University of Basel
Swiss Nanoscience Institute

SNI
SWISS NANOSCIENCE INSTITUTE
EINE INITIATIVE DER UNIVERSITÄT BASEL UND DES KANTONS AARGAU

SNI INSight

Showcasing research and activities at the Swiss Nanoscience Institute

May 2021

Award for the best master's thesis

Two winners this year

Nano Argovia program

Nine new applied research projects

Strong women

Activities for the International Women's Day

News from the network

Exciting scientific results

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Editorial

Dear colleagues and friends of SNI,

One year ago, we were experiencing our first lockdown. Back then, we could never have imagined that the pandemic would continue to exert such a colossal influence on our lives in spring 2021. In fact, many things we would have found highly unusual just one year ago have now become part of our day-to-day lives.

We have grown used to seeing photos and videos of people wearing face masks, and virtual meetings and online conferences are simply part of our everyday routine. At the beginning of the year, the SNI team even decided to move this year's Swiss NanoConvention online, where it will take place from 24-25 June.

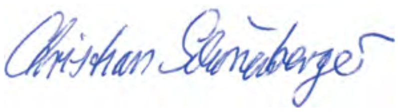
We have curated a varied and exciting program for the SNC 2021 Online, and we are also organizing a range of opportunities for participants to interact and exchange information. Ultimately, we had to reschedule the conference, which was originally set to take place last year, but we hope these online offerings will allow us to reach out to the many scientists who would have been unable to participate in person in Basel. I am already very excited about the conference, and I am looking forward to seeing many familiar faces and meeting new people, too.

At the SNC 2021, we will not only be delving into the fundamental science, but also presenting numerous applications of nanoscience and nanotechnology.

Applied projects have always enjoyed a high standing at the SNI: Every year, around ten applied research projects receive funding as part of our Nano Argovia program. This spring issue of *SNI INSight* is dedicated first and foremost to the exciting new projects that launched at the beginning of the year.

In addition to introducing the Nano Argovia projects, this issue will also feature profiles of two ambitious young nanoscientists: Charlotte Kress and Anna Leder submitted outstanding master's theses in 2020 and will both therefore be receiving the award for best master's thesis. Charlotte completed her accompanying research as part of Marcel Mayor's team in the Department of Chemistry, while Anna worked in Sebastian Hiller's group at the Biozentrum.

We hope you enjoy this issue of SNI INSight.



Prof. Christian Schönenberger, SNI Director

This year we have two winners!

The prize for the best master's thesis in nanosciences goes to two young female scientists

Every year, the Swiss Nanoscience Institute awards the prize for the best master's thesis in nanoscience at the University of Basel submitted in the previous year. In 2021, two young female researchers will receive the award. Charlotte Kress and Anna Leder convinced the selection committee by their work. At the master's ceremony, which is expected to take place on 5 November, 2021, the two young female scientists will receive their awards, which come with prize money totaling 2,000 Swiss francs.

One eye on application

Charlotte Kress thrives at the intersection between classical disciplines

For her master's thesis, Charlotte Kress synthesized a complex organic compound with potential applications in molecular electronics.

Bottom-up instead of top-down

Molecular electronics uses individual organic molecules, for instance as tiny switching elements in a circuit. In this bottom-up approach, larger electronic components are built from scratch using individual molecules, in contrast to the conventional top-down approach of progressively miniaturizing larger components.

Besides offering the researchers fundamental insights into how electricity is conducted at the atomic level, using individual molecules also allows them to explore the extent to which these minute but structurally diverse components can be used to customize certain electrical functions. These findings are of particular interest considering that conventional electronic components are approaching a point where further miniaturization will be impossible for various reasons.

Single molecules as electric conductors

Accordingly, for a number of years researchers in chemistry and physics have been working closely with each other to determine which molecules might be suitable for applications of this sort in electronic components.

Professor Michel Calame (Empa and the Department of Physics at the University of Basel) and his team have developed a technique whereby two individual molecules can be electrically connected between two tiny electrodes, allowing the researchers to investigate the molecules' electric properties. The group led by Professor Marcel Mayor (Department of Chemistry, University of Basel) provides the molecules for these studies, a process that Charlotte Kress contributed to in the course of her award-winning master's thesis.

Charlotte Kress' outstanding work earned her the prize for the best master`s thesis in nanosciences at the University of Basel. Charlotte has synthesized complex organic molecules that can be used in molecular electronics.

Binding properties of sulfur and isocyanide

It has been known for some time that molecules possessing sulfur atoms as functional groups bind well to the gold electrodes used by Calame's team. Another functional group that causes molecules to bind well to gold electrodes is isocyanide – in which a carbon atom is attached to a nitrogen atom by a triple bond.

The two teams, led by Marcel Mayor and Michel Calame, had previously succeeded in building one-dimensional chains between two gold electrodes from benzene rings with isocyanide groups.

In her master's thesis project, Charlotte developed a macrocyclic – or ring-shaped – molecule in which an isocyanide group faces the center of the ring from both sides, thereby replicating the binding properties of the abovementioned one-dimensional chain in relation to gold atoms.

One step at a time

Charlotte spent the first few months of her master's thesis project synthesizing the macrocyclic molecule in a number of steps. "To begin with, we put together a synthesis plan that worked quite well, and only required minor tweaking," she explains. Her goal was to create two different molecules, one in which the isocyanide groups faced inward and another in which they faced outward.

In subsequent titration analyses, Charlotte found that the isocyanide groups bound very well to the gold atoms. The fact that the molecules are stable at room temperature and easy to store in powder form makes them promising candidates not just for applications in molecular electronics, but also as sensors for dissolved gold ions.

An eye on application

Charlotte found synthesizing organic materials to be thoroughly enjoyable. "That said, it is also important for me to

Additional information

Publication
Nature Communications
https://doi.org/10.1038/s41467-018-08025-9

Research group Marcel Mayor
https://mayor.chemie.unibas.ch/en/

Research group Michel Calame
https://www.empa.ch/web/s405/overview

Short video with Charlotte and Anna
https://youtu.be/HDd-LpA-k2CM

“I hope to welcome many more colleagues of Charlotte’s caliber to my research group. Aside from her outstanding technical aptitude and unbridled scientific curiosity, what really sets her apart is her boundless enthusiasm and an inimitably cheerful nature that is contagious to everyone around her.”

Professor Marcel Mayor (Department of Chemistry, University of Basel)

have an application in sight – even if it is a long way off,” she adds. A particularly interesting aspect of this task for Charlotte was how it blurs the boundary between chemistry and physics.

Moreover, as she feels that she is in especially good hands in Mayor’s group, after completing her master’s Charlotte decided to proceed with a doctorate in the same field. To this end, she will continue her work with synthesis in a bid to produce molecules featuring isocyanide groups on both the inside and the outside. Her plan is to sandwich this macrocycle between two electrodes so as to replicate the proposed one-dimensional chain and confirm the accuracy of this hypothesis. Of course, as a determined chemist, she also plans to increase the yield, which currently stands at 7%, and subsequently characterize the new molecules in detail. Her focus here will also be on the molecules’ binding properties in relation to other materials of relevance to electronics besides gold atoms. She is particularly keen to see how her molecules perform in electronic tests in “field trials” by Calame’s team.

Focus on chemistry

Throughout her degree, Charlotte was always especially interested in topics involving two different disciplines. From the beginning, she was primarily interested in chemistry, but what really fascinated her was when a biological or physical aspect was added to the equation. A degree in nanosciences was therefore always going to be ideal.

Charlotte enjoys working in Marcel Mayor’s team. She is therefore pursuing a doctorate in the group after completing her master’s degree.

The 25-year-old German, who grew up in Ticino, had her first brush with the nanosciences during her Matura (school-leaving certificate) project on the functionalization of nanoparticles. After earning her Matura, she felt the curriculum in Basel was a perfect fit, and has no regrets about embarking on a nanoscience degree in 2014.

“It wasn’t all plain sailing,” she remembers. “I really struggled with practical physics and the Physics III exam. In retrospect, however, I benefited immensely from many of these challenging subjects.” A highlight of the bachelor’s degree for Charlotte were the block courses and – as for so many of her fellow students – the fantastic team spirit among the nanoscience students.

Rewarding master’s degree

Overall, for Charlotte the master’s degree felt like “a reward for the bachelor’s”, allowing her to engage with a topic in greater detail and focus more on chemistry.

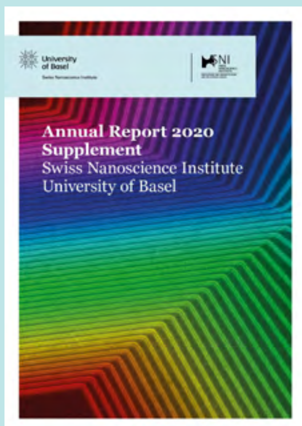
Before beginning her project assignments, Charlotte spent a semester doing a practical chemistry course for chemistry students in the 6^{th} semester in preparation for her chemistry-related lab work. This gave her a solid foundation for her first project assignment at Osaka Prefecture University, involving the production and processing of a protein able to modify the functionalization of a carbon-carbon double bond.

Organic molecules were also the focus of Charlotte’s second project assignment – this time, those being studied by Professor Wenger’s team (University of Basel) for their applications in photovoltaics.

