University of Basel

Swiss Nanoscience Institute

SNI
Swiss Nanoscience Institute
Center of Excellence supported by the University of Basel and the Canton of Aargau

SNI INSight

Showcasing research and activities at the Swiss Nanoscience Institute

December 2023

Nobel Prize for quantum dots

Interview with Jonathan de Roo

Honorary SNI member

Markus Dürrenberger on his career history

Back as a professor

Géraldine Guex becomes a new member of the SNI

Valuable experience

The organizing team report on INASCON 2023

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Dear colleagues and nanoenthusiasts,

Another year is drawing to a close – and it has been a turbulent one, with distressing news from various parts of the world along with many positive moments, encounters and innovations. In these uncertain times, it isn't always clear how we will overcome the challenges of today and tomorrow. One thing is certain, however: We will only be able to overcome them by working together.

"Working together" is also one of the guiding principles that we are currently elaborating at the SNI, where collaboration has always taken place across different disciplines and institutions. It's what makes us so special, but it can also be challenging at times. With the strategy paper still unfinished, we're bound to engage in further discussions on the orientation of our network. For me personally, the process of developing a strategy for the next 10 years is undoubtedly a significant way to deepen my identification with the SNI and appreciate the value of the many opportunities that our network has to offer.

In this edition of *SNI INSight*, you too can immerse yourself in the world of the SNI and the nanosciences. We begin with an article on the three scientists who received the Nobel Prize in Chemistry this year. By working with special nanocrystals, the researchers opened the door to numerous applications, some of which are also being explored within the SNI network.

As well as reports on current research projects, *SNI INSight* also includes information on members of the SNI. For example, we've interviewed our new honorary member Markus Dürrenberger, who has made valuable contributions to the SNI as an expert in microscopy and as the retired head of the Nano Imaging Lab. Also new to the SNI is Géraldine Guex, who joins as principal investigator of a PhD School project. Guex was actually part of the SNI many years ago as a nanoscience student. Now, after working in various other roles, she has returned to the University of Basel as an assistant professor.

We also bring you good news in relation to other young scientists. Thomas Mortelmans, a former SNI doctoral student, recently received the PSI-Impuls Award 2023. This prize is awarded every two years for the best application-oriented doctoral dissertation at the PSI. Congratulations!

Furthermore, praise and thanks goes to the students and doctoral students of the nanosciences who organized the INASCON student conference this summer. The guest article in this *SNI INSight* provides an insight into this special conference, which is organized by and for nanoscience students.

This edition also includes much more information on the fascinating topics that we deal with on a daily basis.

Without further ado, I'd like to wish you a relaxed and enjoyable holiday season and a great start to what will hopefully be a healthy, peaceful and prosperous New Year. It's a real pleasure to work with you all. I'd especially like to thank you for your valuable collaboration and so much positive and productive teamwork. I'm already looking forward to our many meetings and discussions in 2024!

Kind regards,

Prof. Martino Poggio, SNI director

Honored for the discovery and synthesis of quantum dots

The Nobel Prize in Chemistry goes to three nanoscientists

This year's Nobel Prize in Chemistry has been awarded to the three nanoscientists Professor Moungi G. Bawendi (MIT, Cambridge, MA, USA), Professor Louis E. Brus (Columbia University, New York, USA) and Dr. Alexei I. Ekimov (Nanocrystals Technology Inc., New York, USA). Their research has paved the way for the application of versatile nanocrystals known as quantum dots – that, like other nanostructures, are subject to the rules of quantum mechanics. We interviewed Professor Jonathan de Roo from the Department of Chemistry at the University of Basel to find out more about these special nanocrystals and about the nanocrystal applications he is exploring in his research.

SNI INSight: What are quantum dots and what's so special about them?

Jonathan de Roo: Quantum dots are colloidal – that is, finely dispersed – semiconductor crystals that measure only a few nanometers in diameter. These tiny particles contain just a few hundred or thousand atoms, and their properties vary depending on their size. One such property is their color when excited by exposure to light – for example, small quantum dots glow blue when excited with UV light, whereas medium-sized quantum dots emit green light, and larger quantum dots emit red light. By varying the size of the particles, it's therefore possible to define the emission wavelength of quantum dots and, accordingly, the energy or frequency of the light they emit.

SNI INSight: How can this phenomenon be explained in simple terms?

Jonathan de Roo: If we expose a quantum dot to light, the electrons in the semiconductor material absorb energy and rise to a higher energy level. When they fall back to their original energy level, they give off electromagnetic waves in the form of light. The color of this light de-

At the SNI's Annual Event, Jonathan de Roo described his work with colloidal nanocrystals.

Further information:

Webpage Nobel Prize
https://www.nobelprize.org

Research group Jonathan de Roo
https://deroo.chemie.unibas.ch/en/

Quantum dots are colloidal — that is, finely dispersed — semiconductor crystals that measure only a few nanometers in diameter. Depending on their size, they have different properties — for example, their color when excited with light. (Image: Stockphoto)

pends on the energy difference between the excited state and the ground state. Although quantum dots can absorb light with a wide range of energies, the color of emitted light then depends on the size of the crystals.

We can think of this as being like an organ, in the sense that a short organ pipe produces a high-pitched sound with a high frequency, whereas a long pipe produces a deep sound with a low frequency. If the crystals of the quantum dots are small, the emitted light is high-frequency and high-energy – and therefore blue. If the crystals are large, on the other hand, the emitted light has a lower frequency and a longer wavelength – and is red in color.

SNI INSight: What exactly did the three Nobel laureates investigate?

Jonathan de Roo: In the early 1980s, Alexei Ekimov studied glasses that contained finely dispersed copper chloride nanocrystals. Ekimov showed that the color of the glasses varied depending on the size of the copper chloride crystals and that this phenomenon was caused by quantum effects. He was able to control the size of the particles to some extent by varying the heating and cooling of the glass.

A few years later, Louis Brus was the first to investigate quantum dots made of cadmium sulfide crystals freely dispersed in fluids. Brus showed that the size of these crystals influenced not only the color of the emitted light but also other chemical and physical properties.

In 1993, Moungi Bawendi successfully applied the "hot injection method" to the chemical production of quantum dots with a homogeneous size for the first time – thereby achieving the fundamental prerequisite for practical applications of quantum dots.

To this end, Bawendi's team injected organometallic cadmium compounds together with organic selenium compounds into a hot solvent that also contained surfactants. The high temperatures caused the organic parts of the organometallic molecules to break down, and the metal ions bonded with the selenium to form cadmium selenide nanocrystals. Meanwhile, the surfactants in the solution ensured that the crystals were finely dispersed. Although the crystals would continue to grow while the temperatures were still high (between 240 and 360°C) and sufficient source material was available, Bawendi repeatedly took samples and stopped the crystallization process within them. By doing so, he obtained a series of liquids each containing quantum dots of a specific size.

SNI INSight: The first chemical synthesis of homogeneous quantum dots was presented 30 years ago. What progress have researchers made since then?

Jonathan de Roo: Back then, the Nobel laureates were working with highly toxic compounds. Today, we can produce quantum dots from starting materials that are much less dangerous. For each new compound used to produce quantum dots, it's necessary to redefine the conditions – even if some aspects of production remain very similar today.

In the last few decades, researchers have massively increased the quantum efficiency of quantum dots. This was initially around 5% — in other words, it took 20 photons of excitement to produce one photon of emitted light. In modern quantum dots, the efficiency stands at almost 100%. In part, this improvement was achieved by encasing the nanocrystals in an inorganic shell — like an onion having different layers.

It is also important to adjust the reaction conditions so that particles reach the target size at the end of the reaction. To obtain small quantum dots, I can obviously take my samples right at the start of the reaction and halt crystal growth — but then I lose most of the reagents. The aim is to choose components and conditions with a view to maximizing yield by making optimum use of the starting materials. This is another area where researchers have made considerable progress.

SNI INSight: What are quantum dots used for?

Jonathan de Roo: Today, quantum dots are used in numerous areas. For example, they are responsible for the brilliant colors in QLED televisions, where blue light is emitted by a gallium nitride light source and then converted into green and red by the various quantum dots. These three primary colors can then be combined to produce the full color palette.

In QLED lamps, quantum dots convert colors more efficiently than is the case with traditional LEDs, although these QLED lamps are not yet commercially available. It is first necessary to improve the stability of the quantum dots because, unlike a TV screen, an LED lamp becomes very hot and can therefore cause the quantum dots to “die off.”

In the future, quantum dots or nanocrystals may also play a key role in medical applications — for example, in order to visualize certain tissues. This is another focal point of our research.

SNI INSight: Does your team also work with quantum dots?

Jonathan de Roo: We don’t work with quantum dots, but we do use non-toxic colloidal nanocrystals made of zirconium and hafnium oxide. These are close relatives of quantum dots and are produced in a similar manner.

SNI INSight: What applications are you exploring for these nanocrystals?

Jonathan de Roo: We want to use the nanocrystals for diagnostic imaging.

In a project with colleagues from Ghent University Hospital (Belgium), we’re investigating whether the crystals can be used to boost soft-tissue contrast in X-ray examinations. By doing so, we hope to pave the way for the clear identification of “sentinel lymph nodes” in breast cancer patients during surgery. To this end, the nanocrystals are injected into the tumor, the liquid containing the nanocrystals flows through the lymph system to the first lymph node in the armpit, and this sentinel lymph node becomes visible in the X-ray image. As the solution carries a dye, the surgeons can then visualize the sentinel lymph nodes for removal during surgery.

