LIKE A CHAIN UNDER STRESS, BREAKING AT THE WEAKEST LINK"

"3D-printing is about 50 years old," Patrick Anderson explains. "So it is not exactly new. In the past it was mainly used for prototyping. But there have been some recent developments, like a patent that expired. As a result, it has become more interesting for a broader set of applications, such as producing fun products at home." He shows a small plastic statue of a dragon. "Like this, but also for industrial applications." Using 3D-printing has some advantages over conventional production methods, like injection molding and extrusion. You can adjust the shape of every individual product and produce it on demand, whereas conventional processes are designed for large quantities. Therefore, 3D-printing bypasses the need for storage and logistics, which are needed when you produce large quantities at a time.

WEAKEST LINK

However, 3D-printing also has its limitations. "At the moment, the mechanical properties of the 3D-printed polymer products are not nearly as good as those of conventional techniques," says Anderson. This means that you can put a lot more load on conventionally produced products than on 3D-printed products. The reason is that 3D-printing proceeds by building a layered structure, and the connections between those layers can be weak. "It is like a chain under stress, breaking at the weakest link," Anderson explains. "In 3D-printing you have a lot of weak links." To improve the quality of 3D-printed products, the research team had to understand – in great detail – what exactly happens during the printing process.

ANALYZING SELECTIVE LASER SINTERING

There are several techniques for 3D-printing. Anderson and his colleagues focus on selective laser sintering (SLS) which is used for industrial applications. It employs a laser to sinter a powdered material, causing this to heat up and bind together to create a solid structure. The setup consists of a powder bed, a laser and a roller. The laser aims at points in the powder bed which define the 3D model. After one layer of powder is selectively sintered in this way, the powder bed lowers a bit, the roller applies a new layer of powder and the sintering process repeats itself, forming the next layer. SLS has some limitations, other than the weak links. For example, because most SLS printers use nylon powder (polyamide 12 or PA12), the printed product is not very temperature resistant. Furthermore, its surface is not very smooth and may be too porous.

TEMPERATURE AND SIZE

To study the SLS process, the team has built a setup to follow *in situ* what happens when a laser beam hits two PA12-particles. It contains two cameras and a combination of optical, thermal and X-ray scattering analysis equipment. It also enables an extreme control of parameters such as the size of the particles and the laser settings. Research performed with the setup has led to a better understanding of how the crystal structures that form are affected by the combination of temperature and flow – when two particles melt together. Anderson: "We also learned that there is a sweet spot for the particle size." When particles are too large the surface will be rough; when particles are too small they absorb heat much quicker. Then, the sintering goes too fast, which results in the two merging completely into a sphere. That is not what you want, according to Anderson. The research revealed that the best result is obtained when sintering is partial and then stops, causing the two particles to form a small block shaped structure.

"We studied the commercially available PA12 and we are now working on other polymers," says Anderson. The team recently received a contribution from the Gravitation program of the Dutch Research Council NWO for further research. As part of the new Interactive Polymer Materials research center, two PhD students will continue the work. They will be supervised by Anderson in collaboration with Lambèrt van Breemen (department of Mechanical Engineering) and Rint Sijbesma and Hans Heuts (department of Chemical Engineering and Chemistry). Anderson: "It builds on a longstanding collaboration within ICMS, connecting the different disciplines in a beautiful way."

P. Hejmady, *et al.*, "Laser sintering of PA12 particles studied by in-situ optical, thermal and X-ray characterization," *Addit. Manuf.* 52, 102624 (2022). DOI: 10.1016/j.addma.2022.102624

News, awards & grants

Bert Meijer (left) and Ton van Leeuwen

Van 't Hoff Medal 2022 for Bert Meijer

UNIVERSITY PROFESSOR BERT MEIJER RECEIVED THE VAN 'T HOFF MEDAL FROM THE SOCIETY FOR THE ADVANCEMENT OF NATURAL SCIENCE, MEDICINE AND SURGERY IN AMSTERDAM ON MAY 21, 2022. THE MEDAL IS AWARDED ONCE EVERY TEN YEARS FOR OUTSTANDING AND GROUNDBREAKING WORK IN THE FIELD OF CHEMISTRY, EXCLUDING BIOCHEMISTRY. DUE TO CORONA, THE PRESENTATION TOOK PLACE A YEAR LATER THAN PLANNED DURING THE GENERAL ANNUAL MEETING. THE VAN 'T HOFF MEDAL IS NAMED AFTER THE DUTCH CHEMIST J.H. VAN 'T HOFF WHO WON THE NOBEL PRIZE FOR CHEMISTRY IN 1901.

The medal was established in 2011 and is awarded once every ten years, therefore it has only been awarded once before, in 2011 to Ben Feringa, who won the Nobel Prize in 2016. Incidentally, Bert Meijer and Ben Feringa have been friends since their PhD days together, which makes this award even more pleasing for both friends. The premise for awarding the medal is that the recipient's work must be excellent and groundbreaking. In addition, an important criterion is that the scientist must have earned his or her spurs in the field of stereochemistry and/or asymmetric synthesis and/or physical chemistry – in other words, he or she must have followed in Van 't Hoff's footsteps. Last year, the Society decided to award this medal to TU/e's University Professor Bert Meijer.

Bert Meijer says, "As a great admirer of our first Nobel Prize winner in chemistry and his pioneering role in science, I am very honored to receive the Van 't Hoff Medal named after him. I see it as a wonderful appreciation for the research carried out by the many students, PhD students and postdocs in our group over the decades. But also because stereochemistry – what Van 't Hoff introduced and for which he gained worldwide fame – will always have a prominent place in our research."

Meijer received the medal from Ton van Leeuwen, professor at Amsterdam University Medical Center (AMC) and president of the Society. The chairman of the jury Wybren Jan Buma commented, "Bert Meijer is considered worldwide to be one of the founders of the field of supramolecular polymer chemistry. His work has been groundbreaking in understanding the mechanisms underlying chemical self-assembly. He has shown that these types of supramolecular polymer materials offer unique opportunities to successfully develop solutions to challenges in the materials and life sciences. He continues to pursue this work."

Collaborating on a real life Barbapapa

Photo: Nando Harmsen

THE WAY CARTOON CHARACTER BARBAPAPA AND HIS FAMILY MEMBERS TAKE ON ANY SHAPE THEY WANT HAS CAPTURED THE IMAGINATION FOR GENERATIONS. MAKING THIS A REALITY OFFERS UNPRECEDENTED POSSIBILITIES. ALL THE MORE UNDERSTANDABLE IS THE ENTHUSIASM OF THE RESEARCHERS AT EINDHOVEN UNIVERSITY OF TECHNOLOGY WHO HAVE JOINED FORCES IN SOFT ROBOTICS. THIS IS A NEW FIELD WITH COUNTLESS POTENTIAL INNOVATIONS: FROM AN ARTIFICIAL HEART TO ULTRA-SMALL ROBOTS THAT PERFORM INTERNAL SURGERY, DISPENSE MEDICINES OR REPAIR COMPLEX MACHINES. PLANT-BASED FOOD SENSATIONS, SELF-CLEANING COATINGS OR ARTIFICIAL "REMOTE HANDS" ARE ALSO ON THE HORIZON.

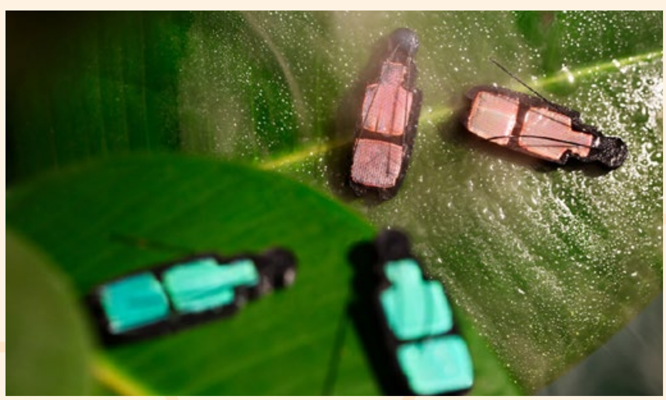
"Scientifically, it's an incubator for new directions and research," said Bas Overvelde, associate professor within the Soft Robotics Group (part of the Mechanical Engineering faculty) and scientific group leader of the Soft Robotic Matter Group at AMOLF. "It's a great topic that brings researchers together, which continually generates new ideas." In 2020, Overvelde received a five-year ERC start-up grant of more than 1.5 million euros to increase the application perspective of soft robots.

To this end, he is collaborating with colleagues from different disciplines and faculties at TU/e, such as Chemical Engineering and Chemistry, Industrial Design and Mechanical Engineering and ICMS. "Such an interdisciplinary approach is characteristic of a new science with which we are pioneering in all kinds of areas: materials, mechanical intelligence, interaction with humans, design. Precisely because it requires a very different way of thinking that goes more towards the intelligence of nature. It's a form of artificial intelligence."

The 4D-printed beetle that changes color when it gets wetter

3D PRINTING HAS BECOME MAINSTREAM. FOR A FEW HUNDRED EUROS YOU CAN BUY A 3D PRINTER ONLINE. BUT WHAT ABOUT 4D PRINTING? HOW DO YOU PRINT AN OBJECT THAT CAN CHANGE OVER TIME, FOR EXAMPLE BY REACTING TO TOUCH, LIGHT OR MOISTURE? IT TURNS OUT THAT THIS IS NOT AS EASY AS YOU MIGHT THINK. PHD STUDENT JEROEN SOL TOOK UP THE CHALLENGE. HE FOUND INSPIRATION IN THE WORLD OF THE LONGHORN BEETLE AND OTHER ANIMALS THAT USE IRIDESCENCE AND OTHER FORMS OF COLOR CHANGE.

Sol's research group, led by professor Albert Schenning, has extensive experience with smart materials that respond to external stimuli, such as light, temperature or humidity. The materials use liquid crystal technology, similar to the techniques used in LCD screens, but applied in plastics. These crystals acquire different properties depending on the direction in which they are aligned (they become anisotropic). This can be either mechanical, in which case they become stronger in one direction than in the other, or optical, in which case they have a different color depending on the angle of incidence of the light.



Under the influence of moisture, the color of the 3D printed beetle changes from green to red, and back again to red (photo: Bart van Overbeeke).