Throughout her nanoscience degree, Charlotte got to know numerous research groups, and over time she developed a keen sense for which topics particularly interested her. The affinity for chemistry that emerged during her school years remains as strong as ever, and she feels very much at home both in Mayor’s team and in the Department of Chemistry. Thanks to her nanoscience degree, however, she is also well equipped to understand the requirements of the physicists who will study her molecules for applications in electronics.

Are you interested in the activities of the Swiss Nanoscience Institute?

An overview of all our projects is available in the Annual Report 2020. The general part provides information on interesting topics related to the network, students, doctoral students and SNI professors written specifically for a general readership. We describe projects from our applied Nano Argovia program, the SNI PhD School and the Nano Imaging Lab. In addition, we report back on the activities of our communication and outreach team. The scientific supplement contains academic progress reports on all Nano Argovia and PhD projects which received financial support from the SNI in 2020.



We would be happy to provide you with a printed copy upon request.

Order form

Annual report 2020:

General part (English)

Scientific supplement (Englisch)

Folding proteins
Anna Leder's fascination with structural biology

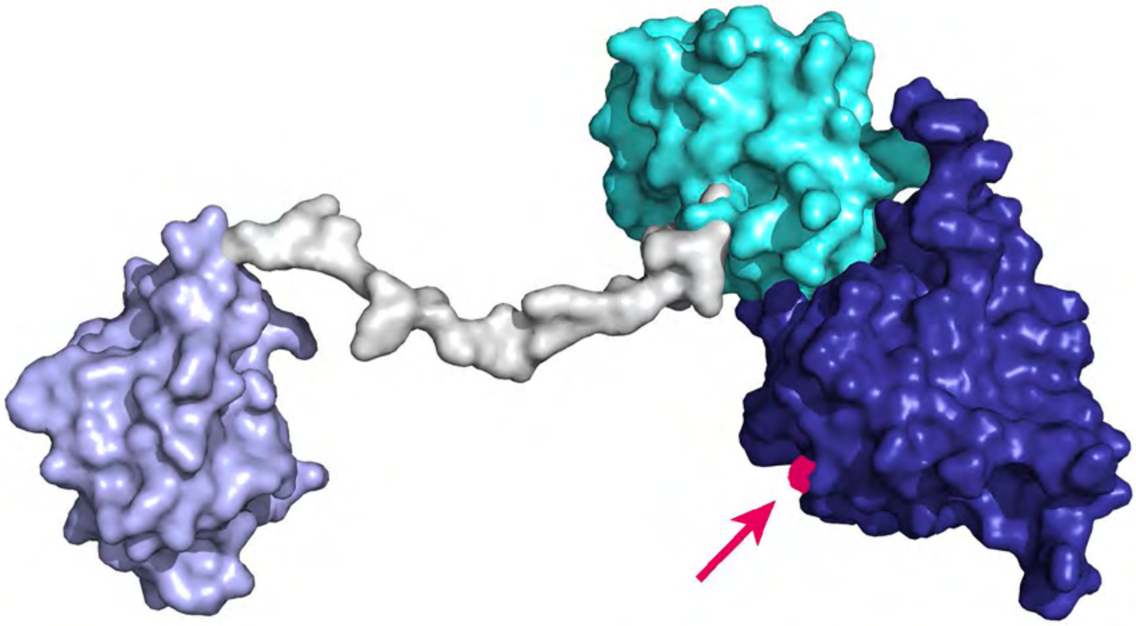
In 2021, one of the awards for the two best master's theses goes to Anna Leder for her paper on the characterization of a helper protein using nuclear magnetic resonance (NMR) spectroscopy. Anna wrote her thesis while working in the research group led by Professor Sebastian Hiller at the University of Basel's Biozentrum.

Anna Leder also received the prize for the best master's thesis in nanosciences this year. In her thesis, Anna elucidated the structure of a protein that plays an essential role in some diseases.

Additional information

Research group Sebastian Hiller
https://www.biozentrum.unibas.ch/research/research-groups/overview/unit/hiller/research-group-prof-sebastian-hiller/

Short video with Anna and Charlotte
https://youtu.be/HDd-LpAk2CM



Helper proteins support processes that lead to the correct folding of proteins. Anna Leder has studied a particular helper protein and elucidated its structure. This has helped to identify the molecular basis of a liver disease that is caused by a change in the helper protein. (Image: A. Leder, University of Basel)

In order for proteins to fulfil their manifold tasks in an organism, they must have the appropriate three-dimensional structure. Helper proteins known as chaperones support the processes that result in the proper folding of proteins. The chaperones themselves do not become part of the protein complexes, but ensure that the protein is arranged into the correct tertiary structure.

Understanding on the atomic level

Sebastian Hiller's group uses nuclear magnetic resonance (NMR) spectroscopy to study these chaperones at the atomic level. This gives the researchers a better understanding of how the chaperones function, and what effect disorders in their activity can have.

For her award-winning master's thesis, Anna characterized a particular chaperone that supports the formation of disulfide bonds using a combination of NMR spectroscopy, various biophysical methods and crystallography. "I took a close look at the function and structure of the chaperone and examined its functional cycle, which is highly complex: besides supporting protein folding, the chaperone also regulates other chaperones," Anna explains.

Various mutations in this chaperone have been directly linked to serious illnesses. Accordingly, in order to develop drugs or treatments, it is important to understand the protein in structural and functional terms. "For example, extensive characterization of the protein has helped us to shed light on the molecular basis of a serious liver disease in collaboration with our partners," the young nanoscientist reports.

Flexibility thanks to the pandemic

If everything had gone according to plan, this project would have been Anna's first project assignment, which she had planned to follow up with a second in Montreal on the subject of crystallography. Her plans were thrown into disarray by the COVID-19 pandemic, however.

In the spring of 2020, when her progress so far would have been enough for a project assignment, there was still hope that a trip to Canada would be possible later in the year. Accordingly, it made sense to continue her work on the helper protein, turn it into a master's thesis and complete her project assignments subsequently. "I was given fantastic supervision from Dr. Guillaume Mas," Anna reports. "I was delighted to have the opportunity and support to keep on working on my project throughout the lockdown."

Unfortunately, as the year progressed it became apparent that the COVID-19 pandemic had ruled out trips abroad for some time, so after completing her master's thesis Anna stayed on in Hiller's lab to write a project assignment there too. To this end, she explored ways to study larger protein complexes using NMR by marking individual amino acids.

In the end, Anna was able to wrap up her nanoscience degree with a project abroad after all, writing her second project assignment in early 2021 at the Max Perutz Lab in Vienna (Austria). For this project, she used optical microscopy to ascertain how the message that a cell contains too many unfolded proteins is passed on to the cell nucleus. Her trip was supported by an Argovia travel grant.

An interest in structural biology

During her highly varied degree, Anna discovered a particular interest in questions of structural biology, prompting her to choose this field for her doctoral dissertation too. She has not yet decided whether she will complete her doctorate at the University of Basel or elsewhere, however. For the next six months, she will continue working in Sebastian Hiller's group as an intern, and then decide what comes next.

A broad range of interests and talents

When Anna started studying nanoscience in 2016, at first she wasn't quite sure whether it was for her. She came to Basel from her hometown of Pontresina to attend a bachelor's information day and form her own impression. At the time, she was particularly interested in the natural sciences, languages and music, and had not yet decided what to study. Keeping an open mind, she chatted with nanoscience students and attended the presentation of the degree program. "It sounded like a great mix, so I decided to give the nanoscience program a try," she recalls, adding that the decision has given her no cause for regret.

Like Charlotte, Anna also found the physics challenging, and remembers the block courses as a highlight of the bachelor's program. These early insights into the practical work being done by different research groups in biology, chemistry and physics were highly motivating, and she thoroughly enjoyed the close connection among students.

"It's a modestly sized program, so we got to know each other very quickly, forming friendships and always supporting each other," recalls the 24-year-old from Switzerland, who before winning the award for best master's thesis had previously been distinguished with a prize for best Matura (school-leaving certificate) at her school, besides winning a "Best Talk Award" at the nanoscience program's Smalltalk symposium.

> "I was utterly astounded by the quality of Anna's work, performed under the challenging conditions imposed by the first COVID-19 lockdown. Thanks to an appropriate combination of biophysical techniques and experiments, Anna succeeded in revealing the protein's entire functional cycle in a remarkably short time. Her results are outstanding, and represent substantial progress for the field as a whole."

Professor Sebastian Hiller, Biozentrum, University of Basel

Don't forget to register!

Information and registration

Swiss NanoConvention 2021 Online

June 24 - 25, 2021

The Swiss NanoConvention is the prime showcase for nanoscience and nanotechnology in Switzerland. It connects key players from science and industry and is the venue for meeting the great minds in these fields.

Keynote speakers:
Jos Benschop, ASML, The Netherlands
Nynke Dekker, TU Delft, The Netherlands
Andreas Heinrich, Center for Quantum Nanoscience, Korea
Wanda Kukulski, Univ. of Bern, Switzerland
David Leigh, Univ. of Manchester, England
Nicole Steinmetz, Univ. of California, USA
Lieven Vandersypen, TU Delft, The Netherlands
Harald Weinfurter, LMU Munich, Germany
Vivian Yam, Univ. of Hong Kong, Hong Kong

Topical sessions:
Nano for Climate
Nano for Healthy Aging
Nano for Photonics and Quantum Communication
Nano for Quantum Computing
Nanoengineered Inorganic Materials
Nanoengineered Organic Materials
Nanotechnologies for Health
Nanotechnology for Antimicrobial Resistance AMR

Applied sessions:
Advanced Manufacturing at the Nanoscale
Nanoanalytics and Imaging for Quality Products
Nano-Innovations
Nanotechnology Startup Contest (Swiss MNT)

Registration is open
https://2021.swissnanoconvention.ch

Sponsors & Partners

Strong women in the SNI network

This year, the SNI held a range of events celebrating International Women's Day on 8 March.