In an SNI project, we’re working with colleagues from the PSI in order to use our nanocrystals to spot rejection at an early stage in transplant patients. First, we equip the nanocrystals with certain antibodies that bind specifically to immune cells. Then, if we add our antibody

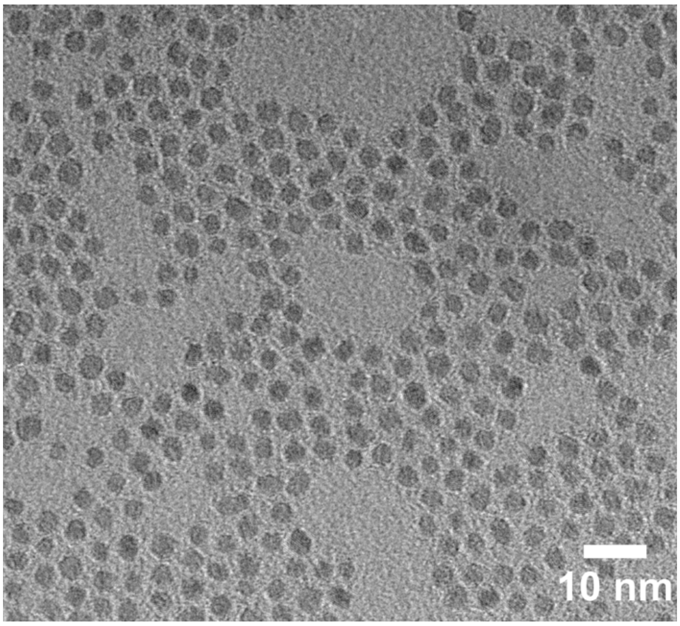
The nanocrystals from the de Roo team can be used to produce detailed images of even the finest blood vessels in the gills of a zebrafish. (Image: Department of Chemistry, University of Basel) nanocrystals to transplanted organ tissue obtained in a biopsy, the antibodies will bind to any immune cells. This allows us to determine whether a large quantity of immune cells are present in the tissue — which would point to the initial stages of rejection.

SNI INSight: What challenges affect the production of nanocrystals?

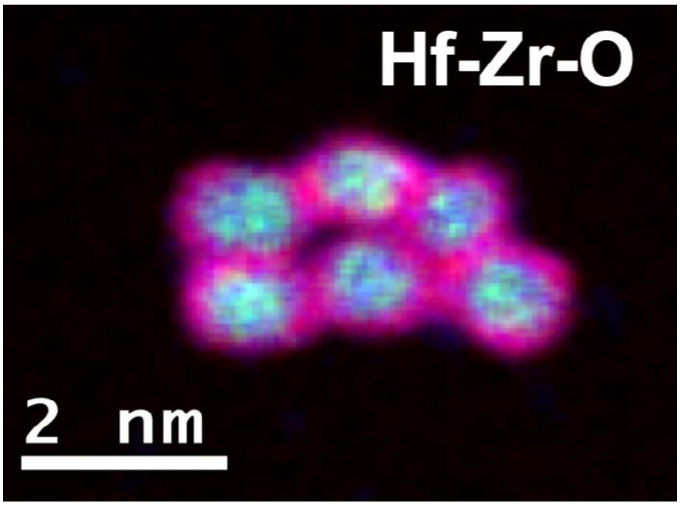
Jonathan de Roo: The oxide nanocrystals that we're investigating are even harder to produce than quantum dots. Zirconium and hafnium carry a multiple positive charge, and their oxides are difficult to produce because they have strong bonds that are not easily broken. At the same time, however, breaking bonds is a prerequisite for repairing defects in the crystals. Once they are produced, the crystals are extremely stable.

We're also studying complex shells of the crystals — which resemble layers of an onion — to further optimizing their properties. On top of that, we're working on producing oxide clusters, which are even smaller than nanocrystals and, above all, atomically precise — unlike the nanocrystals.

In any case, there's plenty of work to do and we still have numerous ideas about how we can provide various colloidal nanocrystals for different applications.



Producing nanocrystals of uniform size is the prerequisite for putting them to use. (Image: Department of Chemistry and Nano Imaging Lab, University of Basel)



Jonathan de Roo's group is investigating hafnium/zirconium oxide nanocrystals (zirconium core and hafnium shell) for use in diagnostic imaging. (Image: Department of Chemistry, University of Basel)

PSI-Impuls Award

Prize awarded to Thomas Mortelmans

The Paul Scherrer Institute (PSI) and the PSI-Impuls Association have presented former SNI doctoral student Dr. Thomas Mortelmans with the PSI-Impuls Award. Mortelmans received the prize, which is presented every two years for the best application-oriented doctoral dissertation at the PSI, for his dissertation on the “Development of a nanofluidic particle size sorter and its biomedical applications.”

Thomas Mortelmans received the PSI-Impuls Award. (Image: PSI)

In his doctoral dissertation, which was funded as an SNI PhD School project, Mortelmans developed a new functional principle for a rapid COVID-19 test that can also be used to detect other viruses such as influenza A or to determine the status of the disease.

Mortelmans carried out his work at the Paul Scherrer Institute in Dr. Yasin Ekinci’s group. In 2022, he previously received the Swiss Nanotechnology PhD Award, which was launched by the Swiss MNT Network and sponsored by Sensirion, for a publication describing the functional principle of the microfluidic test in the journal ACS Applied Nanomaterials.

Mortelmans now works as a device scientist at Johnson & Johnson in Schaffhausen.

> “Our warmest congratulations on this well-earned award!”

Further information:

PSI-Impuls Award
https://www.psi.ch/de/psi-impuls/psi-impuls-preis

Article on Thomas Mortelmans’ PhD dissertation
https://nanoscience.unibas.ch/en/news/details/neues-prinzip-fuer-antikoerpertests-thomas-mortelmans-bekommt-den-von-sensirion-gesponsorten-swiss-nanotechnology-phd-award/

Video on the scientific approach
https://youtu.be/7VKskNZCoMc

Video with Thomas about the SNI PhD School
https://youtu.be/9dqX_vimmcY

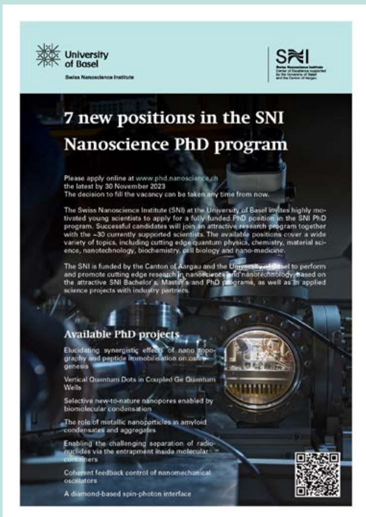
SNI PhD School

Applications still open

Young researchers still have until December 31, 2023, to apply for the projects announced at the SNI PhD School.

Further information:

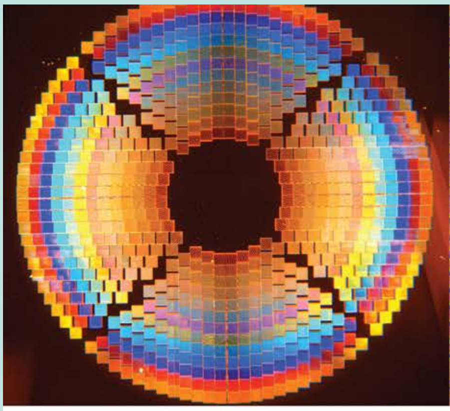
https://nanoscience.unibas.ch/en/forschung/phd-programm/



SNI PhD School
https://nanoscience.unibas.ch/en/forschung/phd-programm/

Nano Image Award 2023

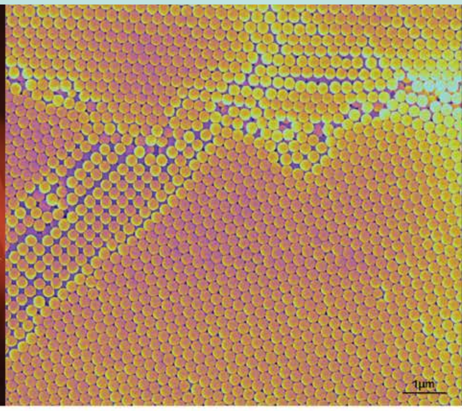
Congratulations to the winners and thanks a lot to all participants!



The harmony of light and X-ray condenser

An X-ray condensing beamshaper, captured under a light microscope. Its intricate geometry diffracts visible light, unveiling a spectrum of radiant colors, where each hue signifies a unique line periodicity. The diameter of the beamshaper is 2 mm, and the thinnest linewidth is 50 nm.
The device was developed for the X-ray microscope operated by the Hereon Research Center, Germany.

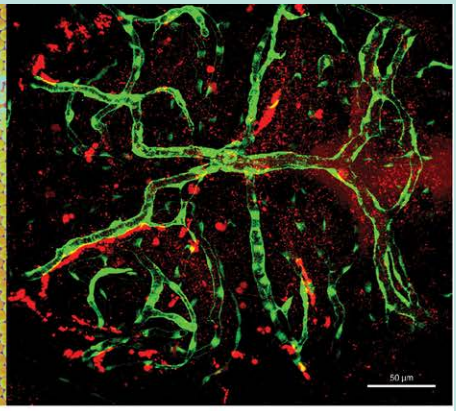
Peng Qi, Joan Vila-Comamala, Di Qu
Paul Scherrer Institute



Microspheres

Microspheres were prepared from styrene via emulsion polymerization by students in the practical training in polymers at FHNW. The spheres are forming hexagonal ordered assemblies when dried on the sample holder. The image was taken with an Electron microscope. The spheres are originally white, the image was colored using Adobe Photoshop.

Vivien Hollenstein, Laura Martinez and Sina Saxer
FHNW School of Life Sciences



Blood-brain barrier

View of the mid-brain region of a zebrafish larva under a confocal microscope, visualizing the green endothelial cells of the vasculature that build up the blood-brain barrier (green). Red fluorescent tracers leaving the green vasculature indicating leakage of the blood-brain barrier in the presence of toxic agents.

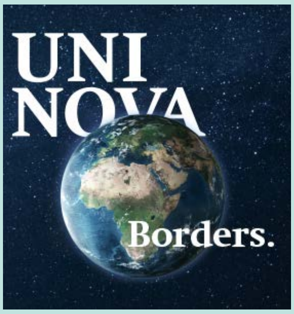
Ramya Deepthi Puligilla
Department of Pharmaceutical Sciences, University of Basel

Series of talks on nanosciences

In collaboration with Volkhochschule beider Basel, the SNI is organizing a series of lectures on the topic of "Nanosciences – interdisciplinary into the future." Using five examples from current research, scientists from the SNI network will demonstrate the potential of the nanosciences.

Further information and registration

Boundaries in the nanosciences



The latest edition of UNI NOVA is all about how borders bind, divide and create obstacles.

We contributed a listicle on boundaries in the nanosciences, of which you can read a longer, slightly more detailed version **here**.

Complete issue of UNI NOVA *Borders*

Passionate about microscopy and technology

Markus Dürrenberger receives honorary membership of the SNI

At this year's Annual Event, Dr. Markus Dürrenberger received honorary SNI membership in recognition of his extraordinary commitment to microscopy and for setting up the Nano Imaging Lab. Dürrenberger is not only an expert in all kinds of microscopes, but also an enthusiastic teacher and an outstanding technician who has brought numerous inventions to the market, as we learn in our interview.