Fulfilling the promise of a brain-on-a-chip

Brain-on-a-chip devices hold great promise for advancing research and improving therapy for neurodegenerative diseases such as Parkinson's Disease. Regina Luttge is eager to fulfil those promises. Recently, teaming-up with the Holst Centre, she took the crucial step of developing a scalable fabrication process for a device that facilitates growing tiny brain-like neural systems and interacting with them. It combines highly precise features at the microscale, specifically known to integrated microelectronic chip technologies, with mass manufacturing capabilities. As beautiful as that might look, work has to be done to close the gap between developing brain-on-a-chip technology and applying it in practice, Luttge says.

As an associate professor at the Microsystems research group and Chair of Neuro-Nanoscale Engineering, Regina Luttge devotes her research to engineering in vitro models that mimic human neural systems functions as realistically as possible. This specific class of Organ-on-Chip models is often referred to simply as "Brain-on-Chip" – even though they include many other functional elements of the nervous system. "The general idea behind the organ-on-a-chip concept is to create a miniaturized environment for life-like culturing of human cells," she explains. "This will ultimately yield us much more information than from cells in in a petri dish or animal testing. In my research I focus on developing the manufacturing technology that will actually make that happen." By focusing on the neural system, and specifically the brain, she sets the bar high, since this is not just any organ. A particular challenge is to establish a hierarchical neuronal structure similar to the layered structure of an actual human brain.

To achieve this, the idea is to use differentiating stem cells in an environment containing the cues for their development into neural networks. Among the determining factors are a proper physical "habitat" and a suitable geometry. Luttge: "Think of small grooves that guide the growth of the cells; separate compartments to house the cell bodies; and small tunnel-like parts where axons can grow, interconnecting the cells. The idea is to achieve a brain-like hierarchy: 'grey matter' consisting of cell bodies, processing information, and 'white matter' consisting of connecting axons." The Luttge group has developed polymer technology to realize this, taking care that the surface morphology of the material is just right for cells to "feel comfortable."

The next important aspect is that real biological nervous system tissue is constantly processing inputs, for instance from the sensory system. "You really have to mimic that to arrive at a realistic brain-on-a-chip model," says Luttge. "We have to make sure the neural system processes signals. And, for that matter, we want to be able to monitor exactly how it does that, and how it might change." By means of microelectronics chip technology, a connection to the nerve cells can be established using electrodes for activation as well as monitoring.

A HYBRID CONCEPT

Recently, in collaboration with the Holst Centre, the Luttge group developed a prototype of a brain-on-a-chip system based on electrically-integrated thin-film polymer processing technology known from the display industry. This hybrid concept makes it truly possible to grow neurons as well as measure their signals in an automated fashion. What's more, the manufacturing method is easily scalable, offering the prospect of widespread application. "Now it's about showing that the cells in such a device are actually going to behave the way we expect," Luttge says. "For example, an important question is how many neurons are

Regina Luttge

needed for a functional neural network that acts as a useful mini-brain. With that, you can start investigating the differences between healthy cells and cells that are involved with neurodegenerative diseases such as Parkinson's and Alzheimer's Disease. Do different networks develop? Is the neural activity different? The hope is that our brain-on-a-chip can help to unravel such possible disease mechanisms. And of course, it could also become a platform for screening drugs that reverse or at least mitigate such mechanisms."

The important thing now is to determine how the novel device will lead to a robust research and screening platform. So that biomedical and clinical research groups can use it in their research. Because that is where the actual research into neurodegenerative diseases takes place. Luttge: "Our role lies primarily in filling the toolbox that all such groups can use to expand or improve their research."

A GAP TO BRIDGE

For now, the organ-on-a-chip concept has yet to find its place in the spectrum of (pre)clinical research and drug development, even despite the anticipated benefits. It's not yet as far as Luttge would like it to be. "There certainly is quite some interest, but most medical researchers, including the researchers in the pharmaceutical industry, prefer a system that they can start working with immediately. The step before that, making it work in their particular setting, they'd rather leave that to a technology developer. So there's a gap we have to bridge." Luttge is pursuing this in particular in the ongoing CONNECT project that in 2019 was awarded almost 7 million euros in the EU's Future and Emerging Technologies (FET) program. The seven partner organizations are developing nervous-system-on-a-chip technology to improve models for neurodegenerative diseases, looking at Parkinson's disease as a showcase. The consortium comprises experts in stem cell technology, microscopy, pathology and other relevant disciplines, including medical neuroscience expertise. "We want to demonstrate the feasibility of the CONNECT nervous-system-on-a-chip platform for testing cultured neural networks," say Luttge. After that, she hopes to find a partner for technical development, like a chip fabrication foundry or equivalent industrial entity.

Luttge is also part of the Dutch consortium for Human Organ and Disease Model Technologies (hDMT). It's a nationwide partnership dedicated to developing organ-on-a-chip applications. "My approach is to engage with partners who can provide essential knowledge and expertise already in the first stages of development. You also must start raising funds early to eventually be able to figure things out. The further away you are from the market potential, the more difficult that is." Luttge feels at home at TU/e and its institutes, like ICMS, where cross-disciplinary networking and collaboration is highly stimulated and considered key to successful innovation. "This inspires me to work on the challenges and develop new engineered solutions to deliver and develop better medicine, even if application may be on a far horizon."

The cellular dynamics of complexity research

At the end of October, ICMS hosted the second in a series of two-day workshops on Grip on Complexity. Bringing together scientists from inside and outside of the TU/e, the two days focused on sharing knowledge and stimulating ideas in the field of Complexity research. Henk Nijmeijer, a key academic in complexity research, led the workshop series together with his colleagues Remco van der Hofstad, Pim van der Hoorn, Erik Steur and Erjen Lefeber.

Henk Nijmeijer

An illustrative example of a complexity issue is the fundamental question of how a single human cell – "dead" on its own – thrives, survives, and serves its host when living amongst a network of other cells. Although not explicitly part of the workshop, it is exemplary of Complexity Research, Nijmeijer explains: "The deceivingly simple occurrence of a single cell's reliance on a network or structure of other cells, is underpinned by the complex fundamental question of how and why cells display novel behavior when they are part of a network." He believes that addressing such a question will have a key impact in the field of Complex Molecular Systems.

GETTING A GRIP ON COMPLEXITY

Answering these how and why questions requires expertise in (single cell) dynamics as well as stochastics in network structures. Designed to focus on the interplay between these fields of dynamics and stochastics, the goal of the workshop was to seek new frameworks and methodologies for Complexity research. Nijmeijer: "Through bringing academics from these two fields together we stimulate collaboration, generate new ideas and hopefully kickstart novel research. Whilst the workshop was focused on answering fundamental questions of complexity, deepening this fundamental understanding will enable scientists to 'get a grip' on the processes at play and start to exercise influence and control over them."

A COMPLEXITY LENS

Featuring eight oral presentations and several posters, the workshop program also left ample time for discussion and debate, which in Nijmeijer's opinion is "where the magic happens." In fact, he argues, the workshop itself can be seen through a cellular complexity lens: "Individual scientists working independently in their own fields can be equated to single cells. The dynamics arise from bringing these scientists together to form a network. This will help to stimulate new ideas and foster collaboration. Potentially producing novel data and scientific impact that – hopefully – is bigger than the sum of the individual efforts."

Key publications

MAY 2022 – OCTOBER 2022

01. A MICROFLUIDIC OPTIMAL EXPERIMENTAL DESIGN PLATFORM FOR FORWARD DESIGN OF CELL-FREE GENETIC NETWORKS
B. van Sluijs, R.J.M. Maas, A.J. van der Linden, T.F.A. de Greef, W.T.S. Huck
Nat. Commun. 13, 3626 (2022)

02. ADAPTIVE BIOSENSING AND NEUROMORPHIC CLASSIFICATION BASED ON AN AMBIPOLAR ORGANIC MIXED IONIC-ELECTRONIC CONDUCTOR
Y. Zhang, E.R.W. van Doremaele, G. Ye, T. Stevens, J. Song, R.C. Chiechi, Y. van de Burgt
Adv. Mater. 34, 2200393 (2022)

03. ARTIFICIAL ANTIGEN-PRESENTING CELL TOPOLOGY DICTATES T CELL ACTIVATION
A.C. Wauters, J.F. Scheerstra, I.G. Vermeijlen, R. Hammink, M. Schluck, L. Woythe, H. Wu, L. Albertazzi, C.G. Figdor, J. Tel, L.K.E.A. Abdelmohsen, J.C.M. van Hest
ACS Nano 16, 15072–15085 (2022)

04. BIOINSPIRED SILK FIBROIN MINERALIZATION FOR ADVANCED IN VITRO BONE REMODELING MODELS
B.W.M. de Wildt, R. van der Meijden, P.A.A. Bartels, N.A.J.M. Sommerdijk, A. Akiva, K. Ito, S. Hofmann
Adv. Funct. Mater. 32, 2206992 (2022)

05. CLOSED-LOOP RECYCLING OF POLY(IMINE-CARBONATE) DERIVED FROM PLASTIC WASTE AND BIO-BASED RESOURCES
K. Saito, F. Eisenreich, T. Turel, Z. Tomovic
Angew. Chem. Int. Ed. 61, e202211806 (2022)

06. CONTINUOUS BIOMARKER MONITORING WITH SINGLE MOLECULE RESOLUTION BY MEASURING FREE PARTICLE MOTION
A.D. Buskermolen, Y. Lin, L. van Smeden, R.B. van Haaften, J. Yan, K. Sergelen, A.M. de Jong, M.W.J. Prins
Nat. Commun. 13, 6052 (2022)

07. DILUTION-INDUCED GEL-SOL-GEL-SOL TRANSITIONS BY COMPETITIVE SUPRAMOLECULAR PATHWAYS IN WATER
L. Su, J. Mosquera, M.F.J. Mabesoone, S.M.C. Schoenmakers, C. Muller, M.E.J. Vleugels, S. Dhiman, S. Wijker, A.R.A. Palmans, E.W. Meijer
Science 377, 213–218 (2022)

08. DIRECT INK WRITING OF 4D STRUCTURAL COLORS
J.A.H.P. Sol, L.G. Smits, A.P.H.J. Schenning, M.G. Debije
Adv. Funct. Mater. 32, 2201766 (2022)

09. HOW SUBTLE CHANGES CAN MAKE A DIFFERENCE: REPRODUCIBILITY IN COMPLEX SUPRAMOLECULAR SYSTEMS
T. Schnitzer, M.D. Preuss, J. van Basten, S.M.C. Schoenmakers, A.J.H. Spiering, G. Vantomme, E.W. Meijer
Angew. Chem. Int. Ed. 61, e202206738 (2022)

10. HYDROPHOBICITY DIRECTED CHIRAL SELF-ASSEMBLY AND AGGREGATION-INDUCED EMISSION: DIACETYLENE-CORED PSEUDOPEPTIDE CHIRAL DOPANTS
G.P. Maurya, D. Verma, A. Sinha, L. Brunsveld, V. Haridas
Angew. Chem. Int. Ed. 61, e202209806 (2022)

11. IN SITU SYNTHESIS OF SUPRAMOLECULAR POLYMERS: FINDING THE RIGHT CONDITIONS WHEN COMBINING COVALENT AND NON-COVALENT SYNTHESIS
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MATERIALS
FOR REGENERATIVE
MEDICINE

A disregarded phenomenon in materials processing

Materials scientist Diletta Giuntini, an assistant professor in the department of Mechanical Engineering at TU/e, has received the Champion H. Mathewson Award. Issued by The Minerals, Metals and Materials Society (TMS) and The American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), it recognizes papers with a notable contribution to metallurgical or materials science. Giuntini considers herself a "materials person": "I care about how things are made."