Contributions International Women's Day

Eight women in the SNI network
https://youtu.be/0tog4hFfArE

YouTube channel "Meet the NCCR women"
https://www.youtube.com/hashtag/nccrwomen

SCNAT portrait Ilaria Zardo
https://www.youtube.com/watch?v=K5saRDYk5sM&t=1s

Some of the women in the SNI network produced short videos for the SNI in which they introduced themselves and discussed the topics they research.

In honor of International Women's Day, the Swiss Academy of Sciences (SCNAT) launched a video series featuring women in the fields of mathematics, astronomy and physics (MAP). Professor Ilaria Zardo, who also collaborated in the SNI video, is one of the scientists spotlighted as part of the series.

Another similar campaign, "Meet the NCCR women," also began on 8 March in recognition of 50 years since women gained the right to vote in Switzerland. Through to the end of October, women working in one of the country's 22 active National Centers of Competence in Research (NCCRs) will talk about who they are, what they do and the motivation for their research.

Take a look at what these women in science have to say. There is plenty to learn!

SNI PhD School
https://nanoscience.ch/en/research/phd-program/

Application for new PhD projects

Principle Investigators, who are interested in the SNI's PhD School, may submit their proposals by 31 May, 2021.

More information

New projects approved

In 2021, nine new research projects were launched within the applied Nano Argovia program

The SNI's Nano Argovia program will be celebrating its 15th anniversary this year. Every year since 2007, this SNI program has financed new projects devoted to investigating applications in nanotechnology. These applications are then realized as part of a collaborative effort with a partner company located in Northwestern Switzerland. At the beginning of the year, nine interdisciplinary research teams at the University of Basel, the University of Applied Sciences and Arts Northwestern Switzerland and the Paul Scherrer Institute teamed up with industry partners to begin their research on a wide array of subjects. Six of the companies are located in the canton of Aargau, two in Basel-Landschaft and one in Basel-Stadt.

Additional information

Nano Argovia program
www.nanoargovia.swiss

New lenses for X-ray examinations

In the Nano Argovia project ACHROMATIX, an interdisciplinary team of researchers is developing a novel lens system that can be used for scientific investigations using X-rays. Dr. Joan Vila-Comamala of the Paul Scherrer Institute is leading the project in which scientists from the Paul Scherrer Institute, the University of Basel and the company XRnanotech are contributing their expertise.

Nowadays, X-rays play an important role not only in everyday medical practice; the special properties of X-rays are also used in research or in material analyses. In X-ray microscopy, lenses are used to focus the X-ray beam on the sample or to create a magnified image. For this purpose, various lenses have been developed in recent years that reflect, refract or diffract the X-rays. These three different types of lenses have advantages and disadvantages.

Differences depending on wavelength

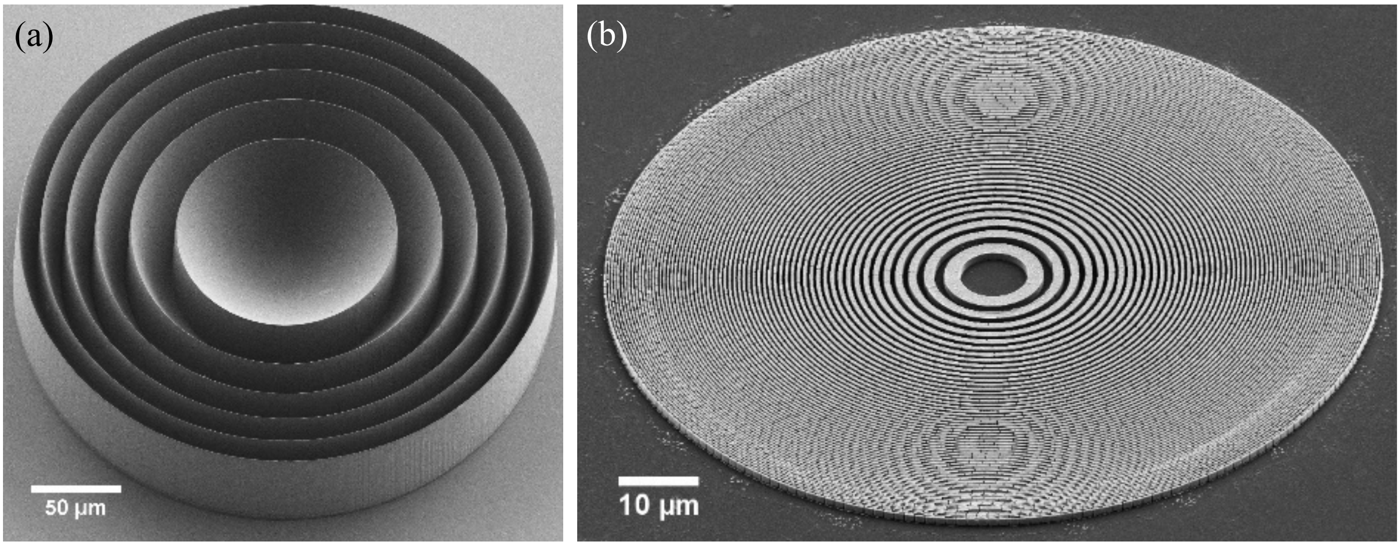
Refractive and diffractive lenses focus X-rays of different wavelengths at different distances. Experts refer to this as chromatic aberration. If X-ray tubes are used as the source of X-ray radiation, it is therefore necessary to reduce the com-

Additional information

XRnanotech
https://www.xrnanotech.com/

Paul Scherrer Institute
https://www.psi.ch/en

Biomedical Science Center University of Basel
https://www.bmc.unibas.ch/index/index.phtml



(a) Refractive X-ray lens with a diameter of 600 micrometers. (b) Diffractive X-ray lens with a diameter of 90 micrometers, that is smaller than the diameter of a human hair. (Image: Paul Scherrer Institute)

paratively broad wavelength range using a monochromator. However, this greatly reduces the number of light particles (photons), which in turn limits the use of the X-ray tube for X-ray microscopy.

Combination of lenses

In the Nano Argovia project ACHROMATIX, scientists are now developing a combination of a refractive and a diffractive lens. The aim is to design this lens combination in such a way that the chromatic aberration of the two lenses balances out.

First, the researchers determine the best lens combination based on theoretical calculations, which they will then manufacture using state-of-the-art nanofabrication techniques. The finished achromatic X-ray lens will then be characterized and tested in detail.

The lens will later be used for transmission X-ray microscopy to perform biomedical laboratory studies. The researchers expect this to result in an approximately tenfold improvement in photon flux. Investigations that are currently only possible using a synchrotron light source should become possible using X-ray tubes with the new lens, thereby significantly advancing and broadening the use of X-ray investigation for scientific purposes.

In addition to the project leader Dr. Joan Vila-Comamala (PSI), Dr. Christian David (PSI), Dr. Georg Schulz (Department Biomedical Engineering, University of Basel), Professor Bert Müller (Biomaterial Science Center, University of Basel) and Dr. Florian Döring from XRnanotech (Villingen) are involved as partners in the project.

"The heart of every microscope is its optics. With new and better optics, unimagined insights into materials and matter can be achieved and new knowledge gained. The Nano Argovia project offers us the opportunity to decisively improve the optics for X-ray microscopes."

Dr. Florian Döring, CEO and Founder of XRnanotech GmbH

A new hybrid pixel detector for cryo-electron microscopy

In the Nano Argovia project HPDET-EM, electron microscopy experts from the University of Basel and the Paul Scherrer Institute, led by Professor Timm Maier (Biozentrum, University of Basel), are collaborating with the team of Dr. Sacha de Carlo from DECTRIS AG (Baden-Dättwil) to install and test a new hybrid pixel detector. The new device will be very specific to the particularities of cryo-electron microscopy (cryo-EM), continuing the success story of cryo-EM in the life sciences.

Additional information

DECTRIS
https://www.dectris.com

Paul Scherrer Institute
https://www.psi.ch/en

Biozentrum University of Basel
https://www.biozentrum.unibas.ch

Three-dimensional structure
Cryo-electron microscopy has evolved tremendously in recent years. New methods of data processing and improved electron detection cameras have led to the identification of individual amino acids. With the help of data from cryo-EM analyses, it is now possible to determine the three-dimensional structure of proteins. This is necessary, for example, to understand life processes and the development of diseases, or to develop new drugs.

In contrast to X-ray crystallography, which is still mainly used to identify the spatial protein structure, cryo-EM analysis does not require crystallization of the protein. Thanks to the Nobel-Prize-winning cryo-EM method developed by Swiss professor Dr. Jacques Dubochet, the sample is shock-frozen, causing water to solidify into amorphous ice at lightning speed. The sample is then analyzed from different directions, and computer programs calculate the three-dimensional electron density. This then leads to the identification of the spatial structure. The disadvantages of cryo-EM are the high cost of modern electron microscopes and detectors as well as the time required for the analyses.