Biology was the right choice

When Markus Dürrenberger's father urged him to study molecular biology at the Biozentrum in Basel, over 40 years ago, the conversation opener at the Dürrenberger household presumably went something like this: "Molecular biology or you can fund yourself!" After completing his Matura (high-school diploma), Dürrenberger had initially started a degree in power engineering but quickly realized that it wasn't the right course for him. It was then that his father was able to help, with his strong sense of where his son's strengths and preferences lay. Even as a child, Markus was always outside playing with his magnifying glass, and at school he was fascinated with natural cycles, microscopes and the life that could be found within a water droplet.

"Luckily, I wasn't given much choice in the matter," laughs Markus. "But then I thoroughly enjoyed studying biology." A particular fascination with viruses led him to research the development cycle of the Escherichia virus T4, a bacteriophage that infects the intestinal bacterium *Escherichia coli* both for his diploma thesis and later doctoral dissertation. As these viruses are only visible under an electron microscope, Markus developed a passion for these complex instruments, which allow detailed imaging of even the smallest and finest structures.

Successful plastic development

In those days, when it came to embedding the infected bacterial cells for examination using electron microscopy, what Markus lacked was an ideal type of plastic that would polymerize and therefore harden in the examination conditions of -100°C under exposure to UV light, allowing him to prepare sections. As part of his work in Professor Eduard Kellenberger's group at the Biozentrum, Markus therefore developed a biocompatible plastic – which was subsequently commercialized by the company Lowi (Germany) under the brand name Lowicryl.

At this year's Annual Event, Markus Dürrenberger (left) was awarded honorary SNI membership by SNI Director Martino Poggio.

"That was a stroke of luck, because we received 5% of Lowicryl's turnover toward our research for a period of 20 years," says Markus Dürrenberger. "Later, at the Maurice E. Müller Institute, we added bone meal to the plastic to develop a bone cement that's still used in implants today. This cement is also found in plastic dental fillings, as we used it to develop various fillings in collaboration with the dental institute later in my career."

Career moves before coming to Basel

These developments took place while Markus was working as a research assistant and head of the Center for Microscopy (ZMB) at the Maurice E. Müller Institute, which was based at the Biozentrum of the University of Basel.

Prior to that, he had already gained some experience in the USA and at the University of Zurich: In 1988, imme-

Further information:

Nano Imaging Lab
https://nanoscience.unibas.ch/en/services/nano-imaging-lab/

Markus Dürrenberger is not only an expert in all kinds of microscopes, but also an enthusiastic teacher and an outstanding technician.

diately after completing his doctoral dissertation, Markus spent a year at the Scripps Research Institute in La Jolla (California, USA) in order to share his experience in the field of plastics processing in microscopy. "I didn't particularly like it there, mostly because of the working environment and conditions, and I quickly applied to the University of Zurich with a view to creating a service department for electron microscopy," Dürrenberger recalls.

Then, after four successful years in Zurich, Professor Ueli Aebi brought Markus Dürrenberger back to Basel in 1993, offering him a position at the Maurice E. Müller Institute in order to set up the Center for Microscopy (ZMB) as a service platform for biological research and analyses. "It was a great time," Markus recalls. "We had just about every kind of microscope that existed back then. The highlight was the world's fastest confocal microscope, operating at 240 frames a second."

Part of the SNI team since 2016
Due to restructuring measures, the ZMB was dissolved in 2016. Markus and part of his team were incorporated into the Swiss Nanoscience Institute (SNI) in the form of the Nano Imaging Lab, where they would devote more of their time to questions relating to materials science.

Since then, the NI Lab has become an important pillar of the SNI. Thanks to the outstanding work of the whole team within the SNI network and beyond, it is now a sought-after partner for all questions relating to imaging and analysis.

Markus worked hard from the outset to renew the NI Lab's infrastructure, making sure it was fit for the future by the time of his retirement in 2023 and providing his successor, Dr. Marcus Wyss, with ideal conditions as he took up his new role. "When I retired in 2023, all of the instruments were under 10 years old. Thanks to an excellent new transmission electron microscope, the NI Lab can fully meet the needs of materials science," he says.

An enthusiastic tinkerer and teacher
In the interview, it quickly becomes clear how passionate Markus is about microscopy and how fascinated he was with the technical aspects of his work. Throughout his career, he was never content simply to apply existing equipment or methods – as soon as he had mastered a machine's operation, he would set about modifying, improving and expanding it.

For example, cooling systems that he developed for the microscopes were subsequently adopted by the manufacturers – and there are also preparation machines that are based on his previous work and innovations. Moreover, he personally built 100 units of a “glow discharger” – a device that uses plasma to make surfaces hydrophilic – and distributed them to colleagues around the world. “I always loved overcoming a technical challenge to make our work easier — and, of course, I always enjoyed excellent support from the mechanical and electrical workshop,” says Markus.

Another of Markus’s passions is teaching. Generations of medical and biology students have completed his three-week microscopy block course and still remember it fondly today. In 2022, he found himself on the operating table at the University Hospital Basel following an accident in the mountains. The operating surgeon smiled at him and said, “I know you,” explaining that he had taken the microscopy block course with him many years ago and still had vivid and positive memories of it.

Still not bored

Even though he is now retired and those tasks fall to someone else, Markus nevertheless remains very active. For the SNI, he does some work with Museum Burghalde in Lenzburg on an hourly basis in order to integrate aspects of the nanosciences into the permanent exhibition. In addition, Markus continues to play an active role in the pension fund of Basel-Stadt and is running as a candidate for its board of directors.

He also has a family as well as various hobbies. His four adult sons and partner of many years, Dominique, are delighted that he can now spend more time with them — in the mountains, for example, or at sea to dive. After all, water — either as snow or in liquid form — is another of his passions, and he was once Swiss champion of the 100 m breaststroke. And anyone who knows anything about Markus Dürrenberger knows that his motorcycle is never in one place for long.

“We would like to thank Markus for his dedication over the years and congratulate him on his honorary membership. We are delighted that he will maintain his links with the SNI network as a member.”

Nano Fabrication Lab
The service unit is growing

In November 2023, two new members of staff joined the team of the Nano Fabrication Lab (NF Lab): Juri Herzog and Xavier Wildermuth will now support Dr. Gerard Gadea and Arnold Lücke in their work. Together, the four-person team will further expand the portfolio of services in the field of nanofabrication.

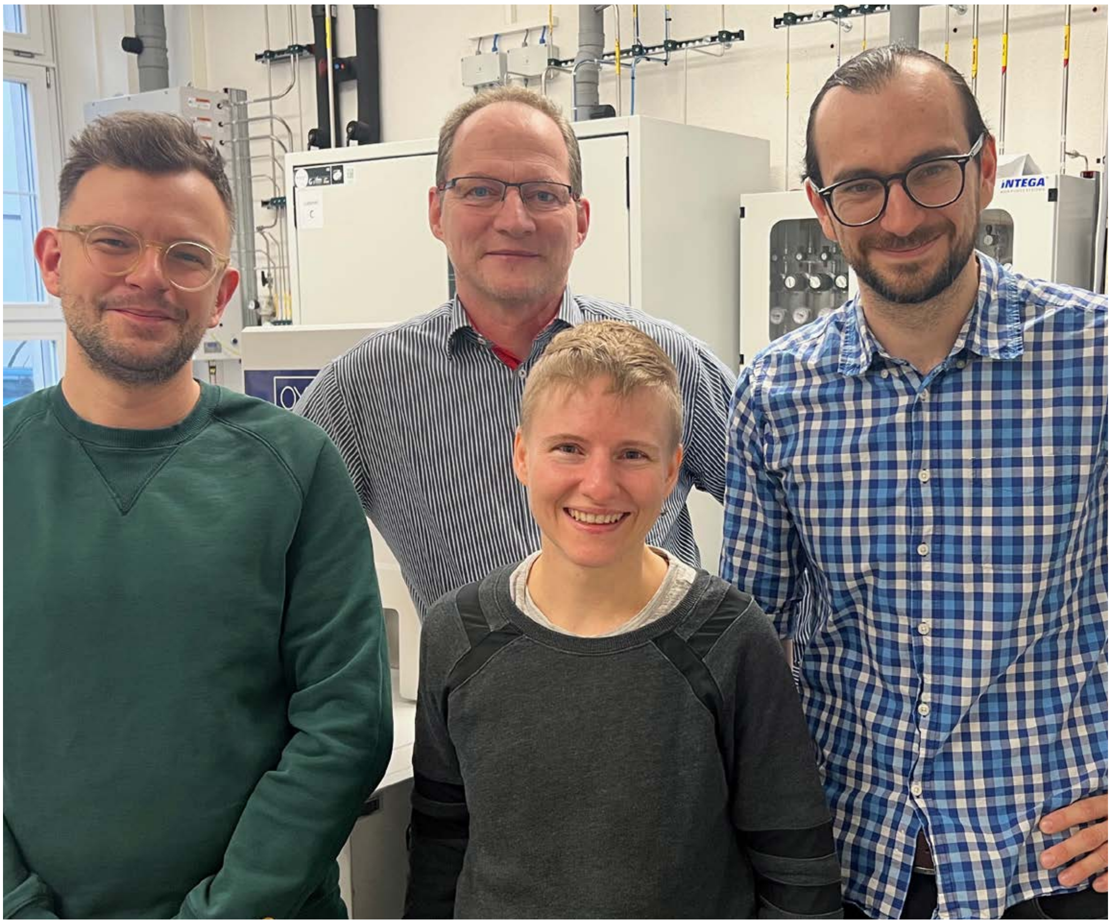
Founded in summer 2022, the NF Lab provides comprehensive nanofabrication services and support to research groups and partners from industry. To strengthen the group and to meet rising demand, additional support will now be on hand for Dr. Gerard Gadea, head of the NF Lab, and Arnold Lücke, who was previously the sole technician.

Juri Herzog and Xavier Wildermuth joined the NF Lab team on November 1, 2023. Both are employed on a part-time basis (60%) and are looking forward to tackling new challenges in the world of nanofabrication.

Herzog initially completed an apprenticeship as a watchmaker before embarking upon a master’s program in micro and nanotechnology while working at Oris. A change to the CSEM followed, where Juri Herzog completed the master’s thesis before working as a technician for nine years. By studying for a Certificate of Advanced Studies (CAS), Juri gained deeper insights into key topics such as

Further information:

Nano Fabrication Lab
https://nanoscience.unibas.ch/en/services/nano-fabrication-lab/



The Nano Fabrication Lab is now supported by a team of four. They're all looking forward to the many new challenges ahead in the field of nanofabrication. From left to right: Xavier Wildermuth, Arnold Lücke, Juri Herzog and Gerard Gadea.

the environment and development, putting this knowledge to use in a temporary role at a major NGO. "I have wide-ranging interests and am delighted at the opportunity to continue learning and taking on new challenges. Beginning a role at the SNI marks another exciting step in my life," says Herzog.