The award was granted to Giuntini and co-authors for a paper that sheds light on a previously disregarded mass transfer phenomenon during the processing of materials. "The way that a raw material is processed at the micro or nano scale ultimately influences how it will perform at the macro scale," Giuntini says. She underpins the importance of "scale bridging," which encompasses a deep understanding of the influence of microscopic phenomena at all stages of material processing. "All interventions during processing – be that heating, cooling, mechanical action, and so forth – will have a collective impact on the macroscopic behavior, the mechanical properties and functionality of the end product."

Diletta Giuntini

In her research, Giuntini focuses in particular on ceramics, which she finds fascinating materials. "They have so many desirable properties," she says. "They are biocompatible, so they can be used as prosthetics. They are light-weight, so you find them in aerospace and automotive vehicles. And they are resistant against incredibly challenging temperature and environmental conditions." On the other hand, the very qualities that make ceramics so exciting can limit their full application potential. "Their heat resistance makes them extremely hard to mold or machine, and their high strength comes with an intrinsic brittleness." Giuntini is optimistic though. The findings in the award-winning paper, that she co-authored in a team of eight researchers, give her hope that it is possible to eliminate some of the less desirable traits.

TAILORING THE NANO- AND MICROSTRUCTURE

Ceramic and metallic components are most often manufactured starting from powders or particles and the paper sheds light on the associated mass transfer mechanisms. In particular, it focuses on an often disregarded diffusion mechanism called "dislocation pipe diffusion." This refers to the movement of matter along the core of dislocations, which are line defects present in a wide variety of crystalline materials. Using modelling and experiments, Giuntini and her colleagues show that this sub-nanoscopic behavior can have a distinct impact on the shape and size of the end product. Giuntini: "Knowing which mass transfer mechanism is dominant during each stage of material processing not only leads to a deeper understanding of how matter evolves at these tiny scales. It also benefits the control and optimization of the manufacturing process. This means we can tailor a material's nano- and microstructure, and thus its properties, while shaping it into macroscale products. Ultimately, we hope that our findings will enable us to develop more sophisticated ceramics with improved mechanical properties."

E. Torresani, D. Giuntini, *et al.*, "Anisotropy of Mass Transfer During Sintering of Powder Materials with Pore-Particle Structure Orientation," *Metall. Mater. Trans. A* 50, 1033–1049 (2019). DOI: 10.1007/s11661-018-5037-x

The wonderful world of fluorescent molecular machines

Stefan Meskers

Imagine a molecular machine made from organic fluorescent material. Marker pen meets transistor. What can you do with that? Associate professor Stefan Meskers of the Molecular Materials and Nanosystems group has a vision of motorized pixels: "A light emitting switch on the molecular level could provide the key to the realm of 3D displays."

Meskers specializes in measuring the polarization of light emitted by molecules. The last six months he has focused on organic light emitting materials – the inks in marker pens. He does this in collaboration with Ben Feringa's group at the University of Groningen, where the focus is on molecular machines. "An important feature of molecular machines is that you can incorporate them in all kinds of materials to switch certain properties," Meskers explains. "Our idea now is to combine molecular motors with organic fluorescent molecules, with the aim to switch the polarization of the emitted light." Manipulating polarized light is already quite common, he explains. "When you go to see a 3D movie, you put on special 3D spectacles. Each eye then sees light that is polarized in a different way. This results in a 3D effect." The big step forward would be to watch a 3D movie on your telephone. "That's what we are working on. Think of a display where many light emitting molecular switches can function as motorized pixels."

OPTICAL CHIPS

Another application is glass with built-in switchable sun protection. But Meskers warns that all this is still a distant future. "We do fundamental research. We know it's possible, but we haven't realized it yet. System integration will be very hard; we cannot control large amounts of pixels yet. Switching speed is also a problem." The most important future application will probably be optical chips. Meskers: "Saving energy is a potent research driver." Internet data centers also use massive amounts of electricity, due to the use of silicon semiconductors. This can be changed by using optical chips, for which organic colorants are promising materials because of their strong interaction with light. New discoveries have recently revived old fashioned pigment chemistry. "Rhodamine B, a red pigment crystal, can be optimized for light reflection," Meskers comments. "If successful, the material would qualify for use in ultra-low power consuming optical electrical switches and amplifiers for future data centers."

MANY ORDERS OF MAGNITUDE

Recently researchers have succeeded in switching at the single photon level. Just like in displays, in optical chips large numbers of photons should be switched. The bottom line is that a revolution is needed to exactly synchronize the movements of electrons at ambient temperatures. Meskers: "With all electrons oscillating in concert, molecules start emitting very pure light in short bursts. But here we are confronted with a similar challenge as with super conductivity: we need extremely low temperatures. But the quest is worthwhile, as it would make computing many orders of magnitude more energy efficient."

MATERIALS
FOR REGENERATIVE
MEDICINE

Aref Saberi (left) and
Nicholas Kurniawan (right)

Improving in-vitro "mini brains"

To study brain development and test treatment of neurological disorders

The brain is the body's most complex organ, more complex than any other structure in the known universe. A human brain consists of almost 100 billion neurons, communicating with each-other in an ingenious network that produces our thoughts, actions, feelings and memories. PhD student Aref Saberi is intrigued by this complex organ – how it develops and how it can give rise to diseases. The lack of models to test treatments for neurological disorders motivates him to develop a novel in-vitro model of the brain, together with his supervisors Nicholas Kurniawan and Carlijn Bouten. "My mission is to be able to rescue a diseased brain."

Research into the living, developing brain is limited to non-invasive clinical tools like electroencephalography (EEG), which measures the electrical activity of the brain.

These measurements do not have cellular resolution. Therefore, little is known about the development of the brain and its diseases at the cellular level. To better understand the brain, researchers developed "mini brains" in petri dishes. These so-called brain organoids or assembloids are three-dimensional (3D) models of brain tissue grown in the lab from pluripotent stem cells. Such models give insights into various aspects of the development of the brain and brain disorders. However, they also have their limits. It remains a challenge to build a controllable in-vitro model to study altered or disrupted interactions between different brain regions, which play a role in epileptic seizures, for example.

ACTIVE AND MIGRATIVE

To improve the lab-grown mini-brains and make them more clinically relevant, Saberi and his colleagues created a novel 3D in-vitro model of the brain. Saberi started developing this method from scratch during his masters project. Like current methods, it starts with pluripotent stem cells, which have the ability to differentiate into any of the cells of the adult body. Unlike current methods, which use a mechanically-enforced way to cluster the cells, in the new method cells spontaneously come together to form the brain tissue. "The stem cells grow in a suspension into spheroids, which turn into tissue by making connections and migrating towards each other," Saberi explains. After about six to seven weeks the tissue is ready for testing its functionality. "The big difference is that in the contemporary method you are actively manipulating during the formation of the tissue," explains Nicholas Kurniawan, assistant professor in the Soft Tissue Engineering and Mechanobiology group. "Whereas in the new method that Saberi developed, it is all driven by the cells themselves. We don't interfere at all, except providing them with the right mechanical and chemical environment."

REPRESENTING AN EPILEPTIC SEIZURE

One of the advantages of growing the mini-brains this way, is that the 3D tissue can be formed based on the suspension they are in. As a proof of concept, the researchers let cerebral tissue form on two sides of a porous membrane. This way, the resulting tissues are chemically separated, while still allowing some cellular connection. "We then altered the activity in one of these tissues and looked at the propagation to the other," says Saberi. He explains that this is an in-vitro representation of an epileptic seizure, which is characterized by a burst of neuronal discharges in one part of the brain and their propagation to nearby tissue. With previous methods it has not yet been possible to show such epileptic signal transmission.

According to Saberi, this new platform will be useful for studying any type of disease or neurological phenomenon that incorporates interactions between two different brain regions. "Like epilepsy, but we also plan to work on Alzheimer's and dyslexia." But first a few limitations need to be resolved. Those include the lack of organization in the tissue, and the issue of clinical readout. Researchers usually study mini-brains using optical techniques and calcium imaging (detecting and characterizing calcium flux in cells). But it is difficult to compare those to clinical measurements like EEG. Therefore, the team is now trying to create stretchable electrodes which can measure the activity of lab-grown tissues in a way similar to measuring the activity in an actual brain.

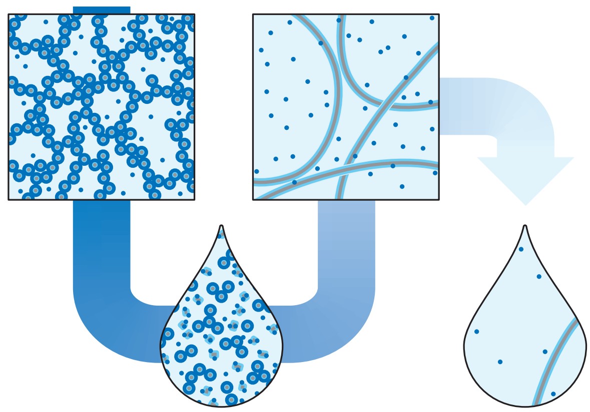
The team is also working on improving the organization of the cells and inducing vascularization – the process of growing blood vessels into a tissue to improve oxygen and nutrient supply. "Our main goal is to keep the biology at the center and to use the technology as a support," Saberi emphasizes. "Everything we do is to make and keep the model as physiologically and clinically relevant as possible."