Better for cryo-EM
Scientists in the Nano Argovia HPDET-EM project are now testing a hybrid-pixel detector that better meets the requirements of cryo-electron microscopy than models used for synchrotron and X-ray analyses. DECTRIS, the world leader in hybrid pixel detectors, is collaborating with University of Basel specialists Professor Timm Maier and Dr. Mohamed Chami as well as Professor Michael Steinmetz of the Paul Scherrer Institute.

In hybrid pixel detectors, a semiconductor sensor and the readout chip are optimized and fabricated independently and then electrically coupled. In the process, individual modules are strung together.

The researchers are now installing and testing a new hybrid pixel detector developed by DECTRIS that has high readout speed and sensitivity. They are developing the necessary protocols for operation and analysis in conjunction with cryo-EM to further advance the technology for application in the life sciences.

"We think that our collaboration aiming at the integration of this promising detector technology into your life sciences cryo-EM workflows as well as your established network within the life sciences and EM community will help DECTRIS reach this important new market segment."

Dr. Sacha de Carlo, Global Sales Manager EM at Dectris

Additional information

credentis AG
https://www.credentis.com

School of Life Sciences (FHNW)
https://www.fhnw.ch/en/about-fhnw/schools/life-sciences

University Center for Dental Medicine Basel (UZB)
https://www.uzb.ch

Treatment for ulcers in the oral mucosa

As part of the Nano Argovia project Hydrogel-Patch, an interdisciplinary team led by Dr. Lucy Kind (University of Applied Sciences Northwestern Switzerland, FHNW) is working with the company credentis AG (Windisch) to develop a plaster for use on nonspecific ulcers in the oral mucosa. The plaster consists of a synthetic, self-assembling peptide hydrogel that initially covers the affected areas and is potentially also suitable for releasing therapeutic agents.

A need for comprehensive therapy

Wounds in the oral mucosa can have a variety of causes, including injuries, infections, reduced immune responses and tumors. Nonspecific ulcers are often caused by a combination of different factors. Whatever their origin, these wounds cause pain during eating or speaking and therefore negatively impact patients' quality of life. Ideally, there would be a treatment that could be applied directly within the mouth and that relieved pain, supported the healing process and was produced without ingredients of animal origin.

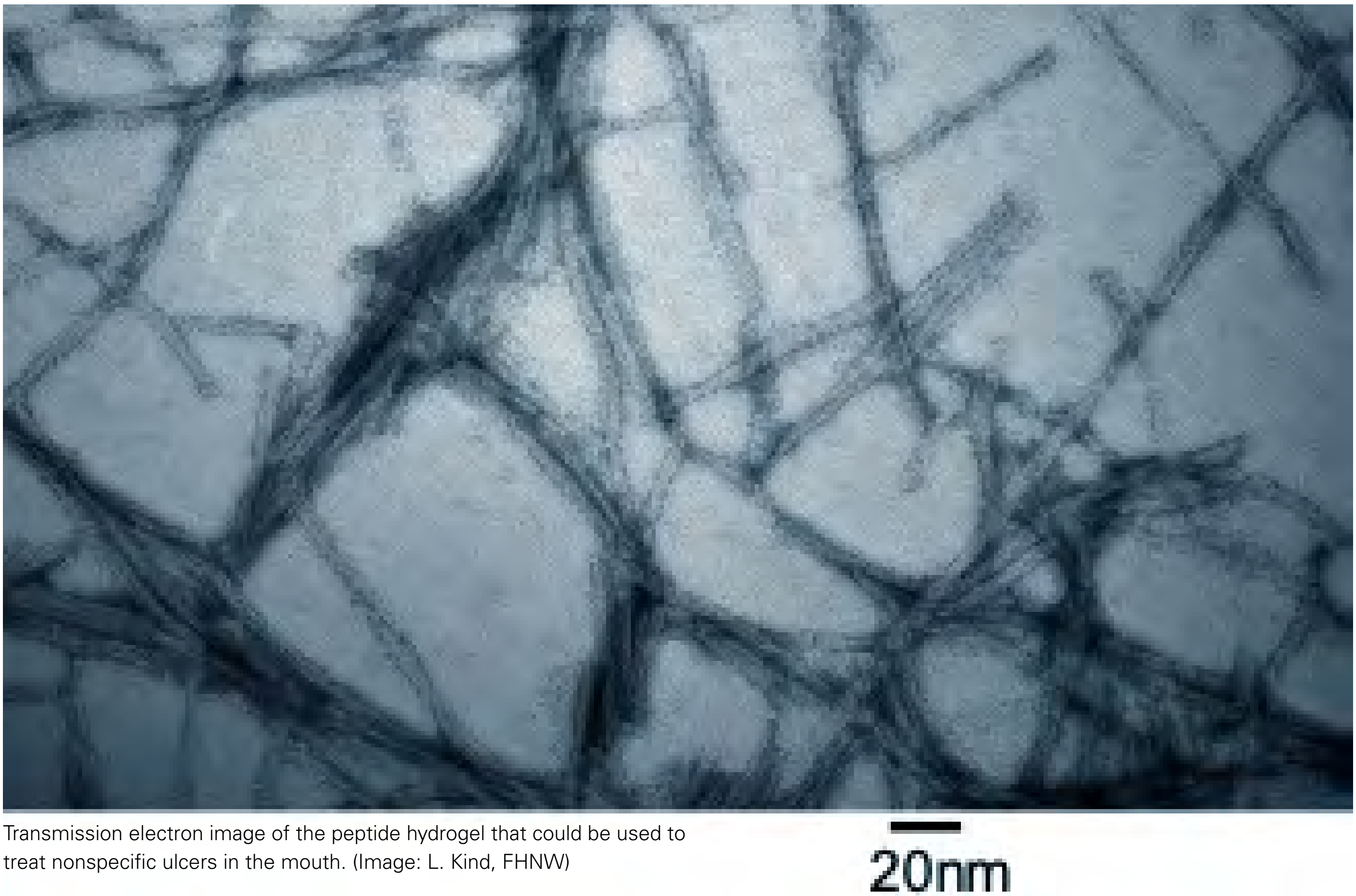
Now, the team of researchers is planning to test a synthetic peptide hydrogel that meets these requirements. The hydrogel in question consists of synthetic, self-assembling peptides that adhere to soft, moist tissue. This fibrous network can be cross-linked by various substances to deliver greater stability.

The technology is already being used for other applications in dentistry, such as the controlled regeneration of enamel, and exhibits excellent compatibility with surrounding tissue.

Building on past experience

As part of the Nano Argovia project PERIONANO, researchers from the SNI network have already studied the use of this hydrogel to treat inflammation around dental implants. Now, the scientists are testing various methods and substances that cross-link and therefore stabilize the hydrogel as part of the new Nano Argovia project entitled Hydrogel-Patch. This work involves examining how the hydrogel adheres to the moist tissue of the mouth and how it can be protected from being washed out. The project team is also investigating topics including biocompatibility and the integration of nanocapsules that release active substances.

In addition to project leader Dr. Lucy Kind, the project includes Professor Falko Schlottig (FHNW), the team of Professor Oliver Germershaus as well as Professor Michael Bornstein from the University Center for Dental Medicine Basel (UZB) and Michael Hug from credentis AG.



Transmission electron image of the peptide hydrogel that could be used to treat nonspecific ulcers in the mouth. (Image: L. Kind, FHNW)

“Over a decade, we have been working successfully with the FHNW. Every credentis product contains a piece of Northwestern Switzerland. In the SNI cooperation with the University of Basel and the FHNW, we would like to go one step further and explore new indications in the oral care field. We expect this to lead to innovative and intelligent regeneration systems in the field of soft tissue management.”

Michael Hug, CTO at credentis AG

Acoustic signal to control laser structuring processes

Additional information

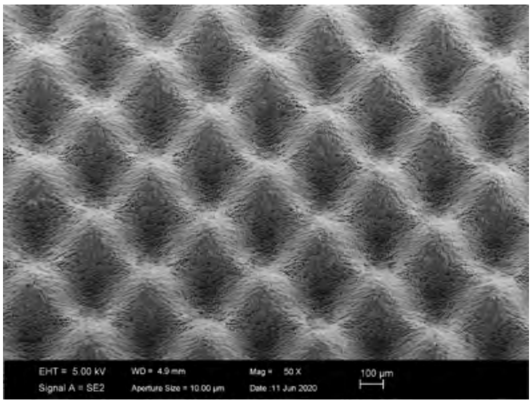
Orvinum AG
https://www.wine-rarities.com

School of Engineering (FHNW)
https://www.fhnw.ch/en/about-fhnw/schools/school-of-engineering

School of Life Sciences (FHNW)
https://www.fhnw.ch/en/about-fhnw/schools/life-sciences

As part of the Nano Argovia project LanakPro, teams from the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) are working with the industrial partner Orvinum AG (Magden) to achieve effective and reliable control of laser nanostructuring processes. The planned instrument will use acoustic signals that provide quick and reliable information on the progress and quality of processing, allowing researchers to control the nanostructuring process.

There is an increasingly wide range of applications for materials whose surfaces exhibit special properties thanks to the presence of miniscule structures. These microstructures and nanostructures are often produced using lasers, but the structuring processes require elaborate monitoring and control. Ideally, there would be an instrument that provided automated process monitoring and independent tracking in order to pave the way for widespread applications in areas such as microfluidics, medical engineering or sensor technology.