Xavier Wildermuth studied nanosciences in Basel and wrote his master's thesis at Dr. Thomas Braun's lab. For his master's research, he developed part of a modular microfluidic system that can be used to stabilize samples prepared for cryo-electron microscopy.

Wildermuth has broad experience in the field of microscopy and has shown himself capable of mastering new tasks quickly and taking on responsibility – for example, as deputy managing director of an events agency. "I'm delighted to have this opportunity to bring my thirst for knowledge and my open-mindedness to the world of nanofabrication," says Wildermuth on this new challenge.

The Nano Fabrication Lab team works in the clean room at the Department of Physics at the University of Basel.

"We'd like to welcome the two new members of staff to the Nano Fabrication Lab and wish them well in their new roles."

Further information:

Video
https://youtu.be/4nbXd3jKkZ0

Uni News
https://www.unibas.ch/en/News-Events/News/Uni-Info/New-assistant-professor-of-oral-implantology.html

UZB
https://www.uzb.ch/forschung/mitarbeitende-forschung/

Back to her roots

Former nanoscience student Anne Géraldine Guex is returning to Basel as a professor

From 2024, the Straumann Assistant Professor Anne Géraldine Guex will become a member of the SNI network. The unusual thing about this appointment is that Guex was part of the SNI at the time of its founding, when she was a student of the nanosciences. Now, she will be supervising nanoscience students herself and will play an active role in SNI-supported research projects, focusing on research into oral implantology. Thanks to her previous work in areas such as tissue engineering and biomaterials, she is ideally equipped to develop new materials for subsequent use in clinical practice for the benefit of patients.

Since April 2023, Géraldine Guex has been Assistant Professor of Oral Implantology at the University Center of Dental Medicine Basel (UZB).

After completing school in Fribourg, Anne Géraldine Guex initially wanted to study medicine and attended the Bachelor's information day at the University of Basel to find out more about medical studies there. She then realized that medicine lacked a research component and that her gut instinct to study medicine was not exactly correct. With that in mind, she also sought out information about the nanosciences degree program, which was completely new at the time. "The nanoscience stand appealed to me immediately. The people were really nice, and I felt like I was in the right place, because I'd always enjoyed tinkering with things and doing my own research," she recalls.

A good start in the nanosciences

Géraldine therefore enrolled on the nanosciences program in 2003, becoming part of the second-year group of students on this demanding, interdisciplinary course of studies. The program had only been founded in 2002 within what was then the National Center of Competence in Research (NCCR) Nanoscale Science. Looking back, she particularly valued the sense of team spirit and mutual support. “We used to meet for a ‘constructive cake session,’” she says. “This was a way of combining exercises relating to the lectures with something fun.” The relatively relaxed relationship with the professors is also something that she still remembers fondly. “Although everything was new, and a bit chaotic at times, we were accepted and integrated wherever we went and also enjoyed a great deal of freedom.”

A focus on chemistry and biology

From the outset, she was primarily interested in questions relating to chemistry and biology. With that in mind, she completed her master’s thesis on tissue engineering in the group led by Professor Ivan Martin, head of the Department of Biomedicine at the University of Basel. Since then, she hasn’t lost her interest in – or fascination with – the production of artificial tissue.

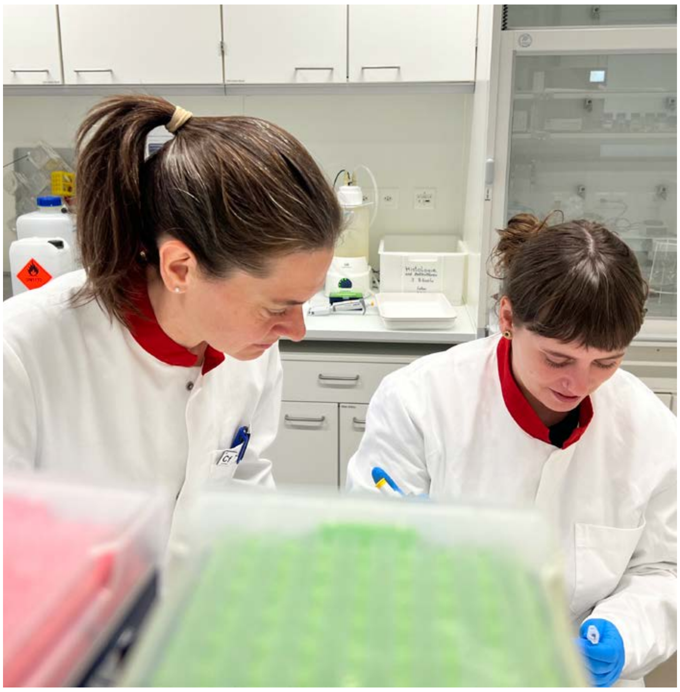
Whereas her master’s thesis explored methods for culturing cartilage in the laboratory, her subsequent doctoral dissertation at the University of Bern focused on muscle cells. “We developed a matrix that was suitable for using mesenchymal stem cells originating from the bone marrow as an implant following a heart attack,” says Géraldine. She continued this research for another year as a postdoc at the Swiss Federal Laboratories for Materials Science and Technology (Empa) and then spent two years studying conductive polymers for bone tissue engineering at Imperial College London as part of an SNSF Swiss Postdoctoral Fellowship.

> “I learned to communicate with experts from very different disciplines and to respect and benefit from different ideas.”
>
> **Prof. Géraldine Guex**
> **University Center of Dental Medicine Basel (UZB)**

Various methods for better healing

After two years in London, Géraldine returned to Empa to research antibacterial wound dressings. There, her investigations focused on various peptides and gallium complexes as potential active substances for tackling bacterial infections. In collaboration with the Laboratory of Organic Electronics at Linköping University, she also evaluated a controlled proton pump that can be used to precisely regulate the pH value in wounds and thus to achieve an ideal, slightly acidic environment for wound healing.

For Géraldine, this was followed by three years as a research scientist at the AO Research Institute in Davos, where she worked with the start-up mimiX and investigated how acoustic waves influence the three-dimensional



Supervising students from different disciplines is one of Géraldine Guex’s core tasks.

orientation of cells within a hydrogel. In another area of research, Géraldine looked at the mechanical simulation of certain cells in the immune system (macrophages) and stem cells from the bone marrow. This work primarily entailed using *in vitro* models to examine how exercise affects the healing process following a bone fracture, for example.

Returning to Basel as an endowed professor

Despite choosing to study the nanosciences instead of medicine, Géraldine has subsequently turned her attention to medical topics over the course of her career. Accordingly, the obvious next step was to continue in this vein. In 2022, she therefore applied to the University of Basel for an assistant professorship in oral implantology sponsored by the Basel entrepreneur and honorary doctor Thomas Straumann. She ultimately prevailed over her competitors and took up the professorship at the University Center for Dental Medicine Basel (UZB) in April 2023.

“Basel is, of course, very attractive as a city – and biomaterials and tissue engineering are subject areas that I’ve been working on for years. Although I had no previous links with dental medicine, I’m very familiar with organic and inorganic materials and the biological principles needed for the projects,” says Géraldine Guex.

Setting up a group

Géraldine is currently supervising a master’s student and two doctoral students from the field of dental medicine, but the group will continue to grow. For example, she is now in a position to take on a doctoral student, a biology lab technician and a postdoc. With this team, Géraldine hopes to develop complex, three-dimensional *in vitro* models consisting of bone tissue in the lower section and soft tissue in the upper section, for example. Models of this kind would allow researchers to investigate how a dental, bone or tissue implant interacts with the body and help to improve our understanding of wound healing processes. They would also make it easier to optimize the surface properties of dental implants using micro and nanofabrication.

With the help of her group, Géraldine is also planning to investigate personalized treatment methods in relation to oral implants. “The methods used in oral implantology today are primarily optimized for healthy patients,” she explains. “If someone with diabetes and impaired wound healing receives an implant, however, standard measures often fail to deliver the desired results.” In this regard, tissue cultured from the patient’s own stem cells, for example, could potentially compensate for the deficits in the body’s own wound healing processes and significantly improve the implant’s chances of long-term success.

Together with Professor Michael Nash of the Department of Chemistry, Géraldine will be supervising a doctoral dissertation at the SNI PhD School from 2024 onward. This research aims to investigate how the formation of bone cells is affected by synergistic effects of nanosurfaces and peptides immobilized on polymer substrates. “We want to understand the influence of surface structure on protein or peptide absorption and how a specific interface affects the differentiation of bone-forming stem cells. The project is also primarily about exploring the interactions between materials and cells using new methods, and about understanding these interactions on the molecular level,” explains Géraldine.

Géraldine Guex is looking forward to the two SNI-funded projects that she will participate in starting in 2024.

“The project is primarily about exploring the interactions between materials and cells using new methods, and about understanding these interactions on the molecular level.”

Prof. Géraldine Guex
University Center of Dental Medicine Basel (UZB).

Together with UZB colleague PD Dr. Nadja Rohr, Géraldine is also participating in a Nano-Argovia project from 2024 onward. Working with project partners from the FHNW School of Life Sciences and the Straumann Institute, the scientists are investigating how to create the optimum surface of zirconia dental implants for effective healing.

Interdisciplinary education pays off

Géraldine is looking forward to the work that lies ahead and to collaborating with researchers from wide-ranging disciplines. It helps that she has already been “immersed in an interdisciplinary environment” during her degree. “I learned to communicate with experts from very different disciplines and to respect and benefit from different ideas,” she explains.

Géraldine left Basel with a master’s degree in nanosciences in 2008 and has now returned as a professor. She says she would choose to study “nano” again today, as it has allowed her to realize her childhood dream: carrying out research into medical issues.

“We’re delighted to welcome her to our network as a project leader, and we look forward to her participation in exciting SNI projects.”

Projects as part of the Quantum Transitional Call
Participation by SNI members

The second half of 2023 saw the launch of four quantum research projects with the participation of SNI members. These projects had been announced as part of the Quantum Transitional Call by the Swiss National Science Foundation (SNSF). For researchers from the Department of Physics at the University of Basel, the support will allow them to continue with their various lines of research, which were previously part-supported by EU funding programs. Although the funding is no substitute for participation in the European programs, it goes some way toward mitigating the impact of exclusion for Swiss research groups.