A. Saberi, *et al.*, "In-vitro engineered human cerebral tissues mimic pathological circuit disturbances in 3D," *Commun. Biol.* 5, 254 (2022).
DOI: 10.1038/s42003-022-03203-4

News, awards & grants

Chemists find a contrary effect: **how diluting with water makes a solution firm**

In chemistry, everyone learns that you can go from a hydrogel to a liquid by diluting the hydrogel with water. For the reverse transition, you increase the concentration. However, TU/e researchers led by Bert Meijer accidentally discovered that their liquid solution turned into a hydrogel when diluted. This phenomenon hadn't been researched or described before and will have consequences in many areas in chemistry and biology. The finding, which appeared in Science Magazine, was a result of exceptional teamwork.



Graphical representation of dilution-induced phase transitions in aqueous solutions, including the supramolecular structures. Squares are the gel-phases, the drops are the liquid phases.

Sputtering ketchup bottle lets soft robots run smoothly

A CLEVERLY DESIGNED PRESSURE VALVE LETS SOFT ROBOTS RESPOND TO THEIR ENVIRONMENT WITHOUT COMPUTER CONTROL. HOW THAT WORKS, IS WHAT RESEARCHERS FROM EINDHOVEN UNIVERSITY OF TECHNOLOGY EXPLAIN IN A RECENTLY PUBLISHED ARTICLE IN THE JOURNAL MATTER. THE RESEARCH BY BAS OVERVELDE, ASSOCIATE PROFESSOR AT THE DEPARTMENT OF MECHANICAL ENGINEERING, AND PHD RESEARCHER LUUK VAN LAAKE, BRINGS ROBOTS THAT MOVE AND FEEL LIKE LIVING BEINGS CLOSER. SUCH DESIGNS ARE BETTER SUITED FOR EXPLORING ROUGH AND UNFAMILIAR TERRAIN OR FOR MEDICAL APPLICATIONS.

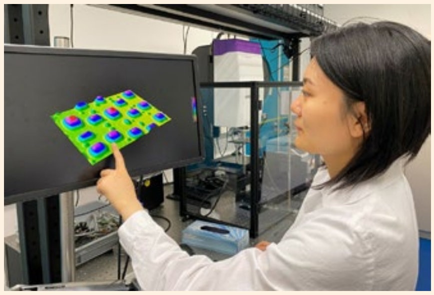
Robots are still mainly associated with hard machines, controlled by a central computer that has to think about each step. Living beings, on the other hand, move smoothly because intelligent behavior is embedded in their bodies, which is also ideal for robots that constantly interact with people, such as in medical care. The research field of soft robotics therefore works on robots made of soft, flexible materials that respond to changes in their environment without external control.

Artificial skin sweats on command

Following the breakthrough with their first sweating artificial skin two years ago, Danqing Liu's multidisciplinary team hasn't been sitting still. Their goal: an artificial skin that sweats as naturally as possible. They have succeeded in this, as can be read in their article in Angewandte Chemie. There, they explain how they managed to be the first team in the world to be able to accurately control where, when and how much an artificial skin sweats and also where the liquid collects.

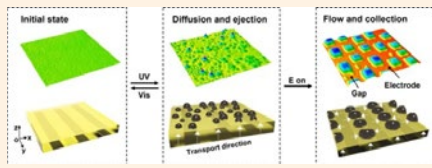
Sweating robots

In the previous breakthrough by the team, it became apparent that



Yuanyuan Zhan with experimental results. Photo: Yuanyuan Zhan

an artificial skin that can sweat on command could have numerous practical applications. Back then, the artificial skin could secrete the fluid evenly and equally everywhere. An evenly sweating artificial skin can help cool the surface of robots. In social applications, it could help make the robot as human-like as possible, which includes sweating. Or consider special bandages that can deliver controlled drugs to human skin or to a wound surface such as a burn.

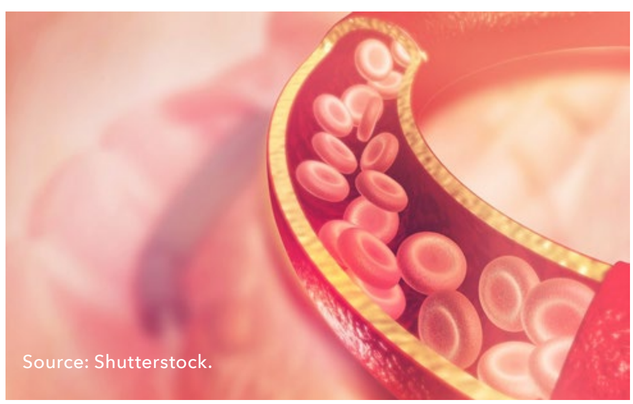


Schematic representation of the secretion of liquid by the artificial skin with different external stimuli. Image: Danqing Liu.

Cell chatter tells the story of arterial thickening

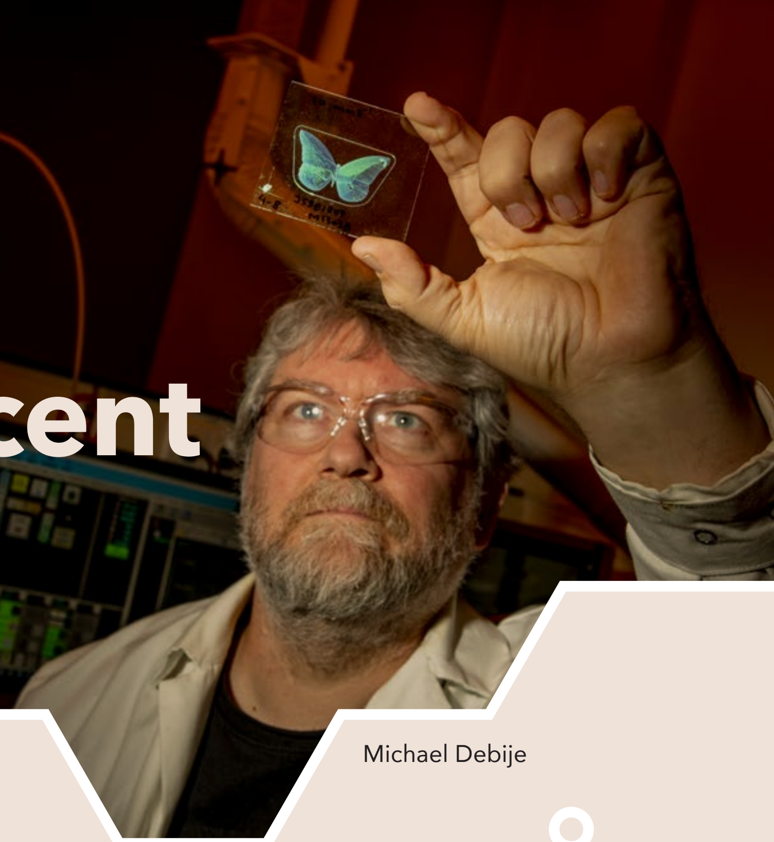
Arteries can become thicker due to high blood pressure. However, the cause of this thickening is unclear. TU/e researchers along with colleagues from Trinity College Dublin in Ireland have developed a new computer model to study the arterial thickening in detail. The model shows that both mechanical changes in the artery due to higher blood pressure and cell communication involving so-called vascular smooth muscle cells could be critical for arterial thickening. The same model could be used to guide future approaches to therapeutic and regenerative treatments.

The growth and changing of arteries in the body depends on many factors, such as blood pressure. Arteries are known to become thicker due to higher blood pressure. "When the blood pressure increases, the artery stretches more and experiences higher forces. This leads to changes in the mechanics of the artery, and in response the artery gets thicker," says Jordy van Asten, PhD researcher in the department of Biomedical Engineering and the Institute for Complex Molecular Systems (ICMS). "But other factors might be important too, such as how the artery cells talk to each other."



Source: Shutterstock.

The luminescent scientist



Michael Debije

When he moved to the Netherlands to work as a researcher, he was free to explore whatever he wanted. He felt like a kid in a candy shop. While having a million ideas, he decided to work on luminescent solar concentrators. Now Michael Debije is an associate professor in the research group Stimuli-responsive Functional Materials and Devices and he recently joint forces with ICMS. This will help getting his extraordinary inventions out there. What Debije will start with at ICMS? "Swimming robots."

"Ever since I was a kid I was curious about everything around me. And I would think about the possibilities to make things work a certain way. In time I learned to look more outward and ask myself: what sort of impact can I make in the world?" One of society's major concerns is the generation and conservation of energy. So Debije started working on luminescent solar concentrators: pieces of plastic that catch sunlight so that it can be collected from its edges. Solar cells at those edges then can generate electrical power. A few years later, Debije branched out and started working on responsive polymer materials, giving plastics the ability to change when exposed to different triggers. Think of using humidity, light or temperature to make them change color, become reflective, or move. "We made 3D printed liquid crystalline miniature robots. These can walk over a surface when you shine light on them."

SWIMMING ROBOTS

"I'm looking forward to working together with ICMS. The interdisciplinary collaboration will have students in different fields have their work intertwined." Debije plans to start a project on swimming robots. In cooperation with mechanical engineers he wants to convert his existing robots into devices that display the sweeping swimming motion of a sea turtle and the buoyancy of a fish, all controlled from the outside. Debije can already see it: "Making the devices biocompatible could make them deployable in a human body and swim in the bloodstream towards a tumor. They could release a drug after you trigger them, for instance with a light signal." The same robots could also clean an oil spill in the ocean: "I send out the robots, they collect oil droplets and I recollect them with a magnet, cleaning the ocean."

Ultimately, Debije wants to combine his knowledge about luminescent concentrators and how to control light with his robots. He envisions an object that collects light, changes the color and direction of that light to ultimately send it to another object that can interpret that change. Though it's still a bit far from reality, with his imaginative ideas Debije hopes to create simple things that can help to save the environment. Simple things that can be done by regular people at a very simple level. "Lots of small impacts that have a global impact." Michael Debije is an associate professor with big dreams about even bigger inventions.