Researchers working on the Nano Argovia project LanakPro have a plan to use acoustic signals to control laser structuring processes - here a titanium surface.
(Image: A. Stumpp, Institute of Product and Production Engineering, FHNW)

Recording an acoustic fingerprint

Under the leadership of Armin Stumpp (FHNW), the team behind the Nano Argovia project LanakPro is now using acoustic signals to enable control of the structuring process. To do this, they first record an "acoustic fingerprint" of the optimum structuring process, which can then be compared with the true signal pattern in real time when it comes to measuring a real sample. Thanks to new, fast and robust algorithms and an underlying database, it will then be possible to register deviations immediately, intervene in the process and make the necessary adjustments.


Claudio Furrer is part of the project team.
(Image: A. Stumpp, Institute of Product and Production Engineering, FHNW)

The participating researchers from the teams led by Armin Stumpp, Professor Matthias Hoebel, Claudio Furrer (all of the FHNW School of Engineering), Dr. Frank Dieterle (FHNW School of Life Sciences) and Dr. Markus Ehrat (Orvinum AG) are developing this instrument in order to improve development times and processing costs for laser nanostructuring processes. Their focus is on applications with particularly stringent requirements in terms of processing quality and efficiency, especially those involving materials such as glass or plastics and sensitive substrates such as ceramics.

Multiple steps are required

Over the next few months, the project team will now select suitable sensors, taking care to ensure that they offer a high level of sensitivity in the relevant frequency ranges. The team will then record the acoustic fingerprints for various materials during laser structuring and filter out key signals for the process sequence before carrying out the first laser structuring processes with acoustic monitoring.

Based on this work, the researchers then plan to develop a device that allows even users who lack special training to carry out sophisticated laser processes for various substances quickly and in a reproducible manner.

> "The process monitoring developed as part of this project will have a beneficial impact on the precision, robustness and duration of processing and therefore open up new applications for laser nanostructuring."
>
> **Markus Ehrat, CSO of Orvinum AG**

Hydrogel template for a better integration into soft tissue

In the Nano Argovia project LIGARECO, researchers from the University of Applied Sciences and Arts Northwestern Switzerland (FHNW), the University of Basel and the industrial partner NovoNexile AG are investigating the prophylactic use of a hydrogel template to prevent inflammation around dental implants. The project is led by Dr. Joachim Köser (FHNW) and Dr. Khaled Mukaddam (University of Basel).

Nowadays, the placement of dental implants is an everyday procedure at dental practices, with implants offering numerous advantages for patients. Sooner or later, however, one in four cases is affected by inflammation around the implant (peri-implantitis), which can sometimes even result in the loss of the implant.

Additional information

NovoNexile AG
http://novonexile.com/

School of Life Sciences (FHNW)
https://www.fhnw.ch/en/about-fhnw/schools/life-sciences

University Center for Dental Medicine Basel (UZB)
https://www.uzb.ch

> “The Nano Argovia program is a valuable opportunity to work with two leading regional institutions, in the form of the FHNW and the University of Basel, in order to develop the next generation of functional biomaterials.”

Dr. Stefano Tugulu, founder and director of NovoNexile AG

Lack of integration

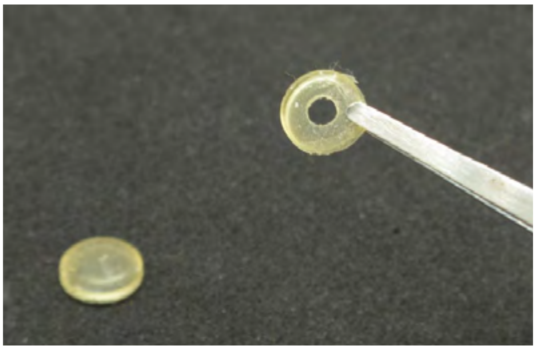
These inflammatory processes can be attributed to a lack of integration of the implant into the surrounding soft tissue. Until now, efforts have focused on anchoring the implant safely and securely into the bone, but it is also necessary to ensure an optimum connection between the soft tissue and the implant.

In the case of a natural tooth, a structure consisting of radial collagen fibers, known as the peridontal ligament, creates a stable connection between the tooth and the surrounding tissue. With implants, these bundles of collagen are sometimes also formed on the soft-tissue side, but they generally have a different orientation than they would with a natural tooth. The bond is mechanically weaker and can allow the entry of inflammatory bacteria.

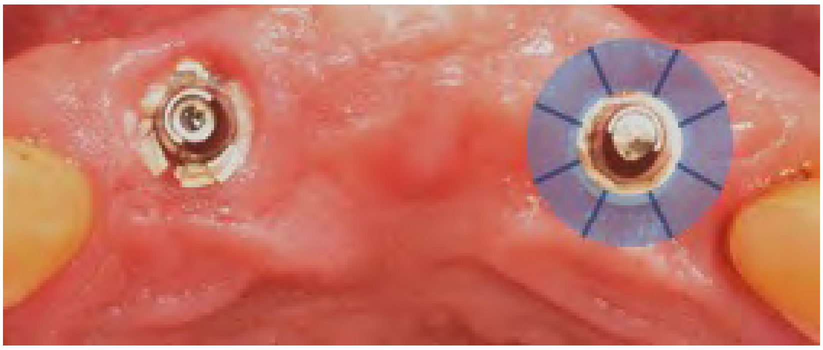
Anchor into the soft tissue

In the Nano Argovia project LIGARECO, the aim is now to develop an absorbable, microstructured hydrogel template that is designed to stimulate the targeted formation of collagen fibers around dental implants. Like with a natural tooth, these fibers are intended to anchor the implant collar into the surrounding soft tissue more effectively in order to form a barrier that prevents the entry of bacteria and therefore protects the implant against bacterial infections.

In addition to the two project leaders – Dr. Joachim Köser (FHNW School of Life Sciences) and Dr. Khaled Mukaddam (University Center for Dental Medicine Basel, UZB) – the project team also includes Professor Sebastian Kühl (UZB) and Dr. Stefano Tugulu from NovoNexile AG (Füllinsdorf, Basel-Landschaft). The researchers are initially investigating the production of the hydrogel template. They will then turn their attention to the functional microstructuring and nanostructuring of the hydrogels, which control the settlement of ligament-forming cells and the formation of the desired fibers.



Hydrogel template (Image: FHNW, NovoNexile)



Jaw with two implants. Left: unguided soft-tissue growth around an implant; right: a diagram of the hydrogel template with growth channels. This template is inserted between the bone and the exposed soft tissue during implantation. (Image: K. Mukaddam, UZB, FHNW)

Nanoscale magnetic field sensor

An interdisciplinary team is cooperating closely to develop a novel magnetic field sensor. The planned sensor will be much smaller than commercially available ones, but will nevertheless be suitable for mass production. Under the coordination of Professor Joris Pascal, researchers from the School of Life Sciences, the School of Engineering and industry partner Camille Bauer Metrawatt AG (Wohlen, AG) will combine known principles in search of a way to produce minute magnetometers with potential applications in a variety of fields, including magnetic cameras, quality control or medical technology.

Additional information

Camille Bauer Metrawatt AG
https://www.gmc-instruments.ch

School of LIfe Sciences (FHNW)
https://www.fhnw.ch/en/about-fhnw/schools/life-sciences

School of Engineering (FHNW)
https://www.fhnw.ch/en/about-fhnw/schools/school-of-engineering

Sensor for magnetic field

A traditional compass is nothing other than a magnetic sensor. The compass needle reacts to the Earth's magnetic field, causing it to point north. Countless other magnetic field sensors are at work in our everyday life – for the most part, without our realizing it. In a modern automobile, for instance, some 70 magnetic field sensors are responsible for ensuring safety, control and comfort. Mobile phones employ microelectronic magnetic sensors that help determine the device's location, while in medical technology magnetic sensors are already used to monitor the activity of pacemakers and drug delivery systems.

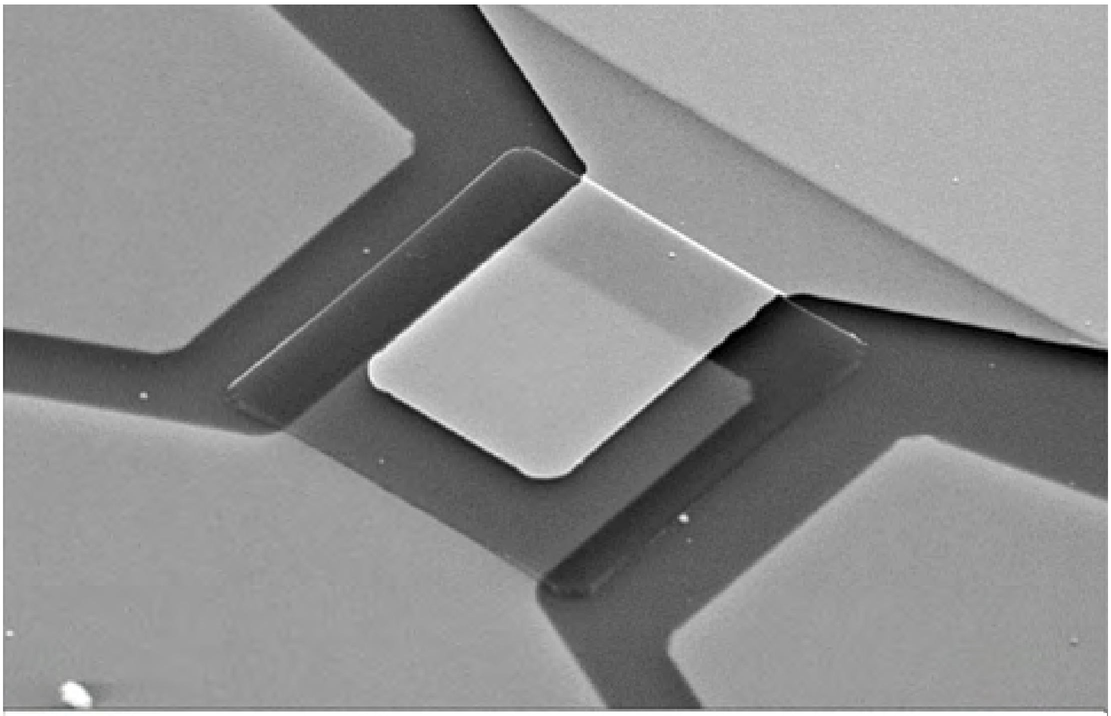
Nanoscale and suitable for mass production