On the road to quantum networks
Numerous research groups worldwide are investigating quantum networks with a view to the wide-ranging applications they promise, such as the interlinking of quantum computers or quantum sensors, secure quantum communication, or the investigation of many-particle systems. The construction of complex quantum networks, however, represents a major technological challenge that is yet to be overcome.

Combined expertise
A powerful platform for such quantum networks is being developed by researchers led by Basel professors Philipp Treutlein and Richard Warburton together with colleagues from the Swiss Center for Electronics and Microtechnology (CSEM) in Neuchâtel.

The researchers are using a platform that appears to offer feasible upscaling from a technological perspective. For each node point in the network, the platform allows researchers to combine a source of single photons, which transport information, with a single-photon memory. The photons are placed in a quantum mechanical superposition state, with one part being stored in the memory while the other part relays quantum information to the next node points, in order to generate entanglement within the network.

Quantum dots and atomic vapor cells
Richard Warburton's group has already shown that semiconductor quantum dots can emit single photons at a high rate and with excellent spectral purity. In the SQnet project launched in September 2023, the researchers will now use novel quantum dots that emit photons of a specific wavelength that is compatible with rubidium atoms. For the quantum memory, the researchers are using atomic vapor cells developed by the Treutlein team. "These are glass bulbs filled with rubidium gas that, unlike other quantum memories, also work at room temperature and don't need to be intensely cooled in a cryostat. This is vital when it comes to upscaling the technology for a complex network," explains Treutlein.

The researchers have already performed a proof-of-principle demonstration with a quantum memory, but they will need to miniaturize the technology in order to build a more complex network. The glass cylinders used so far are a few centimeters in size and are individually produced by a glassblower. Thanks to the expertise of CSEM colleagues in miniaturization, nanofabrication and nanophotonics, it will be possible to produce quantum memories of a significantly smaller size and to automate the production process.

Background information

Within the international research program known as Horizon Europe, Switzerland is currently classed as a non-associated third country, meaning that researchers from Swiss research institutions have been excluded from many EU research programs. Switzerland's State Secretariat for Education, Research and Innovation has therefore mandated the Swiss National Science Foundation to develop a transitional solution, leading to the announcement of the Quantum Transitional Call in 2022 with a view to allowing researchers involved in quantum research programs under Horizon Europe to continue pursuing their research projects. Five SNI members from the Department of Physics at the University of Basel are involved in successful projects that began in the second half of 2023 and are set to receive funding over a period of four years.

Further information:

Interview with the successful professors from the University of Basel:
https://www.unibas.ch/de/Universitaet/Administration-Services/Vizerektorat-Forschung/Grants-Office/Grants-Office-News/Grants-Office-Newsletter-2023-7/Quantum.html

Research group Philipp Treutlein
https://atom.physik.unibas.ch/en/research/

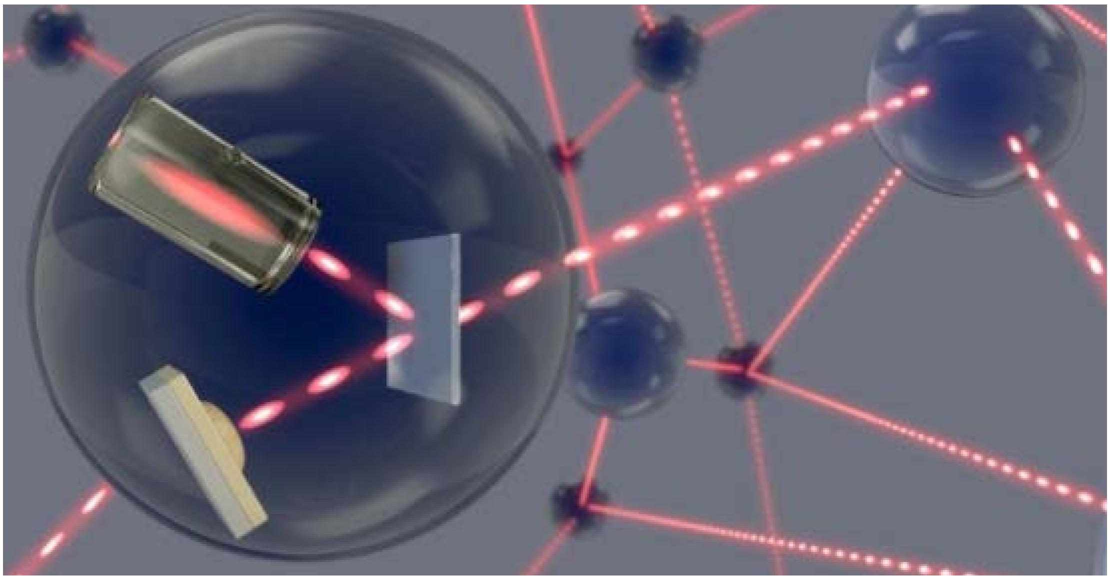
Research group Richard Warburton
https://nano-photonics.unibas.ch

Contribution *Physics World*
https://physicsworld.com/a/rubidium-vapour-makes-a-good-quantum-memory/

Research group Martino Poggio
https://poggiolab.unibas.ch

Research group Patrick Maletinsky
https://quantum-sensing.physik.unibas.ch/en/

Research group Andrea Hofmann
https://hofmannlab.physik.unibas.ch/en/


At each node point in the quantum network, the aim is to link a photon source with a quantum memory. The information is then transmitted using entangled photons. (Image: Department of Physics, University of Basel)

"Our partners at CSEM have managed to produce 700 of these vapor cells on a wafer," says Treutlein. "We can use these tiny quantum memories to make the individual nodes of the network significantly smaller, so that we can potentially build larger networks. It may also be possible to equip individual nodes with multiple vapor cells and thus to increase the processed data volume – but there's a lot of research to do before we reach that stage." Two doctoral students and one postdoc will push ahead with this work at the Department of Physics.

Wavelength adjustment

Another challenge facing the researchers are the glass fibers that connect the nodes. Transmitting data over large distances will require the wavelength of the photons to be within the range used by existing telecoms fiber – which is not the case for the spectral lines studied so far. In the scalable system, the researchers must therefore incorporate a photonic chip that allows them to convert the wavelength. This then combines the red photons of the existing system with an infrared pump laser so that they generate photons suitable for telecom networks. Every single photon is converted into exactly one photon of the required wavelength.

Sensors for superconducting quantum bits

For Professor Martino Poggio's group, the funding received will allow the continuation of research in the field of quantum sensors for superconducting quantum bits. Starting in December 2023, two PhD students and one postdoc will advance the Poggio Lab's promising research into scanning probe microscope imaging.

The researchers will study superconducting qubits – as these are being used as a promising platform for realizing a quantum computer by large companies such as Google and IBM. Working designs with tens to hundreds of qubits already exist, but the much larger numbers needed for a working quantum computer require a better understanding of defects and vulnerabilities – in terms of both the material and the design of the superconducting circuits.

Tracking down defects

The superconducting qubits studied by the Poggio team are largely fabricated by colleagues at ETH Zurich from thin layers of aluminum and niobium or tantalum. The Poggio group uses highly sensitive scanning probe imaging with superconducting quantum interference devices (SQUIDs) at the probe's tip to identify, localize and ultimately contribute to solving problems that arise when the number of qubits is scaled up.

Currently, researchers from the Department of Physics study the qubits in a cryostat at 300 millikelvin. "With the help of the SuperSQUID project, we will be able to upgrade our cooling system so that we can cool them down to temperatures of 10 millikelvin," reports Dr. Floris Braakman, who is responsible for the project in the Poggio team.

"The superconducting qubits normally operate at these low temperatures. So, it's important for us to be able to work with our scanning SQUID microscope in these conditions." In addition, the researchers plan to implement a high-speed microscope that can capture rapid changes.

Over the next four years, the researchers will use these methods to create spatial maps of material defects and to map magnetic fields as well as current flow and losses in the superconducting circuits. The data will help to better understand the mechanisms for the loss of quantum properties, known as decoherence, and to provide recommendations for improved circuit design and the quantum bit fabrication process.

Rotation and temperature measurements using diamonds

In recent years, tiny diamonds with defects known as nitrogen-vacancy centers have become an established tool for the development of powerful, highly sensitive quantum sensors for electric and magnetic fields. Accurate temperature measurements can be obtained via the spin of individual electrons orbiting within the vacancy centers, while rotation can be measured by analyzing the angular momentum of the atomic nuclei.

In the ensQsens project, researchers from the University of Basel, the Swiss Center for Electronics and Microtechnology (CSEM) in Neuchâtel and the Laboratoire des Sciences des Procédés et des Matériaux (CNRS) will develop quantum thermometers and rotation sensors of this kind. The researchers will also initiate the miniaturization and integration of these sensors into housings on the centimeter scale. Launched in October 2023, the project will further promote the applicability and distribution of quantum sensors.

The research will be carried out by two doctoral students and one postdoc in the group working under principal investigator Professor Patrick Maletinsky from the Department of Physics. Teaming up with CSEM and the CNRS, the researchers will pursue the use of ensembles of nitrogen-vacancy centers (NV centers) as sensors in complementary lines of research. On the one hand, they are using nuclear spin ensembles in diamonds to develop a novel rotation measurement device that could be used in portable navigation systems and could operate more accurately and more robustly than existing rotation sensors. On the other hand, their research aims to produce a tiny thermometer based on electron spin ensembles. This could have applications in areas such as electronics.

Use of electron and nuclear spins

The researchers believe that the spins in diamonds are particularly promising, for they operate at room temperature and have already proven themselves to be robust sensors. Each of the NV centers contains six orbiting electrons, whose intrinsic angular momenta (spins) react very sensitively to electric and magnetic fields in their environment, and which together behave like a tiny magnet. The electrons are excited and then emit individual photons, which deliver information about the spin state and therefore about the electric and magnetic fields.

For the envisaged temperature measurements, the researchers are planning to use probes featuring a conical diamond tip with a diameter of only around 10 nanometers at the point and numerous NV centers at the base. Since diamond is an excellent conductor of heat, the temperature "felt" by the tiny tip influences the interactions between electrons of the NV centers. The individual NV centers are not particularly affected by these interactions – which is what makes them so robust in other applications. If numerous NV centers are combined, however, the thermal expansion of the diamond crystal can be used for temperature determination. Using the planned setup, the researchers expect to achieve a spatial resolution of some 10 to 20 nm.