Towards predictable complexity of tissue engineering

How can mathematical models contribute to regenerative medicine?

Associate professor Modelling in Mechanobiology Sandra Loerakker creates mathematical models that help predict how to design synthetic materials for regenerative medicine. With her recently acquired Vidi grant, Loerakker can move closer to her ultimate goal: to understand the development and adaptation of living tissues and identify strategies to steer this using engineering approaches. She already achieved a first success with the complex cardiovascular tissue of heart valves.

Worldwide there have been problems with failing tissue-engineered heart valves that could not adapt properly to their environment. Loerakker created mathematical models that helped to find a possible cause for the misadjustment. "With my model I was able to identify the cause of the problem, and predict how it could be avoided. Subsequent animal studies confirmed this, and it led to enormous improvements. It is a nice example of the added value of mathematical models to regenerative medicine."

VIDI GRANT

In July of this year, the Dutch Research Council NWO award Loerakker a Vidi grant worth 800,000 euros. The grant enables experienced researchers to develop their own innovative line of research and set up their own research group in the coming five years. Loerakker submitted her Vidi grant application a year ago. The idea for her application arose because current mathematical models predicting the adaptation of biological tissues aren't able to predict the complete transition from synthetic materials to living biological materials. This is in particular the case with more complex tissues such as heart valves. "With my Vidi project I want to develop new computational methods in which we can model the entire process from the implantation of a synthetic material to its full adaptation in the body. This also enables us to understand and predict important aspects of heart valve regeneration." To achieve this, Loerakker and co-workers first need to understand what mechanisms play a role, for example how cells move into a synthetic material. Then she wants to model experimental observations to subsequently understand how to improve the outcome of regeneration. "We will develop a numerical method in which we can describe the cell migration in a complex environment such as the heart valve. Next, we will model how certain distributions of cells in a synthetic material regulate its transition into a biological tissue."

OPENING DOORS

"Developing such mathematical models for cardiovascular applications involves a great deal of complexity," says Loerakker. "I find that very challenging." With her five-year scholarship she hopes to develop new computational methods that allow her to study the regeneration not only of heart tissue, but of complex tissues in general. This could then start a completely new line of research, applied to all kinds of different (complex) tissues. "And when we understand it, we want to know how we can steer regeneration as well."

Sandra Loerakker

POLYMER SCIENCE AND TECHNOLOGY

Modelling the manufacturing of organic thin films

René de Bruijn

René de Bruijn, a PhD student at the Soft Matter and Biological Physics group supervised by professor Paul van der Schoot, is developing theory and simulation software to study the coating process for fabrication of organic electronics. In a collaboration with the Max Planck for Polymer Research (Mainz, Germany) he aims in particular to obtain a better understanding of their morphology and thus their electronic performance. How can we control exactly which microstructures are formed?

Thin polymeric films are often used as an active layer in organic electronic devices such as solar cells or displays. Compared to traditional, silicon-based electronics, their manufacturing is relatively easy and cost-effective. Most often this is done by means of "solution processing" where polymers and other components are dissolved and the resulting solution is cast onto a substrate. After evaporation of the solvent, a thin polymeric film emerges. "From a manufacturing point of view, you want to obtain a high-performance layer as efficient as possible," says René de Bruijn. "However, the performance strongly depends on the microstructure of the layer. Which in its turn depends on the evaporation process: there's phase separation, nucleation, all with its own timescale. That's why it is important to understand what structures are created under what conditions. So that you can create layers with exactly the right structure and properties to achieve the desired electronic properties."

COMPUTER SIMULATIONS

To aid this, De Bruijn is developing theory and simulations of the coating process. He focuses on so-called meniscus-guided coating techniques, which offer fast and continuous manufacturing of thin polymer films. Here, a meniscus is formed between a coating head (delivering the solution) and the substrate, due to capillary action. "In general, the microstructures emerging in the thin polymer layer result from rather complex crystallization kinetics of the dissolved molecules, the hydrodynamic and diffusive transport processes in the meniscus, the solvent properties, and the structure and type of substrate," de Bruijn explains. "Simulating meniscus-guided coating means that next to all this you also have to take into account the speed of the coating head moving across the surface."

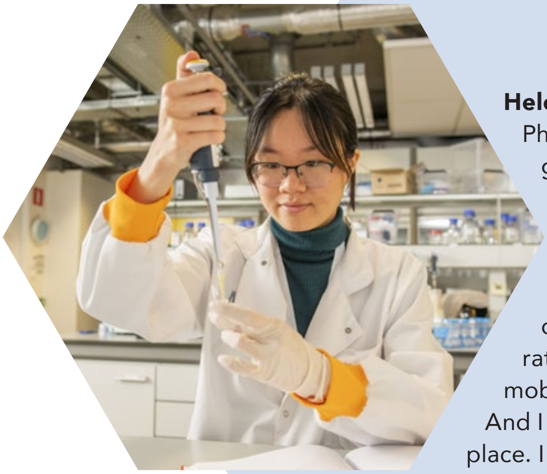
De Bruijn spent four months in Mainz at the Max Planck Institute for Polymer Research, in the group of Jasper Michels who specializes in modelling the demixing of complex fluids, such as those present during meniscus coating. Michels and Van der Schoot for long had ideas for such joint research and this fitted very nicely within the framework of the ICMS-MPIP collaboration established in 2019. Writing all the code by himself, De Bruijn developed and validated a dedicated modelling program for simulating solution processing. He is currently implementing the meniscus and hopes to obtain the final simulation results in the coming months. The ultimate test is of course that the model will predict the morphology that will actually occur in practice, he says. "We're hoping to see that happen!"

ADVANCED ANALYSIS
OF COMPLEX
MOLECULAR SYSTEMS

Training PhD students in the ICMS spirit

From left to right: Lorenzo Albertazzi, Menno Prins and Peter Zijlstra

Marie Curie Innovative Training Networks (ITNs) are European collaborations linking PhD research projects across Europe. With their focus on complementarity and interdisciplinarity, the ITN concept fits quite well with the mission of ICMS. It may come as no surprise then that many ICMS members are involved in one or more ITNs. As principal investigator – supervising PhD students – or even as initiators and coordinators of an entire ITN. We asked Lorenzo Albertazzi, Menno Prins and Peter Zijlstra, who coordinate the ongoing ITNs Theracat, Consense and SuperCol, about their experiences. And we asked PhD students of these ITNs how they feel about doing their PhD in the ICMS environment.



Helen Tan

Helen Tan is in the second year of her Consense PhD research in the Molecular Biosensing group, guided by Menno Prins and Arthur de Jong. She works on continuous biosensors based on the diffusional motion of particles at a sensor surface. "I applied for this Consense PhD position because I was attracted by the interdisciplinary context. And well, it's a Marie Curie ITN, which is rather exclusive and it promotes a lot of international mobility. In fact, I discovered ICMS not until I started. And I have to say I'm really happy that I chose this place. I visited talks and workshops and that was a great experience for me. ICMS is really beneficial for early career researchers. It provides an interesting interdisciplinary network and it provides access to a lot of advanced equipment which really benefits your research. Furthermore, meeting other researchers is also important from a personal perspective, to share experiences. It's not just about the research. It's also about personal growth."

The Innovative Training Networks were established as part of the Marie Skłodowska-Curie Actions scheme within the European Union research funding program. They are among Europe's most competitive and prestigious research and innovation instruments. The Innovative Training Networks involve up to 15 PhD students (called Early Stage Researchers or ESRs) in a partnership between universities, research institutions and companies across Europe. A key aspect of these networks is that they facilitate the sharing of knowledge through collaborations, networking activities, workshops and conferences. In addition, the PhD students are trained through secondments to other partners in the network.

To Menno Prins, coordinating the Consense ITN, the concept and popularity of the training networks in fact confirms how visionary it was to establish ICMS back in 2008. "What we now see across Europe has been acknowledged here right from the start: how important it is to build bridges between disciplines. We are in full swing with that approach – and indeed quite successful." Peter Zijlstra adds that being an ICMS member has helped him to establish the SuperCol ITN, because of the experience in connecting, discussing, and collaborating with colleagues from very different fields. "Adding to that, the combined ICMS expertise and infrastructure significantly strengthens a proposal. It underpins that we have the right environment to troubleshoot issues that might be outside our comfort zone."

"IT IS THIS SCIENCE-BASED APPROACH COMBINED WITH CREATIVITY THAT FORCES UNEXPECTED BREAKTHROUGHS"

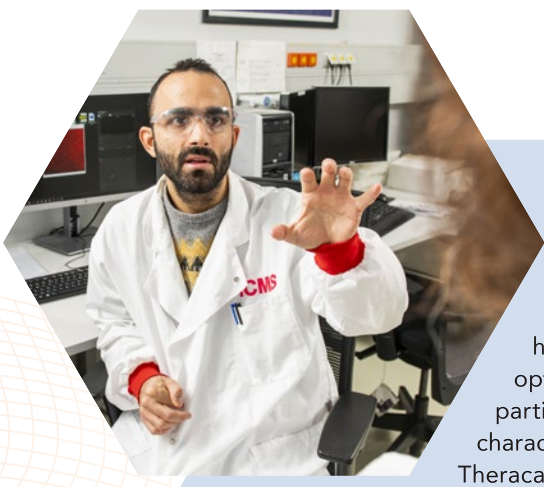
UNDERSTAND THE COMPLEX SYSTEM AT HAND

All three ITNs fit nicely within the scope of ICMS research, as they rely on biochemically functionalized particles for biomedical applications. At the same time, they differ from each other: Theracat focuses on catalytically active particles for drug delivery applications, Consense on the development of continuous biosensors, and SuperCol is about methods to synthesize the particles and characterize them using correlative super-resolution microscopy. Theracat coordinator Lorenzo Albertazzi underpins that all three ITNs are about connecting the chain of particle synthesis, functionalization, characterization, and application. "The common approach here is to understand the complex system at hand and go beyond trial-and-error."