The team working on the Nano Argovia project Nanocompass now hopes to develop the first nanoscale magnetic field sensor that can be produced using a widely available industrial manufacturing process. To this end, the researchers – led by Professor Joris Pascal (FHNW School of Life Sciences), Professor Stefan Gorenflo (FHNW School of Engineering) and Thomas Keusch (Camille Bauer Metrawatt AG) – will combine two well-known principles: The fluxgate principle, which to date has mostly been used in macroscopic sensors, will be implemented on a spintronic component.

The first nanoscale magnetic field sensor will be extremely compact, requiring very little electricity and allowing industrial mass production. This will make it possible to implement a large number of magnetic field sensors, along with their conditioning and processing electronics, on a single chip, enabling a broad range of applications in numerous fields.

"The Nanocompass project opens up new industrial prospects, especially for contactless measurement of electric currents."

Thomas Keusch, Head of Research & Development, Camille Bauer Metrawatt



The minuscule new magnetic field sensor will be suitable for mass production (Image: Spintec/FHNW).

New ultrashort pulse laser source for nano-materials processing

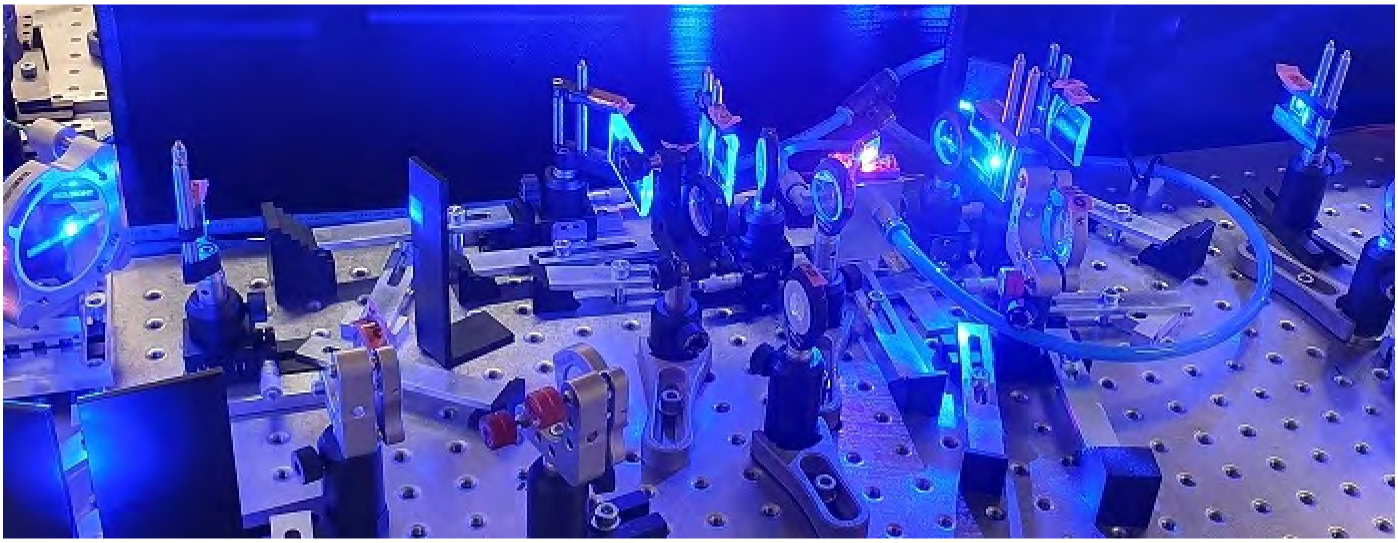
In the Nano Argovia project NanoLase, a team from the School of Engineering (FHNW), the Paul Scherrer Institute and the company TLD Photonics AG (Wettingen, AG) is developing a novel laser source that generates ultrashort pulses. The new device is expected to be more cost-effective, reliable and compact compared with existing laser systems. It will also generate several times shorter pulses compared with current industrial lasers enabling transition from laser micromachining to laser nanomachining. In addition to industrial materials processing, such a laser source would be very beneficial in life sciences and numerous other scientific applications.

Additional information

TLD Photonics
https://tld-photonics.odoo.com/de/

School of Engineering (FHNW)
https://www.fhnw.ch/en/about-fhnw/schools/school-of-engineering

Paul Scherrer Institute
https://www.psi.ch/en



Experimental setup of the femtosecond laser. Blue light is emitted from the new pump diodes. (Image: B. Resan, FHNW)

Different parameters

Today, lasers are used to process a variety of materials. The wavelength, average power, pulse energy and pulse duration of the laser are parameters that must be adapted to the particular material and project and are decisive for the result of the processing. How much the material heats up and degrades the quality of the microstructure, and the amount of material removed by the laser in the process, are determined primarily by the duration of the laser pulse and the irradiance.

If heat generation is to be reduced to a very small zone (heat-affected zone < 1 micrometer) when processing with a laser, pulses of extremely short duration of less than 100 femtoseconds (1 femtosecond = 10^{-15} seconds) are required. Until now, this was only possible using scientific laser setups in the scientific labs and low power. This leads to results that are not reproducible and long processing times that are not acceptable for industrial applications.

Shorter pulses

In the Nano Argovia project NanoLase, the teams of project leader Professor Bojan Resan (FHNW), Dr. Alexandre Trisorio (PSI) together with industry partner Stephan von Wolff (TLD Photonics AG) are pursuing a new approach that allows higher precision processing due to shorter pulses, for polymers and glass with lasers with emission wavelength in the infrared range, and for metals with the laser wavelength converted to the UV region.

The researchers aim to achieve this by developing a laser amplifier made of titanium-doped sapphire with a new single-crystal geometry (SCF). The SCF geometry enables manifold increase in the average laser output power due to higher efficiency cooling. In addition, the scientists will use novel low-cost blue laser diodes with a wavelength of 445 nanometers (mass produced for displays and the car industry) to pump titanium-doped sapphire lasers, which will make the lasers compact, low cost and industrial grade.

The results of this project are expected to address the current lack of compact, low-cost and reliable lasers that produce high power and ultrashort pulses suitable for industrial micro- and nano-machining.

"The NanoLase project is very exciting and promising for TLD Photonics as it helps to develop new technology, as well as to demonstrate its use in materials processing. It will bring the new product line to TLD Photonics, which could represent a breakthrough from laser micro- to laser nano-machining."

Quote Stephan von Wolff, CEO of TLD Photonics AG

Crossing the blood-brain barrier

In the Nano Argovia project NANO-thru-BBB, an interdisciplinary team led by Professor Patrick Shahgaldian (FHNW) is developing a platform to design nanoparticles that can cross the blood-brain barrier (BBB). The project involves researchers from the School of Life Sciences (FHNW), the University of Basel and the industrial partner Perseo Pharma AG (Muttenz).

Additional information

Perseo pharma AG
https://perseo-pharma.com

School of LIfe Sciences (FHNW)
https://www.fhnw.ch/en/about-fhnw/schools/life-sciences

Department of Pharmaceutical Sciences University of Basel
https://pharma.unibas.ch/en/