Electron spins offer only limited suitability for the accurate detection of rotation. This is because they respond too sensitively to magnetic fields, whereas the spins of atomic nuclei (nuclear spins) are much better suited to this application. Not only are these spins less sensitive to external magnetic fields, but they can also be addressed optically – as Maletinsky's group was able to demonstrate for the first time last year. With that in mind, the group is working with the project partners to explore the use of diamond nuclear spins as rotation sensors in another subarea of the project. The aim is to integrate these sensors into a compact housing in collaboration with the project partners at CSEM. In the future, this may lead to applications in the navigation and stabilization of self-driving vehicles or drones.

Qubits made of graphene

Professor Andrea Hofmann was a successful co-applicant in the GraQuaDotQb project. Led by Professor Thomas Ihn (ETH Zurich), this project will see Hofmann and her group investigate how quantum dots can be formed in coupled graphene layers. In collaboration with the researchers from ETH Zurich, Hofmann's team will then study these bilayer graphene quantum dots as substrates for spin, valley or spin-valley qubits.

Currently, however, Andrea Hofmann is immersed in an even more exciting project, having become a mother in mid-October. Our congratulations and best wishes to her and her family!

Guest article Alexa Dani

Looking back on INASCON 2023

A “journey” organized by students

The journey of the International Nanoscience Student Conference (INASCON) began in Silkeborg, Denmark, in 2007 with a visionary idea: a conference organized by students for students. Since then, the meeting has traversed eight countries and attracted bachelor’s, master’s and PhD students from across Europe and beyond. This year, Basel hosted the conference for the third time from 22 to 25 August.

Global collaboration

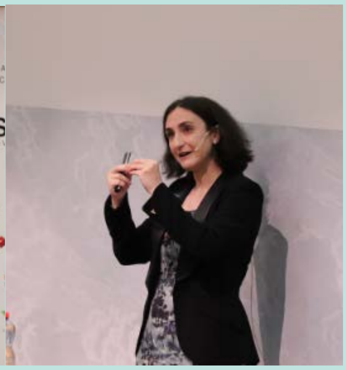
Putting the “international” in INASCON, the event in Basel in August 2023 brought together over 60 participants from 26 universities in 15 countries. Thanks to generous support from our sponsors, INASCON was able to welcome not only doctoral candidates but also students, as well as numerous guests. It was very important to us that, thanks to financial support, all visitors were able to attend. Over three quarters of participants stayed at Hotel Odelya and made contacts extending well beyond the conference program.

The diverse group of participants in INASCON 2023 thoroughly enjoyed their time in Basel. (Image: Peter Dani)

Our program

Under the motto “Make Nano Visible,” this year’s program culminated with fascinating talks by well-known scientists: Anne Géraldine Guex, Sabina Caneva and Patrick Shahgaldian shared their specialist knowledge and highlighted the importance of interdisciplinary approaches in the biosciences. James Wootton from IBM Research Europe – Zurich brought a spot of humor to the conference with his talk on quantum error correction. In another highlight of INASCON, Clarice Aiello gave a public talk on quantum biology, captivating over 170 science enthusiasts and triggering the longest Q&A session of the conference. We were also privileged to welcome two Nobel laureates among our guests: Kurt Wüthrich, who provided some insights into 60 years of research in the field of protein NMR, and Morten Meldal, who explained his groundbreaking work in the area of click chemistry and offered us an insight into the Nobel Prize award ceremony.

Professor Morten Meldal at his talk “Molecular Click Adventures — A Leap from the Shoulders of Giants.” (Image: Tania Beringer)


Professor Clarice Aiello at her public talk on the subject of quantum biology. She explained how nature uses quantum processes to achieve optimum operation and how we can control these processes for therapeutic benefit. (Image: Tania Beringer)

> “Last week, I had the great pleasure of speaking before brilliant young minds at INASCON in Basel.”

Professor Morten Meldal

The SNI-sponsored "Wickelfisch" waterproof swim bag was a prized goody for Basel's hot summer days and — with its bright red color — has been spotted in the Rhine repeatedly since the conference.

Another item on the agenda was the Enterprise Fair, which offered participants an opportunity to make contact with leading industry experts from various sectors of the nanosciences. The event served as a bridge between aspiring talents and the organizations shaping the nanosciences of the future. (Image: Tania Beringer)

Our culinary offerings were just as varied as the scientific discussions. From pizza to Mediterranean delicacies, there was something to suit all tastes – and gastronomic highlights included the surprise gelato break from Gelateria di Berna and our conference dinner at the Teufelhof hotel.

On the lab tours, participants had the chance to get to know various research groups in the fields of physics, chemistry and biology from the University of Basel and the University of Applied Sciences Northwestern Switzerland (FHNW) in Muttenz. There was also an opportunity for everyone to discover the city of Basel on a Foxtrail tour, as part of a visit to Museum Tinguely or under their own steam – equipped with their waterproof swim bags.

Our motto "Make Nano Visible" was well received by bachelor's, master's and PhD students from across all disciplines, who presented their innovative research projects in fascinating talks and at an informative poster session. The prize for the best poster went to Fabian Scheidler from the University of Würzburg, and the prize for the best talk to Amir Nazemi from FHNW Muttenz. These two outstanding contributions were rewarded with cameras from our sponsor Nikon!

United in diversity

INASCON 2023 brought together brilliant minds from different areas of research, universities and cultures, not only yielding new ideas and opportunities for semesters abroad but also opening up potential career pathways and collaborations. With their different origins and goals, all participants played a part in making nano more visible.

INASCON 2024: Assembling the Future

We're now eagerly awaiting the next installment of INASCON, which will be held at the University of Twente in Enschede, Netherlands. Under the motto "Assembling the Future," INASCON 2024 promises to be another extraordinary milestone in research and innovation.

The organizing team in Basel: Elaine Schneider, Lukas Schneider, Timon Flathmann, Alexa Dani, Luca Forrer, Rahel Kaiser, Mathias Claus and Valerie Bendel.

> "For the organizing committee, the process of planning INASCON over a period of almost 12 months presented us with repeated hurdles. With some stamina, creativity and support from the SNI, we were able to overcome these hurdles as a team and learned a great deal in the process. We're delighted that INASCON 2023 in Basel proved to be an educational and exciting experience for all!"

Organizing team of the INASCON 2023

Further information:
INASCON
https://inascon.org/

Further information:

Nano Imaging Lab
https://nanoscience.unibas.ch/en/services/nano-imaging-lab/

Matura theses
https://nanoscience.unibas.ch/en/services/nano-imaging-lab/publikationen/internships/

Support in the form of detailed imaging

The Nano Imaging Lab is a popular destination for high-school diploma projects

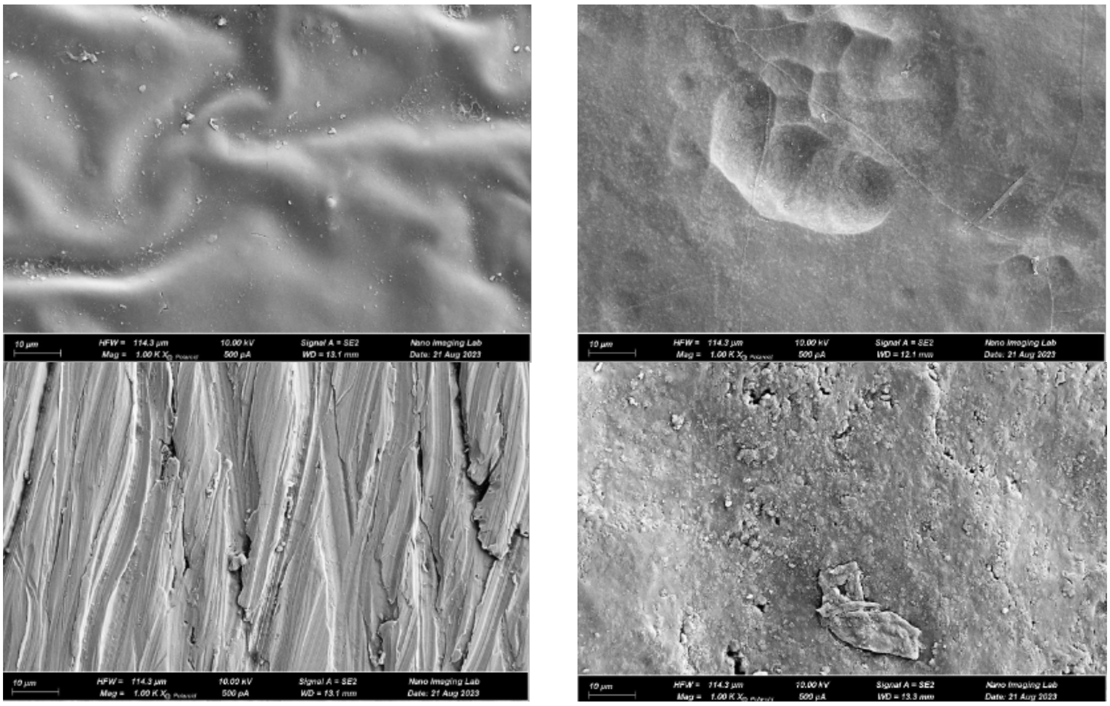
The work of the Nano Imaging Lab team provides numerous companies and research groups with valuable information as well as support for wide-ranging research projects. A few times a year, however, high-school students have the chance to explore interesting research questions with the help of staff from the NI Lab. In 2023, four Matura students worked on investigations at the lab as part of their high-school diploma projects.

It all depends on the material

Antoine Schneider from Gymnasium Liestal completed a project in which he investigated whether the results of the standardized wipe test could be applied to other materials. This test is required in Switzerland and the EU for the approval of bactericidal surface disinfectants.

Surface disinfection plays a key role in curtailing infections that are contracted by patients during medical treatment. Before a new disinfectant is approved, its disinfectant properties are tested in a standardized wipe test on a PVC surface.

As part of his high-school diploma (Matura) project, Schneider examined two approved disinfectants and found that the wipe test doesn't always ensure the elimination of microorganisms on other materials used in operating rooms. With support from Professor Marek Basler's team at the Biozentrum, Schneider used quantitative microbiological methods to show that the tested agents sufficiently disinfected stainless steel and a PVC flooring material in a wipe test and that the materials exhibited bactericidal properties even without being treated. In contrast, a high-pressure laminate that the researchers investigated did not meet the requirements.