Of course that is also an important aspect at ICMS, says Prins: "We try hard to make molecular systems work, but we also want to know how they work. We take the time to do analysis, reveal underlying mechanisms, develop models and perform calculations.” To facilitate that, ICMS has state-of-the-art infrastructure in microscopy, spectroscopy and computing. “It is this science-based approach combined with creativity that forces unexpected breakthroughs,” says Prins. Zijlstra adds: “To synthesize and functionalize colloidal particles, characterize them using microscopy, and to apply them in biosensing and drug delivery applications requires knowledge in chemistry, physics, and biology. There is no researcher that possesses all this knowledge individually, so it is very much in the spirit of ICMS that you achieve this through interdisciplinary collaborations. What’s more, the broad and diverse consortia we work in naturally stimulate out-of-the-box thinking. And the intense collaborations create ideas that may otherwise not be thought of.”

Bárbara Malheiros

Bárbara Malheiros is in the third year of her SuperCol PhD research in the Self-Organizing Soft Matter group of Ilja Voets. She synthesizes and characterizes DNA coated colloids in different sizes and studies their assembly behaviour. “I really like the idea of working together with all SuperCol PhDs at universities across Europe and collaborating a lot. And through my fellow ICMS PhDs of Consense and Theracat I have access to a huge European network! It’s a really nice idea that I am, in an indirect way, in touch with all these other researchers. And of course even in a direct manner, when ESRs of other ITNs visit Eindhoven for their secondments. When I started working, I found out that ICMS was a big community and that was a great surprise. I feel like I have an ITN within the university; it’s easy to be in touch with all these other ICMS groups. I can just knock on their doors and have a chat or ask for assistance. That really helps me in my research.”



Emmanouil Archontak

Emmanouil Archontak is is in the last year of his Theracat PhD project and is currently writing his thesis. In his research he employed optical super-resolution microscopy, in particular single-molecule microscopy, to characterize nanomaterials developed by other Theracat ESRs. “It was a very multidisciplinary effort with many different people. I really wanted to work in a Marie Curie ITN because of the collaborations and the connection to companies. What ICMS added to that was the infrastructure. I was very impressed with the state-of-the-art-microscopes, its modalities and functionalities. To have that all at your fingertips is truly amazing. What I also like very much in ICMS is that it sort of feels like home. It doesn’t look like academia here in Ceres. It’s a very professional but at the same time very open environment. You can easily walk into someone’s office, ask a question or have a coffee break and speak science. I experienced this daily connection with people as really helpful and made me comfortable with things that were initially outside my comfort zone.”

SCAL/e lab: single cells in the spotlight

Marloes Janssen

For a few years now, researchers with a specific question at single cell level have been able to contact SCAL/e lab. As its official opening coincided with the first pandemic lockdown, the facility in the Ceres building is still relatively unknown within the TU/e community. Even so, lab manager Marloes Janssen notices that more and more scientists find their way to SCAL/e and use the high-tech equipment available to analyze single cells.

Somewhat hidden in the back of Ceres' ground floor are two small lab rooms. These are no ordinary laboratories, as together they form the Single Cell Analysis Lab Eindhoven – SCAL/e for short. Established in 2020, this really is a unique lab, says Marloes Janssen enthusiastically. As lab manager, she took care of bringing the equipment together and now supervises this ICMS facility. "We focus on the triangle of single cells, materials and immunoengineering. Researchers with a question in this area can come to SCAL/e to isolate immune cell subsets, make single cell suspensions and analyze individual cells."

One of the main users is the Immunoengineering group of Jurjen Tel. Its researchers are developing an innovative "single cell technology toolbox" within SCAL/e, Janssen explains as an example. "They would like to compartmentalize single cells or small groups of cells in chambers or droplets. This allows the design of 'minimal environments' in which most of the external factors influencing cellular behavior are excluded."

ADAPTED SETUP

To work with biological agents that have been genetically modified, if required, SCAL/e features an ML-I and ML-II lab with standard (cell culture) facilities. Janssen is proud to have some high-tech equipment. "Other cellular labs within TU/e tend to focus on robust methods, and have to be suitable for education as well. Our setup is completely adapted to research within the mentioned unique triangle. We have a special setup to make a droplet emulsion, which is used to capture individual cells. There are also some special microscopes. One is for high content screening when you want to study large surfaces, such as a chip on which cells grow. Another microscope is equipped with various pumps for microfluidics research."

SHOWPIECE

The most advanced microscope – frequently used by researchers – is a Stimulated Emission Depletion (STED) microscope. A real showpiece, according to Janssen. "With this, super-resolution images can be made, soon even of living cells; we are now working on a surrounding cell culture box. The clustering of certain devices here within Ceres results in a small center of expertise that is slowly emerging. Many different groups work here, it is truly a cross-disciplinary lab. This also encourages collaborations. For example, a group of users is currently creating a rotation scheme for isolating immune cells from human blood, which can be used on demand."

DO YOU WANT TO PERFORM EXPERIMENTS IN SCAL/E?

ICMS researchers with a suitable question can perform experiments within SCAL/e and use the equipment available. For more information, please contact lab manager Marloes Janssen via W.J.T.Janssen-v.d.Broek@tue.nl.

News, awards & grants


Bert Meijer receives award.
Photo: Patricia Dankers

Hermann Staudinger Prize for Bert Meijer

THE PRIZE WAS PRESENTED AT THE BIENNIAL MEETING OF THE GDCH DIVISION OF MACROMOLECULAR CHEMISTRY IN AACHEN, GERMANY ON SEPTEMBER 12TH 2022. THE AWARD HONORS OUTSTANDING CONTRIBUTIONS TO POLYMER CHEMISTRY. BERT MEIJER RECEIVED THE PRIZE FOR HIS OUTSTANDING AND CREATIVE CONTRIBUTIONS TO THE FIELD OF SUPRAMOLECULAR POLYMER CHEMISTRY.

As university professor at the department of Chemical Engineering & Chemistry and member of ICMS, Meijer's research interests include self-assembled materials, the non-covalent synthesis of functional supramolecular systems, and functional supramolecular polymers.

ERC Proof of Concept Grant for research on success rate of cancer treatment

LORENZO ALBERTAZZI

The European Research Council (ERC) recently awarded a € 150,000 Proof of Concept Grant to Lorenzo Albertazzi. The grant will be used for translating ongoing research into diagnostic applications that can improve personalized immunotherapy.

Immunotherapy is a treatment intended to drive a patient's immune system to fight cancer cells. Some tumors can stop immune cells (such as T-cells) in the human body from doing their job, which is to eliminate cancer cells. One way to help T-cells become active again lies in the use of drugs known as checkpoint inhibitors.

These drugs are very powerful and show they can completely eradicate cancer but have a big disadvantage: they only work for forty percent of the patients while the others do not respond and would benefit from other type of treatments. Being able to give the right drug to the right patients is of key importance (personalized medicine).

Polymerization using electrostatic template now controllable

Regulating the polymerization process is of great interest for both industrial, but also medical applications. In an article published in Angewandte Chemie, TU/e Researchers show they not only control the process and are able to switch it on and off, but they can also control the properties of the resulting polymer materials.

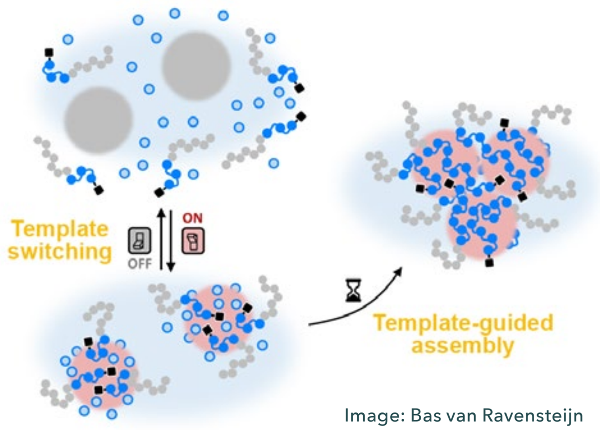
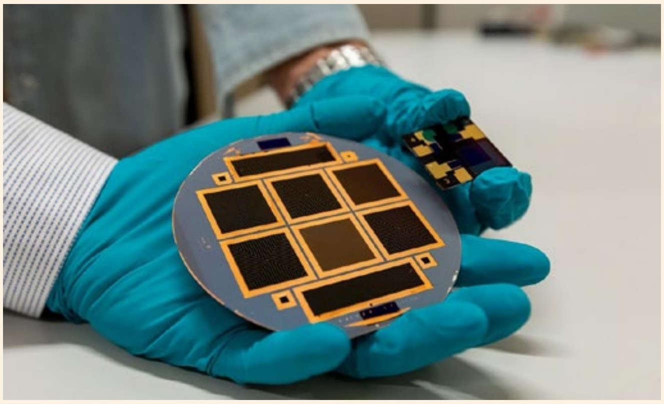


Image: Bas van Ravensteijn

Making polymers (long molecular strands) using a template has already been possible for quite some time. In the Self-Organising Soft Matter research group of the Department of Chemical Engineering and Chemistry at TU/e, research led by professor Ilja Voets and Bas van Ravensteijn has now shown that they can also switch the polymerization process on and off by using a switchable template.

Ilja Voets.
Photo: Vincent van den Hoogen

Four terminal perovskite-silicon PV tandem devices hit 30% efficiency



Lower silicon solar cell and upper perovskite solar cell with transparent contacts (Photo: Niels van Loon).

TNO, TU Eindhoven, imec and TU Delft, partners in Solliance, joined forces to further push the conversion efficiency of tandem solar cells to beyond the limits of today's commercial photovoltaic (PV) modules. For the first time, four-terminal perovskite/silicon tandem devices with certified top cell pass the barrier of 30%. Such high efficiency enables more power per square meter and less cost per kWh. The result is presented during the 8th World Conference on Photovoltaic Energy Conversion (WCPEC-8) in Milan, and it has been achieved by combining the emerging perovskite solar cell with conventional silicon solar cell technologies. The perovskite cell that features transparent contacts and is part of the tandem stack has been independently certified.

ADVANCED ANALYSIS OF COMPLEX MOLECULAR SYSTEMS

Molecular construction for the advanced

New ICMS member Pepijn Moerman designs innovative DNA droplets

Pepijn Moerman

As a PhD he was prompted by a chase movie to design a minimal model system with deflating droplets. Still today as a new ICMS member he tries to continue pioneering creatively. After a postdoc position at Johns Hopkins University, Pepijn Moerman joined the Colloidal Assembly group led by Ilja Voets. There, he aims to combine his love for education and innovative research.