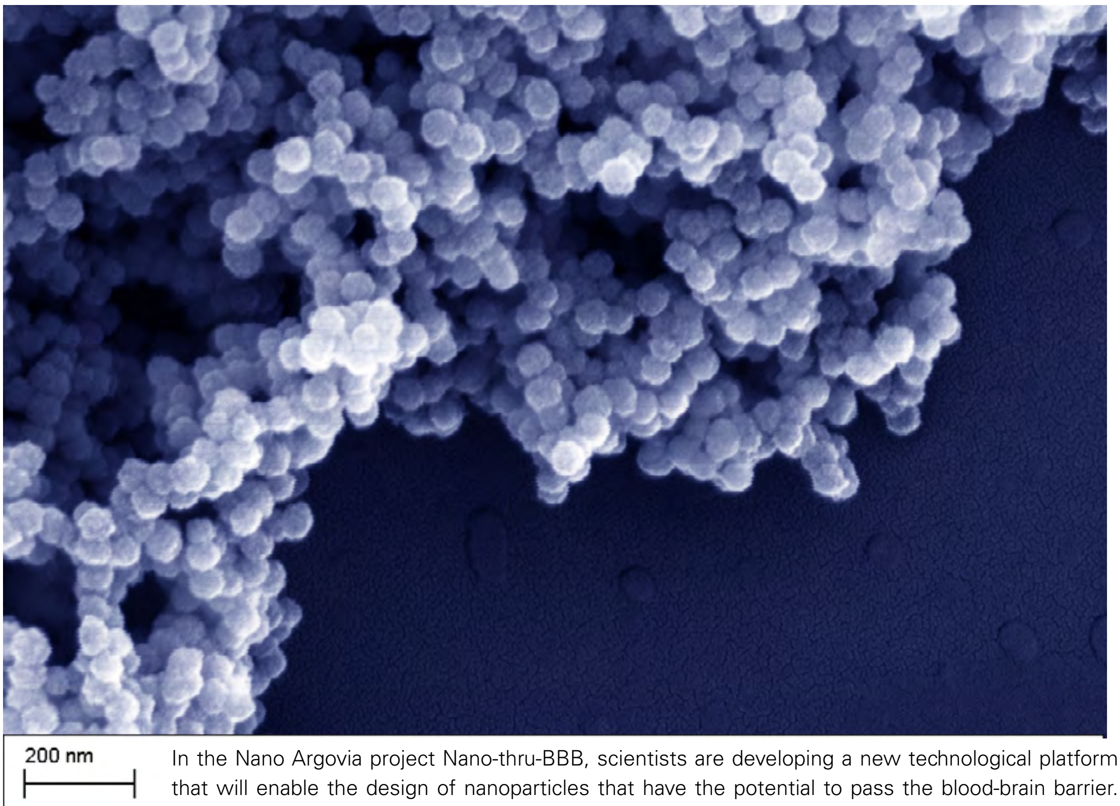
Selective entry

The blood-brain barrier is a complex, selective barrier that protects the brain from harmful substances or pathogens found in the bloodstream. Nutrients needed by the brain enter the brain only through specific, controlled transport processes, while numerous macromolecules are denied entry. Biological therapeutics that could be used to treat neurological diseases in the brain are also generally unable to cross the blood-brain barrier.

However, nanoparticles in which these biological macromolecules are "packaged" can pass the barrier under certain circumstances. To date, however, no study exists that systematically identifies which surface properties the optimal nanotransporters should have.

Interdisciplinary team

The research groups of Professor Patrick Shahgaldian, Professor Laura Suter-Dick (both FHNW), Professor Jörg Huwyler (University of Basel) and Dr. Yves Dudal



In the Nano Argovia project Nano-thru-BBB, scientists are developing a new technological platform that will enable the design of nanoparticles that have the potential to pass the blood-brain barrier. (Image: Perseo pharma) and Dr. Emilie Laprévotte (both Perseo pharma) are now planning to develop a new technological platform that will enable an optimized design of such nanoparticles.

Based on a novel method of combinatorial surface modification, the researchers will study the chemical structure and nanoparticle design and test them on cellular BBB models (*in vitro*) and on zebrafish models (*in vivo*). Supported by computer analyses, the scientists will be able to determine the most appropriate nanoparticle structure that enables passage through the blood-brain barrier.

Specifically, the project aims to introduce enzymes into the brain through the blood-brain barrier that can be used to treat hereditary lysosomal storage diseases. In the long term, the project will provide a solid database to conduct clinical trials with nano-formulated enzymes against these metabolic diseases.

"Approximately thirty enzyme replacement therapies are available on the market for the lifelong treatment of a family of inherited metabolic disorders called lysosomal storage diseases. However, these drugs do not reach the patient's brain. Consequently, the children can experience life but most often grow with very significant mental issues. The possibility to bring these therapeutic enzymes to the brain would represent a major breakthrough for all these patients. Perseo pharma is highly motivated to provide a preclinical proof of concept for this breakthrough and to further develop a new generation of enzyme replacement therapies."

Dr.-Ing. Yves Dudal, CEO of Perseo pharma

Nanocomposite electrodes for clinical diagnostics

An interdisciplinary team of researchers in the Nano Argovia project PEPS are developing a novel diagnostic device for particular biomarkers that is designed for use in point-of-care testing (POCT). Point-of-care testing refers to diagnostic testing methods that do not require a specialized medical laboratory, such as the now familiar Coronavirus rapid tests and blood sugar monitoring for patients with diabetes.

Additional information

MOMM Diagnostics
https://www.mommdiagnostics.com

CSEM
https://www.csem.ch/Home

School of Life Sciences (FHNW)
https://www.fhnw.ch/de/die-fhnw/hochschulen/lifesciences

Several advantages

POC testing not only allows patients to monitor relevant markers independently in their own homes, it also provides medical staff with fast, easily administered tests that lead to safe and more efficient treatments. In areas where staff have limited access to specialized diagnostic facilities, these types of POC tests, which do not require additional technical equipment, have enormous potential to offer.

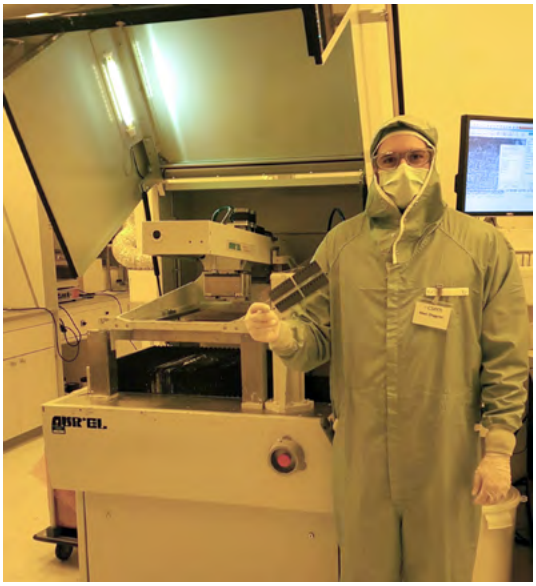
The team, which includes researchers from CSEM Muttenz, the University of Applied Sciences and Arts Northwestern Switzerland, and MOMM Diagnostics (Basel) supervised by Dr. Marc Zinggeler (CSEM Muttenz), is now developing a digital POC device equipped with an electrochemical sensor designed to detect specific protein biomarkers. These biomarkers serve as indicators of different diseases, such as pre-eclampsia, a complication in pregnancy once referred to as "pregnancy poisoning." Young start-up MOMM Diagnostics, founded by former nano science student Dr. Mathias Wipf, specializes in diagnosing this disorder, which poses risks for both mother and child.

Mixture of materials

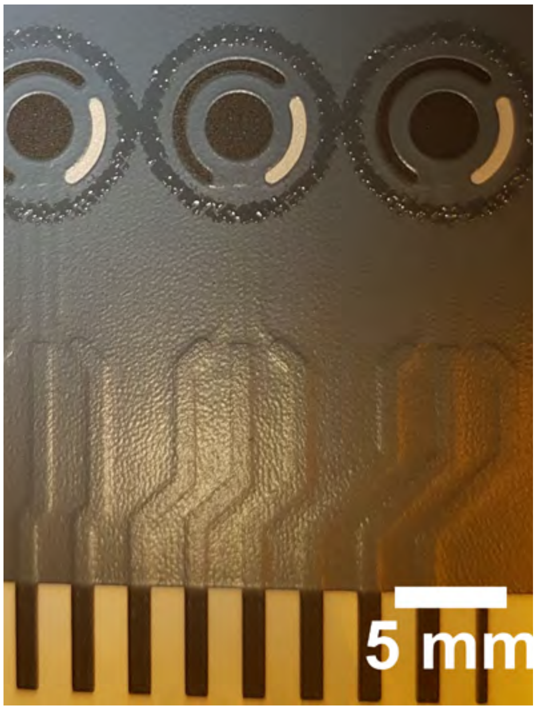
The novel aspect of the approach selected for the PEPS project is the team's plan to use affordably manufactured, conductive nanocomposite electrodes made from a combination of carbon nanotubes and a hydrophilic polymer. This mixture of materials gives the electrodes the outstanding conductivity needed to generate electrochemical readouts during testing. In addition, the material demonstrates remarkable antifouling properties which effectively protect the sensing surfaces from contamination by non-specific adsorption processes in the biological samples (such as blood serum).

Initially, the team will concentrate on refining the nanocomposite electrodes that were produced as part of their preliminary work. Afterwards, they plan to create a platform for demonstrating the analysis of clinically relevant biomarkers. Once they have completed this phase in the first year, the team of scientists plans to integrate a microfluidic platform and finalize their POC test.

Throughout their research, the members of the PEPS team – project leader Dr. Marc Zinggeler and industry partner Dr. Mathias Wipf, Dr. Silvia Generelli (CSEM Landquart), and Prof. Daniel Gygax (FHNW Muttenz) – will be exploring the potential of expanding their sensor manufacturing operation for high volume production so that their platform can be manufactured at industrial scale in the future.



Dr. Marc Zinggeler with printed PEPS electrodes in the CSEM cleanroom in Basel. (Image: CSEM)



Close-up of electrodes (Image: CSEM)

"The PEPS nanocomposite electrodes blend high electrical conductivity with superior antifouling properties. This combination could be the key to producing highly sensitive electrochemical POC tests."

Dr. Mathias Wipf, founder and CEO of MOMM Diagnostics

Do not miss the deadlines!

Various awards at the Swiss NanoConvention 2021!