Scanning electron microscope images of standard PVC, high-pressure laminate (HPL), stainless steel and PVC flooring reveal the different surface structures of the various materials. (Image: A. Schneider and Nano Imaging Lab, SNI, University of Basel)

At the Nano Imaging Lab, analyses were carried out using a scanning electron microscope and a 3D laser-scanning microscope with the help of Susanne Erpel and Dr. Monica Schönenberger. The results indicated that disinfectability depends on surface structure. Given that the high-pressure laminate has a much smoother surface than the other materials, it may be that wettability and therefore disinfectability increase due to adhesive capillary forces on corrugations, pores or grooves in the stainless steel or PVC.

Printed models for teaching

For his high-school diploma thesis, Yanick Samuel Bader from Gymnasium Liestal explored how a three-dimensional reconstruction method known as photogrammetry can produce 3D-printable models from scanning electron microscope (SEM) images. These models can then be used as teaching aids in the natural sciences.

Supervised by Daniel Mathys from the Nano Imaging Lab, Bader first produced SEM images of various objects. These images were intended to capture the various examples — a camera sensor, a normal fruit fly and a mutant fruit fly — from various perspectives in order to depict the samples as completely as possible. Bader used freely available software (including Alicevision Meshroom, Agisoft Metashape and OpenSFM) to generate digital raw models of the samples, which he then improved and simplified using various programs. To save material during the subsequent 3D printing, he hollowed out the models before embedding them in a stand and fitting them with support structures. Lastly, he successfully printed and postprocessed the models using a photopolymer printer. Bader was actively supported in this work by Dr. Ludovit Zweifel from the Research Instrumentation Facility of the Biozentrum.

Model of the head of a fruit fly with and without supporting structures, based on scanning electron microscope images. (Image: Y. S. Bader)

Bader's project demonstrated that photogrammetry is suitable for the reconstruction of 3D models from SEM images without any special calibration, although the models are not suitable for quantitative measurements.

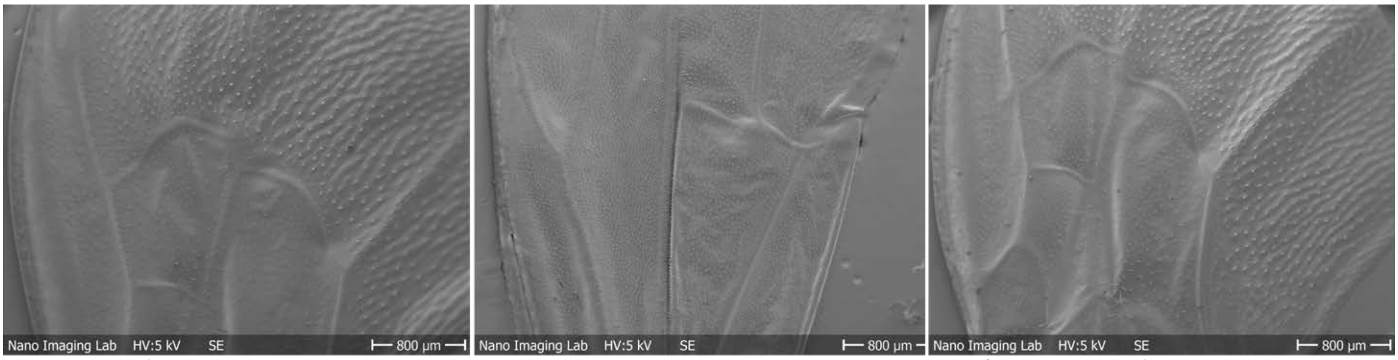
Branched and species-specific

In her high-school diploma project, Jana Egli from Gymnasium Oberwil investigated and compared the vein systems in bee, wasp and bumblebee wings.

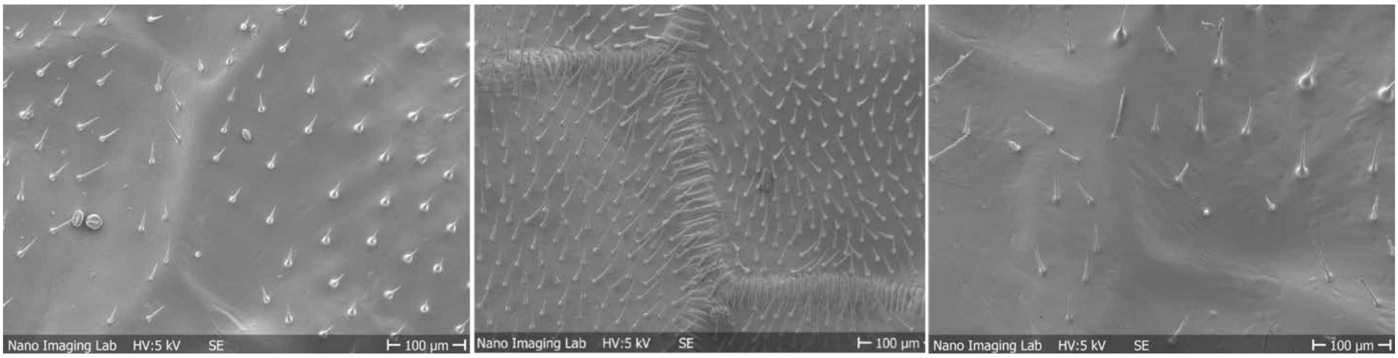
The veins in wings play a significant role for these "hymenopterous" insects — that is, insects with membranous wings — by forming a network of longitudinal and transverse veins that contribute to the structural stability of the wing. Nerves running through the veins relay important information from mechanical receptors that grow as tiny hairs on the wing surface. The veins also act as a route for transporting hemolymph, which not only supplies the animal with nutrients and fluid but also protects the wing from drying out.

Egli examined five front right wings each from honeybees, common wasps and buff-tailed bumblebees on a scanning electron microscope and then compared them with the left wings of each animal.

By doing so, she found that the vein pattern does not vary significantly within a species, but that there are considerable differences between the patterns for the three species. In the case of wasp wings especially, it is clear that the wing surface of the veins is ribbed, whereas the veins in bee and bumblebee wings have a smooth surface. Egli also used the images to show that an animal's two front wings are vertical mirror images of one another and that the size of the wings is correlated with the size of the insect.



Vein patterns of a honeybee, a common wasp and a bumblebee. (Image: J. Egli and Nano Imaging Lab, SNI, University of Basel)



Structure of the wing surface in the vein system of a honeybee, a common wasp and a bumblebee. (Image: J. Egli and Nano Imaging Lab, SNI, University of Basel)

The "song" of the Jamaican field cricket

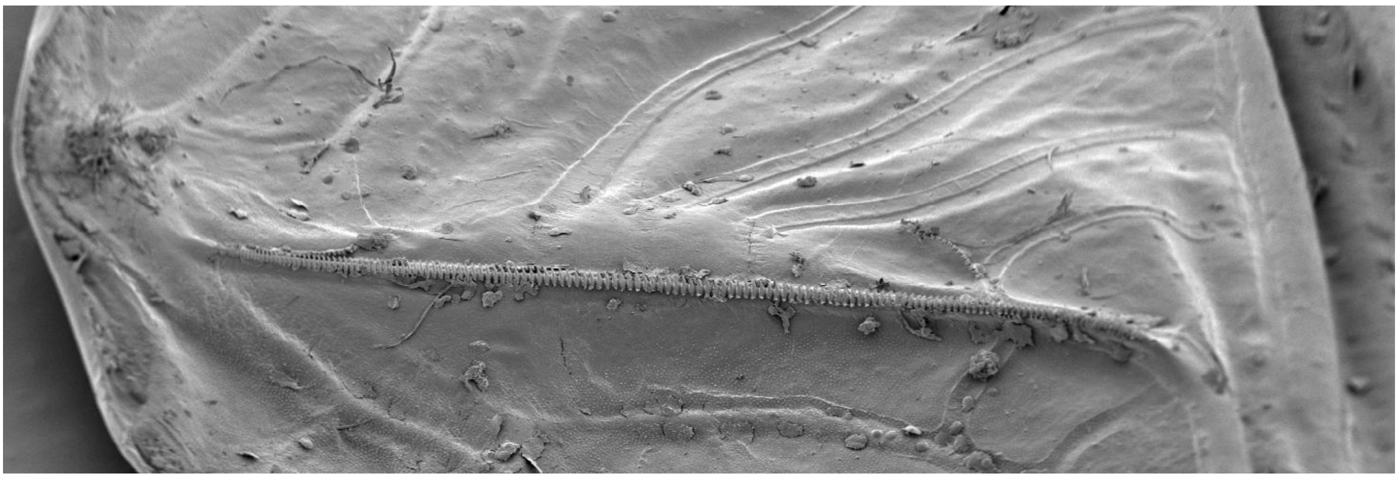
For his Matura thesis, Tim Zimmerli from Gymnasium Münchenstein analyzed various influences on the calling song of Jamaican field crickets. As part of this work, he received support from the team of the Nano Imaging Lab, among others.

Male crickets produce a calling song to attract females by rubbing a special structure known as a scraper on one wing across a file, with numerous teeth, on the other.

In his project, which was supported by the Nano Imaging Lab, Zimmerli studied the number, structure and width of the file teeth of a male Jamaican field cricket and determined their influence on the frequency of the calling song. Contrary to his hypothesis, he found that the width of the file teeth had only a minor influence on the dominant frequency of the call.

> "Working on the scanning electron microscope was a real highlight of my Matura project."

Tim Zimmerli on the support he received from Evi Bieler and Dr. Monica Schönenberger of the Nano Imaging Lab



The shrill bar with numerous teeth on a wing of the Jamaican field cricket is clearly visible. (Image: T. Zimmerli and Nano Imaging Lab, SNI, University of Basel)

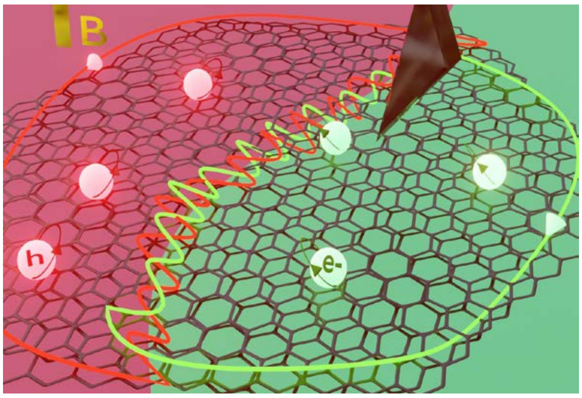
News from the SNI network

Investigation of "magic" graphene

Researchers from the SNI network have used an atomic force microscope in pendulum mode to study a two-layer graphene device. In this bilayer graphene, the two layers of pure carbon were rotated by the "magic angle" of approximately 1.1° relative to one another. The results provide empirical proof that the method can be used to fine-tune not only current flow but also magnetization in the device. The results formed part of a doctoral thesis funded by the SNI and were recently published in the journal *Communications Physics*.