"You can keep watching it," chuckles the newly appointed assistant professor. He shows the clip again – a classic from the 1950s – in which an immune cell chases a bacterium like a true Pac-Man. It triggered his curiosity about cellular communication and was one of the reasons to do a PhD project at Utrecht University. That turned into four years full of droplets: "I wanted to investigate what minimum cells need to communicate with each other. Using a model system of deflating droplets dispersing oil in an aqueous solution, I was able to show that they 'feel' each other via surface tension. In the end, even the droplet-level chase scene worked out and I had my own video of two droplets chasing each other."

A WARM BATH

Working at the Voets lab in Eindhoven required some shifting after a three-year stay in Baltimore (US) where he worked at Rebecca Schulman's lab at Johns Hopkins University. "But it feels like a warm bath here," he emphasizes. "Being at an institute like ICMS certainly contributes to that. It is very valuable to have regular multi-disciplinary contact with other researchers. And the availability of equipment – which comes with expertise – is very useful in a practical sense. When working on multidisciplinary research questions, the feasibility of experiments sometimes is underestimated; there is often a variety of equipment involved, which quickly makes it prohibitively expensive."

CONTROL SELF-ASSEMBLY

Next to his American wife – whom he met during an internship in New York – Moerman mainly took a lot of knowledge in the field of DNA nanotechnology to the Netherlands. "I employed genetic regulatory networks to control self-assembly of colloidal particles. I would like to continue that here, and connect the way cells communicate with each other to self-assembly in new projects. For example, by writing a recipe in DNA, can we make a material that we can't make otherwise? I am also designing an experimental model system of lipid vesicles with DNA on their surface. That should mimic how clumps of cells split into an inner and outer side during early embryogenesis. And when we can make model membranes with tunable rigidness and stickiness, these could potentially be a very useful scaffold to grow organoids on."
Moerman is a passionate researcher but education is as least as important to him. With a "Best Teacher Award" from University College Utrecht in his pocket, he will work in the coming years to make Eindhoven students enthusiastic about his field as well.

Postdoc events at ICMS

Postdocs @career crossroads

The postdoc community at ICMS consists of a diverse group of researchers. For some, Ceres is their home base, while others only participate in a few interdisciplinary projects. However, all have in common that this phase in their scientific career offers many opportunities, while it is also a time that demands making decisions. As ICMS fellows, we aim to connect the postdocs at ICMS and support them in shaping their future.

In a series of events, we give senior community members a platform to reflect on their carrier paths and decisions. In July 2022, Bert Meijer was the first to look back on his career and he shared many valuable lessons. One of the key messages was that in the early stages of his career, the changing environment brought out the best in him and boosted his development as an independent researcher. Meijer's inspiring story invoked many questions from the audience, and he took all the time to answer them, resulting in an excellent discussion. The discussions continued at the networking drink arranged by ICMS. It gave rise to new connections between members of our postdoc community.

On December 5, 2022, the series continued with a reflection on the early years of the career of Lorenzo Albertazzi, who worked at different research institutes before joining ICMS.

Are you a postdoc at ICMS but missed the previous event? Then, feel free to contact us, and we will happily add you to the mailing list and ensure you stay up to date.

contact:
postdoc_association@tue.nl

Next-generation lipid nanodroplets for immunotherapy

Roy van der Meel

Vidi grant for Roy van der Meel

Roy van der Meel, nanotechnologist at the Precision Medicine group, has been awarded a prestigious Vidi grant worth 800,000 euros. He received the grant to develop novel nanoparticles that consist of natural building blocks. These nanoparticles should deliver mRNA drugs to specific immune cell populations as an innovative strategy for effectively treating diseases such as cancer.

The COVID-19 pandemic resulted in the breakthrough of mRNA technology with the successful development of anti-SARS-CoV-2 vaccines. This involves injecting miniscule lipid particles containing mRNA. In the human body, this piece of genetic code is translated into a protein, which in the case of vaccines should trigger immune cells to launch a specific response to the coronavirus. In the coming years, we will see increasing applications of mRNA therapeutics, expects Roy van der Meel. He aims to make an active contribution by developing new nanotechnology to package and deliver mRNA, explains the passionate scientist. Unprotected mRNA is very unstable and is almost immediately degraded by the body. For successful therapeutic applications, both mRNA modifications and robust delivery nanotechnology are essential.

"Compare it to a delivery service: I make tiny parcels on a small scale, and design packaging that ensures the contents arrive whole, at the right address in the body."

NATURAL BUILDING BLOCKS

Van der Meel develops lipid nanoparticles coated with natural building blocks, called apolipoproteins. These proteins are the major component of HDL complexes that transport fats in the blood, such as cholesterol. As apolipoproteins have a natural affinity for innate immune cells and their progenitors, they can be used to promote mRNA delivery to these cells in the bone marrow and the spleen. "Depending on the mRNA code, we can on the one hand train cells to boost the immune response as a treatment for cancer. On the other hand, we can also reprogram immune cells to dampen the immune response as a treatment for autoimmune diseases."

FROM LAB TO PATIENT

At the Precision Medicine group, Van der Meel is currently establishing the right formula for these nanoparticles: which composition results in bone marrow accumulation and functional delivery of mRNA to specific immune cells? Through his colleague Willem Mulder, the group is strongly linked to the Department of Internal Medicine at Radboudumc in Nijmegen, where Mulder was appointed professor in early October. As a result, they have one foot in the clinic so that new nanotechnology developed at the lab bench can be translated to patients. "In this way we are involved in the entire cycle of developing nanoimmunotherapy that can regulate and rebalance the immune response. Once we have established the right formula, therapeutic mRNA applications can be implemented quite fast, from protein replacement therapy to personalized anti-cancer vaccines."

CHEMICAL BIOLOGY

A continuous sensor for single molecule detection

Continuous monitoring of molecules at extremely low concentrations is quite challenging. At the Molecular Biosensing research group, PhD candidates Alissa Buskermolen and Laura van Smeden rose to that challenge and developed a sensor that is able to detect even single molecules. To achieve such sensitivity, they employed moving functionalized particles of micrometer size. The sensor could be useful for assessing biomarkers in the blood stream or monitoring ecological environments and industrial processes. The work was recently published in Nature Communications.

At the heart of the sensor are thousands of freely moving particles of about one to three micrometer in diameter. Consisting mainly of polystyrene, the particles "hover" about a micrometer above a surface and their motion can be observed through a microscope. "It's a bit like watching a crowd throwing beach balls during a concert," Laura van Smeden says. She explains that normally the particles display the random Brownian motion of all small particles. To use the particles for sensing purposes, they have been adapted. Each is functionalized with antibodies or small pieces of DNA attached to its surface. This enables them to reversibly bind to the molecules that are the subject of the sensing. Once these analyte molecules
are present, they not only bind to the particles, but also to the underlying substrate that has been functionalized as well. Alissa Buskermolen: "As a result we detect a decline in the movement of the particles, which can be related to the concentration of analyte." In fact, the fixation of just one of the micro particles can indicate the presence of a single molecule.

Laura van Smeden (left)
and Alissa Buskermolen (right)

A PROGRAMMABLE SENSOR

The sensor is "programmable," as Van Smeden explains. Adjusting the binding moieties on the particles and the substrate allows the sensing of a broad range of molecules. "We can integrate antibodies, DNA, or proteins," she says. "With some optimization steps our technique is generally applicable." Another improvement would be to reduce the system size. Buskermolen: "It now fits inside a shoe box, but with the current technological advances we should be able to make it as small as a euro coin." A first use case might be just around the corner. The researchers are already working with dairy producer Campina to detect certain compounds of milk. Also, checking the health of organ transplants during transport is being researched. "I like the fact that we have the freedom that comes with basic research, while some of our applications already seem quite close," says Buskermolen.

A.D. Buskermolen, *et al.*, "Continuous biomarker monitoring with single molecule resolution by measuring free particle motion," *Nat. Commun.* 13, 6052 (2022).
DOI: 10.1038/s41467-022-33487-3

Alberto Credi

"MIMICKING NATURE MAKES SENSE, BUT NOT FOR THE SAKE OF MIMICKING."

Dutch prize for Italian builder of molecular nanobots

Big robots can build cars, small robotic arms can operate on a human through a tiny incision. So how small could robots actually get? Italian researcher Alberto Credi is known for his development of motors and robotic parts down to the nanometer scale. Not resembling traditional robots in any way, they could one day lead to "nanobots" working independently in our body. Credi visited our country to receive the Netherlands Scholar Award for Supramolecular Chemistry.

Credi is professor in the Department of Industrial Chemistry of the University of Bologna and he creates molecular complexes of about two to five molecules. These complexes can be thought of as machines on the nanoscale that perform a task. Currently, in most cases this consists of a mechanical motion such as moving molecular parts in a particular direction. In the future this might be extended to robotic tasks like gripping and cutting. To explore the possibilities, Credi and colleagues are developing a "molecular construction kit" containing the building blocks for the nanobots. Think Lego, but on a molecular scale. For his work, Credi was presented with the 2021 Netherlands Scholar Award for Supramolecular Chemistry. This bi-annual award is issued by the Research Center for Functional Molecular Systems and honors outstanding junior scientists working in supramolecular chemistry. According to the jury consisting of professor Bert Meijer, Nobel laureate Ben Feringa, and professors Wilhelm Huck and Roeland Nolte of Radboud University, the nanomotors of Credi are world renowned. Recently he came to the Netherlands to receive his award and tour the Dutch universities involved in this field of research.

NOT BEYOND THE LAB

The list of potential applications of nanobots is long. In medicine they could help detecting disease related markers directly in the body, or carry medicines to certain areas of the body. Nanobots could also be used for chemical sensors in industry. And they can play a role in ultrasmall logical devices. Credi already investigated molecular "switches", "cables" and "memories." But we should not get carried away; according to Credi, real application of these nanobots is still something of the future. Right now, the bots don't go beyond labs like his. "We study molecular complexes in solution and that may not be the situation in which many of these nanobots will eventually be used," he says. "For instance, when the robots are used as logical devices they will probably be fixed on a surface where they can be more easily addressed."