Swiss Nanotechnology PhD Award
The Swiss Micro- and Nanotechnology Network has announced five prizes for excellent scientific first author publications in the field of nanotechnology and nanoscience published by PhD students in 2020/2021. The prizes are sponsored by Bühler, Hightech Zentrum Aargau, IBM Research Europe, Sensirion, Zeiss and Gloor Instruments.
Deadline: 14 May 2021
Further information

Nanotech Start-up Prize
The Swiss MNT Network will again sponsor a Nanotech Start-up Prize in 2021. Swiss start-ups founded between 2015 and 2020 can participate and will present their company in a special session during the SNC 2021 Online.
Deadline: 31 May 2021
Further information

SNC2021 Image Award
The Swiss MNT Network also sponsors the SNC2021 Nano Image Award, which is open to all SNC participants.
Deadline: 21 May 2021
Further information

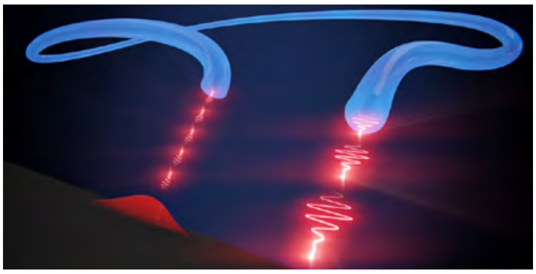
News from the network

Electrically switchable qubit can tune between storage and fast calculation modes

To perform calculations, quantum computers need qubits to act as elementary building blocks that process and store information. Now, physicists have produced a new type of qubit that can be switched from a stable idle mode to a fast calculation mode. The concept would also allow a large number of qubits to be combined into a powerful quantum computer, as researchers from the University of Basel and TU Eindhoven have reported in the journal *Nature Nanotechnology*.

Media release
Publication *Nature Nanotechnology*

Electrically switchable qubit (Image: University of Basel, Department of Physics)



The new single-photon source is based on excitation of a quantum dot (shown as a bulge on the bottom left), which then emits photons. A micro-cavity ensures that the photons are guided into an optical fiber and emerge at its end. (Image: University of Basel, Department of Physics)

Physicists develop record-breaking source for single photons

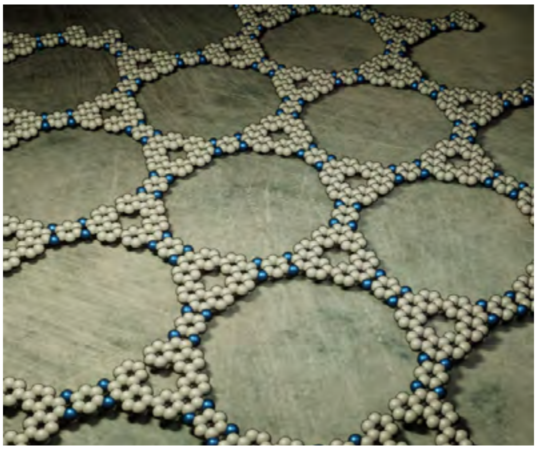
Researchers at the University of Basel and Ruhr University Bochum have developed a source of single photons that can produce billions of these quantum particles per second. With its record-breaking efficiency, the photon source represents a new and powerful building-block for quantum technologies.

Media release
Publication *Nature Nanotechnology*

Kagome graphene promises exciting properties

For the first time, physicists from the University of Basel have produced a graphene compound consisting of carbon atoms and a small number of nitrogen atoms in a regular grid of hexagons and triangles. This honeycomb-structured "kagome lattice" behaves as a semiconductor and may also have unusual electrical properties. In the future, it could potentially be used in electronic sensors or quantum computers.

Media release
Video
Publication *Angewandte Chemie*

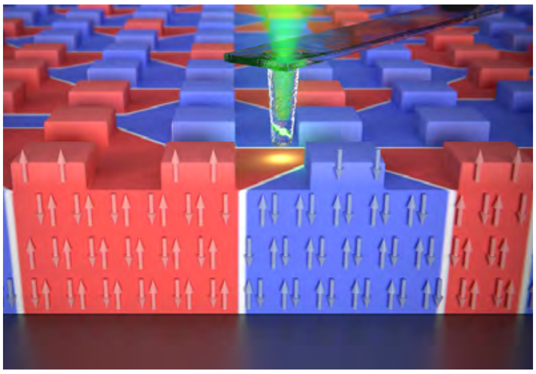


Kagome graphene is characterized by a regular lattice of hexagons and triangles. It behaves as a semiconductor and may also have unusual electrical properties. (Image: R. Pawlak, Department of Physics, University of Basel)

Concept for a new storage medium

Physicists from Switzerland, Germany and Ukraine have proposed an innovative new data storage medium. The technique is based on specific properties of antiferromagnetic materials that had previously resisted experimental examination.

Media release
Video
Publication *Nature Physics*

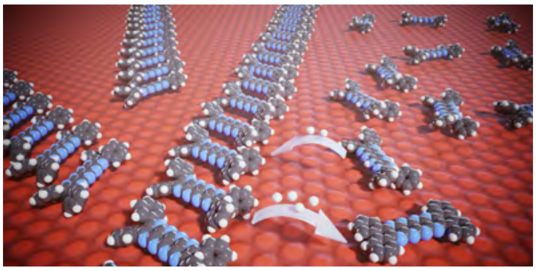


In an antiferromagnetic single crystal, regions with different orientations of the antiferromagnetic order have been created (blue and red regions), separated by a domain wall. Their course can be controlled by structuring the surface. This is the basis for a new storage medium concept (Image: Department of Physics, University of Basel).

New class of substances for redox reactions

An interdisciplinary, multinational research team presents a new class of chemical compounds that can be reversibly oxidized and reduced. The compounds known as 'pyrazinacenes' are simple, stable compounds that consist of a series of connected nitrogen-containing carbon rings. They are suitable for applications in electrochemistry or synthesis, as the researchers describe in the science journal *Communications Chemistry*.

Media release
Video
Publication *Communications Chemistry*

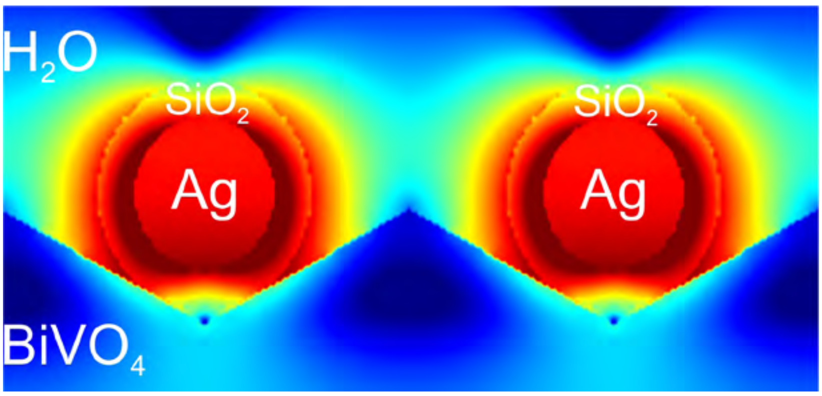


After synthesis, the pyrazinacenes are present in the reduced form. After a first oxidation step, they form chains. In a second oxidation, they are isolated again, but are now completely planar. (Image: Department of Physics, University of Basel)

On the way to sustainable hydrogen

Researchers in the SNI network have developed a theoretical method to analyze and optimize water splitting by exploiting optical effects. The work, published in the *Journal of Physical Chemistry C*, will help to advance sustainable hydrogen production without emitting CO_2.

Publication *Journal of Physical Chemistry C*



Theoretical calculations were used to calculate the light intensity distribution during the splitting of water. A photoelectrode made of bismuth vanadate ($BiVO_4$) structured with silver nanoparticles on its surface was used. The silver nanoparticles help to concentrate more light in the photoelectrode (light blue areas). The silver nanoparticles are surrounded with a silica shell to protect the silver from corrosion in water (Image: L. Driencourt, CSEM Muttenz and Swiss Nanoscience Institute, University of Basel)

Professor Murielle Delley. (Image: Karissa Van Tassel/zvg)

Murielle Delley has been appointed as assistant professor

The chemist Murielle Delley researches the fundamentals and mode of action of catalysts. Now the President's Board of the University of Basel has appointed her as a new assistant professor of chemistry.

Information University of Basel

Sebastian Hiller, professor at the Biozentrum of the University of Basel, and his team clarified the amazing mechanism of action of the antibiotic darobactin. (Image: NFP 72, Nadine Kägi)

Novel antibiotic deceives bacteria through mimicry

Most antibiotics need to penetrate their target bacteria. But Darobactin, a newly discovered compound, is much too large to do so. Nonetheless, it kills many antibiotic-resistant pathogens – by exploiting a tiny weak spot on their surface. Researchers at the University of Basel's Biozentrum have now revealed the amazing mechanism at play and thereby opened the door to developing completely new medicines.

Media release
Publication *Nature*

Tell us your news!

Do you belong to the SNI network and have you published a paper or have other exciting news? Let us know!

Together, we can write a short summary and post it on our social media channels. A media release or the production of a short video may also be worthwhile.

We look forward to a hearing the range of exciting news from our network (c.moeller@unibas.ch).

SNI INSight – Showcasing research and activities at the Swiss Nanoscience Institute
Concept, texts und layout: C. Möller, C. Schönenberger
Translations: S. Regan and team (UNIWORKS, Erlangen, Germany)
Images: C. Möller and mentioned sources

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www.nanoscience.ch