Current research is mostly focused on finding out how the nanobots can be synthesized, how they work and how they can be made to work more efficient. The practice of building nanobots could not be more different from building macrobots – the robots as we know them. Credi and colleagues often use molecules such as rotaxanes and catenanes, which look like a dumbbell with a ring on it and like two interlocked molecular rings, respectively. Movements of these molecular complexes can be fueled by light, by chemicals, or an electric potential. Putting the nanoparts (the molecules) together requires a series of chemical steps, in which for example molecular rings are interlinked. The precise function of the nanobot can then be tuned using slightly different subunits in the molecular components.

Credi and his colleagues are "programming" the nanobots by changing the energy landscape of molecular interactions. The goal is to promote movement of the molecules in one particular direction while making the movement in other directions more difficult. The actual motion of nanorobots (for example the movement along a certain path) is driven by external stimuli like light, electrical or magnetic fields, or chemical energy from the environment. Many of Credi's bots use ultraviolet light that once absorbed is converted in a chemical potential that drives the nanobot. According to Credi, the type of application of the nanobots is one of the factors that determines the fuel choice. For use in a larger electrical machine, electricity would be more logical. In a biological system, chemical metabolites would be more suited as fuel.

IMITATING NATURE

Engineers of life-size robots often take inspiration from nature and supramolecular chemists do the same. Many biological systems, like the cells in our body, use highly efficient nanobots. Take for example the so-called kinesins that "walk" along a microtubule in a cell and transport chemicals. Or proton pumps that create chemical gradients by transporting protons through a membrane while consuming energy rich molecules such as ATP. Chemists are in awe by such biological nanobots and even make them work in an artificial environment, but they cannot build them themselves. Indeed, the complexity of many biological systems exceeds that of their artificial counterparts. Also, the latter are in general less efficient and robust.

According to Credi it's not necessarily his goal to imitate nature: "That may not be needed to achieve our goals." He mentions the first engineers that wanted to move things mechanically. "They did not come up with a mechanical horse but quickly discovered that using wheels is much more effective," he says. "Mimicking nature makes sense, but not for the sake of mimicking. We always keep in mind the function we want the nanobot to have, and then it maybe not useful to make artificial walking kinesins." Another important point is keeping the synthetic process as simple as possible, Credi explains. "More complex molecules are also more difficult to synthesize. This often results in smaller amounts of nanobots we can produce and study. To do an effective characterization and a meaningful exploration of a possible application you want to have grams of the material, not milligrams. Then the molecules become more interesting for our research."

The molecular "toolbox" of Credi and other supramolecular chemists in the world is slowly being filled. Credi: "We try to make the molecules in a modular way so they can be easily used in other complexes and applications by other scientists. In that sense we are creating a toolbox that now already has tens of different molecular tools that are share by the whole world."

Theses

MAY 2022 – OCTOBER 2022

The advanced continuous-wave electron injector
WIEBE TOONEN
May 10, 2022
PhD advisors:
O.J. Luiten
P.H.A. Mutsaers

Understanding allosteric modulation of nuclear receptors by engineering proteins and assays
IRIS LEIJTEN-VAN DE GEVEL
May 25, 2022
PhD advisors:
L. Brunsveld
C. Ottmann

Synthesis, functionalization, and self-assembly of isotropic and patchy microparticles
PATRICK HAGE
May 31, 2022
PhD advisors:
I.K. Voets
E.W. Meijer
J. Meijer

Decoding functional heterogeneity in immune cells: new avenues for immunotherapy
NIKITA SUBEDI
June 3, 2022
PhD advisors:
C.V.C. Bouten
J. Tel

Hybrid integrator-gain systems: analysis, design, and applications
SEBASTIAAN VAN DEN EIJNDEN
June 3, 2022
PhD advisors:
H. Nijmeijer
M.F. Heertjes
W.P.M.H. Heemels

Atomically thin semiconductors for nanophotonics
RASMUS GODIKSEN
June 9, 2022
PhD advisors:
J. Gómez Rivas
A.G. Curto

Engineering protein organization in coacervate-based protocells
WIGGERT ALTENBURG
June 22, 2022
PhD advisors:
J.C.M. van Hest
A.F. Mason

Phase transitions of hard colloidal mixtures and soft block copolymers
JOERI OPDAM
June 22, 2022
PhD advisors:
R. Tuinier
A.C.C. Esteves

Energy consumption prediction for electric city buses: using physics-based principles
CAMIEL BECKERS
June 28, 2022
PhD advisors:
H. Nijmeijer
I.J.M. Besselink

Biomaterials for kidney organoid-based regenerative therapy
JOHNICK VAN SPRANG
July 8, 2022
PhD advisors:
P.Y.W. Dankers
C.V.C. Bouten

Mixed-halide perovskite semiconductors for multijunction photovoltaics
KUNAL DATTA
September 2, 2022
PhD advisors:
R.A.J. Janssen
M.M. Wienk

Control for cooperative merging maneuvers into platoons
WOUTER SCHOLTE
September 13, 2022
PhD advisors:
H. Nijmeijer
P.W.A. Zegelaar
T.P.J. van der Sande

Biotribology of cartilage resurfacing implants
ALICIA DAMEN
September 16, 2022
PhD advisors:
K. Ito
C.C. van Donkelaar

Molecular mapping of nanoparticle targeting: a super-resolved journey
LAURA WOYTHE
September 16, 2022
PhD advisors:
L. Albertazzi
M.W.J. Prins

A few statistical contributions for the analysis of high-dimensional data
ALBERTO BRINI
September 20, 2022
PhD advisors:
E.R. van den Heuvel
J. Engel

A human ex vivo model for evaluation of osteochondral regeneration and integration
MEIKE KLEUSKENS
September 23, 2022
PhD advisors:
K. Ito
C.C. van Donkelaar

Evolutionary optimization of nanophotonic design for optical and optoelectronic applications
PING BAI
September 23, 2022
PhD advisors:
J. Gómez Rivas
A. Fiore

Food emulsifier structures in solution and at interfaces
MACHI TAKEUCHI
September 27, 2022
PhD advisors:
R. Tuinier
H. Friedrich

Controlling light-matter interactions in silicon metasurfaces
GABRIEL CASTELLANOS GONZALEZ
October 6, 2022
PhD advisors:
J. Gómez Rivas
A. Fiore

Engineering interactions at the interface of living and synthetic cells
MARLEEN VAN STEVENDAAL
October 11, 2022
PhD advisors:
J.C.M. van Hest
J.J. Jansen

Optical indicators based on cholesteric liquid crystal polymers
YARI FOELEN
October 14, 2022
PhD advisors:
A.P.H.J. Schenning
C.W.M. Bastiaansen

Dynamic modelling of Saccharomyces cerevisiae central carbon metabolism
DAVID LAO MARTIL
October 20, 2022
PhD advisors:
N.A.W. van Riel
P.A.J. Hilbers

News, awards & grants

Winner Best Master Teacher Award Sandra Loerakker:

"Interaction is what works best for me"

Sandra Loerakker is TU/e's best master teacher.
Photo: Tim Meijer

Sandra Loerakker was overjoyed and utterly surprised to receive the Best Master Teacher Award during the Momentum ceremony. She is responsible for the Numerical Analysis of Continua II course, and has been familiar with the subject since she herself took the course as a student in 2005. How did she adapt the course to the needs of both the students and herself?

Right before her maternity leave, Sandra Loerakker heard that she had been nominated for the Best Master Teacher Award and was thus invited to give a pitch. "That was quite challenging because that pitch was during my leave and work was the furthest thing from my mind at the time. Also, I found it difficult to pitch about teaching instead of research, which is something I'm more used to. But given the fact that I'd been nominated by students, I really wanted to do my best. Still, I never expected my pitch to win." After four months of leave and having welcomed her third son into the world, she returned, and Rector Frank Baaijens presented her with the award for the Numerical Analysis of Continua II course, which is taken by some 60 master's students.

IPM Research Center at NWO 2022 Gravitation Awards Ceremony

TU/E RESEARCHERS WERE IN THE SPOTLIGHT DURING THE NWO 2022 GRAVITATION AWARDS CEREMONY ON OCTOBER 10TH AT THE HOFTOREN IN THE HAGUE.

Jan van Hest (departments of BmE and CE&C), Patricia Dankers (BmE), Anja Palmans (CE&C), Rint Sijbesma (CE&C), Jom Luiten (AP&SE), Jaap den Toonder (ME) and other fellow TU/e researchers, raised more than 15 million euros to establish the Interactive Polymer Materials (IPM) Research Center on October 1, 2022. The award was presented by none other than Minister Robbert Dijkgraaf.

The IPM Research Center is affiliated with the Institute for Complex Molecular Systems (ICMS) and focuses on materials research.
Within this center, they will develop a new generation of smart and dynamic polymer materials with exceptional properties, which will undoubtedly be necessary for 21st century applications.
The IPM Research Center will host a festive launch event on January 20, 2023. Congratulations again on this unique achievement and we hope that this alliance will continue to be a hotspot for polymer knowledge and an incubator for related products.

Patricia Dankers, Anja Palmans, Jan van Hest, Minister Robbert Dijkgraaf, Jaap den Toonder, Jom Luijten and Rint Sijbesma.

Smart cells Eindhoven students triumph in Paris

The iGem-team after their victory in Paris

TU/E'S IGEM TEAM HAS FINISHED FIRST AT THE GIANT JAMBOREE IN PARIS, THE INTERNATIONAL COMPETITION FOR INNOVATIONS IN SYNTHETIC BIOLOGY. THE STUDENTS DEVELOPED A CELL THERAPY TO TREAT AUTOIMMUNE DISEASES SUCH AS ANCA-ASSOCIATED VASCULITIS, A CHRONIC INFLAMMATION IN BLOOD VESSELS. WORLDWIDE, 400 MILLION PEOPLE SUFFER FROM THIS TYPE OF DISEASES, WHICH CAN BE FATAL. THE EINDHOVEN TEAM MANAGED TO BEAT THE OTHER TWO CONTESTANTS FROM HONG KONG AND FRANCE IN THE FINAL OF THE UNDERGRAD CATEGORY. IT IS THE FIRST TIME THE STUDENT TEAM HAS WON THE INTERNATIONAL COMPETITION.

iGEM is an international student competition in which participants try to solve a variety of problems using techniques from synthetic biology. A total of more than 350 teams from around the world participated this year in the three categories High School, Overgrad and Undergrad, including more than 180 Undergrad teams. They gathered in Paris this year for the annual Giant Jamboree. During this event, the teams present their work to a jury and a 4,000-strong audience.

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