Further information:
https://nanoscience.unibas.ch/en/news/details/untersuchung-von-magischem-graphen/

Original publication:
https://www.nature.com/articles/s42005-023-01441-4



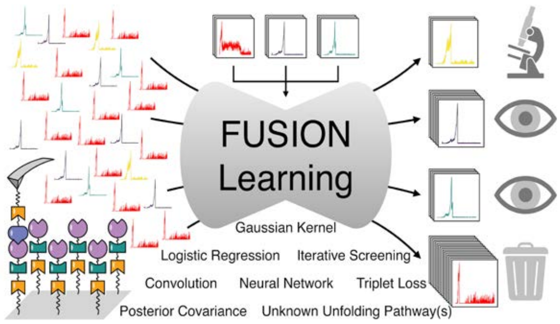
The two graphene layers are twisted relative to one another by the magic angle of approximately 1.1°. Depending on how many electrons a single cell is filled with, the graphene exhibits different electrical and magnetic properties. Measurements can be made using the oscillating tip of an atomic force microscope. The green surface is doped with an excess of electrons, while the red surface is underdoped. Polarized circular currents are induced by the magnetic field. (Illustration: Department of Physics, University of Basel)

Better classification with machine learning

Researchers from the SNI network have introduced a new machine learning technique specifically designed to enhance the analysis of protein unfolding using Atomic Force Microscopy (AFM) data. The team of Prof. Michael Nash (University of Basel and ETH Zurich) recently published the work in the scientific journal *Nano Letters*.

Further information:
https://nanoscience.unibas.ch/en/news/details/bessere-klassifizierung-mithilfe-von-maschinellem-lernen/

Original publication:
https://pubs.acs.org/doi/10.1021/acs.nanolett.3c03026



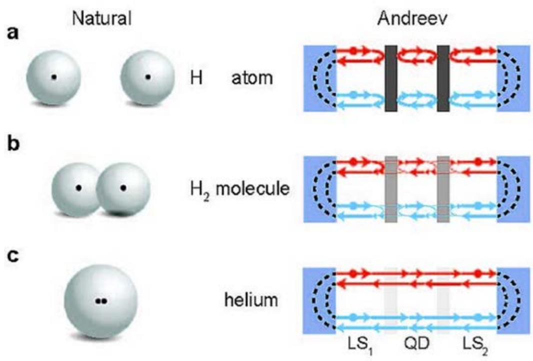
Machine learning enhances the classification of unfolding patterns in proteins. (Image: V. Doffini, Department of Chemistry, University of Basel)

"Andreev chemistry" on a nanowire

Researchers at the University of Basel and Lund University have generated superconducting pair states of electrons on several segments of a nanowire, separated by grown barriers. Depending on the height of the barriers, these pair states can be coupled and fused. The results were recently published in the scientific journal *Communications Physics* and provide important insights for the development of new quantum states.

Further information:
https://nanoscience.unibas.ch/en/news/details/andreev-chemie-auf-einem-nanodraht/

Original publication:
https://www.nature.com/articles/s42005-023-01273-2



a) Andreev atoms: At high barriers, single, independent Andreev bound states are formed – analogous to two single hydrogen atoms. b) Andreev molecules: If the barriers between the segments are reduced, coupled Andreev bound states are formed – analogous to a hydrogen molecule. c) Andreev helium: At very low barriers, the individual ABSs merge so that the pair states extend over the entire nanowire – analogous to a helium atom – conducting electric current without dissipation.

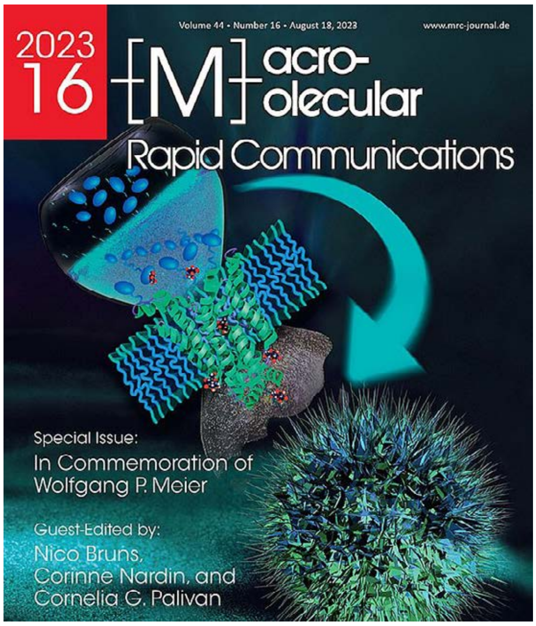
Special issue in commemoration of Wolfgang P. Meier

A special issue of *Macromolecular Rapid Communications* has been published dedicated to Wolfgang P. Meier, who passed away in January 2022. In the editorial of the journal, Nico Bruns, Corinne Nardin and Cornelia G. Palivan describe the career of Wolfgang Meier and list all the articles contributing to this special issue. In their text, they also make it clear what a wonderful person Wolfgang Meier was, with whom we all associate very positive memories.

Further information:
https://nanoscience.unibas.ch/en/news/details/sonderausgabe-zum-gedenken-von-wolfgang-p-meier/

Editorial special issue:
https://onlinelibrary.wiley.com/doi/10.1002/marc.202300401

Complete issue:
https://onlinelibrary.wiley.com/doi/10.1002/marc.202300401



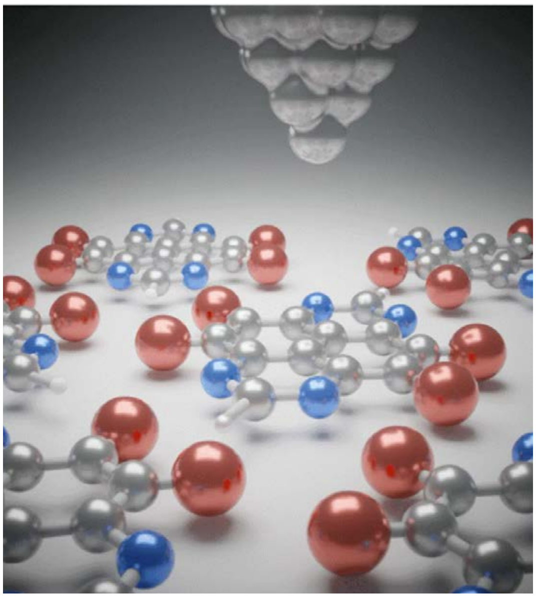
The special issue is dedicated to Wolfgang Meier.

Vibrations of molecules visualized and studied

Researchers from the SNI network have developed a new method for imaging the vibration of molecules. The scientists, led by Professor Ernst Meyer from the Department of Physics at the University of Basel, have studied a specific pyrene molecule on a silver surface using a scanning tunneling microscope (STM). Understanding molecular vibration is of crucial importance in a wide range of areas in molecular electronics, spintronics or in the development of quantum computers, since vibrations affect transport properties and spin dynamics. The work was recently published in the scientific journal "Nature Communications".

Further information:
https://nanoscience.unibas.ch/en/news/details/vibrationen-von-molekuelen-dargestellt-und-untersucht/

Original publication:
https://www.nature.com/articles/s41467-023-41601-2

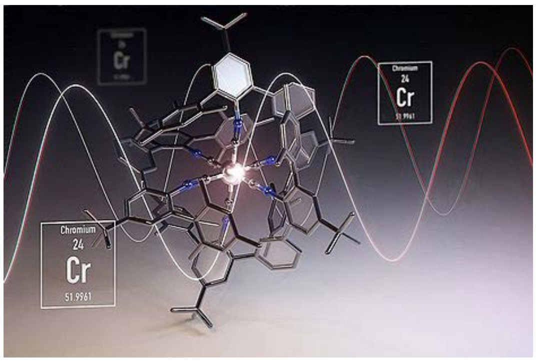

TBTAP molecules on a silver surface initially are negatively charged. If a positive voltage is then applied to the tip of an STM and brought close to the molecule, the molecule discharges.This discharge does not occur in one go, but rather in an oscillating manner. (Animation: Department of Physics, University of Basel)

Chromium replaces rare and expensive noble metals

Expensive noble metals often play a vital role in illuminating screens or converting solar energy into fuels. Now, chemists at the University of Basel have succeeded in replacing these rare elements with a significantly cheaper metal. In terms of their properties, the new materials are very similar to those used in the past.

Further information:
https://chemie.unibas.ch/en/news/details-524/chrom-ersetzt-seltene-und-teure-edelmetalle/

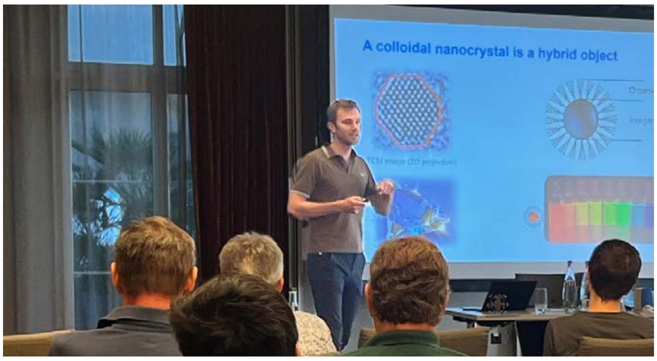
Original publication:
https://www.nature.com/articles/s41557-023-01297-9



State-of-the-art chromium compounds act as luminescent materials and catalysts. (Image: University of Basel, Jo Richers)

SNSF Starting Grant for Jonathan de Roo

The Swiss National Science Foundation (SNSF) is awarding six SNSF Starting Grants to the University of Basel. Prof. Jonathan De Roo, assistant professor with tenure track at the Department of Chemistry at the University of Basel, has been awarded one of these grants to develop recyclable sponges with programmable structures made of metal-oxo clusters. These sponges have applications as catalysts, for example in the production of pharmaceuticals or in water purification.



Jonathan de Roo has been awarded an SNSF Starting Grant.

Further information:
https://nanoscience.unibas.ch/en/news/details/snsf-starting-grant-fuer-jonathan-de-roo/

Marek Basler newly elected EMBO member

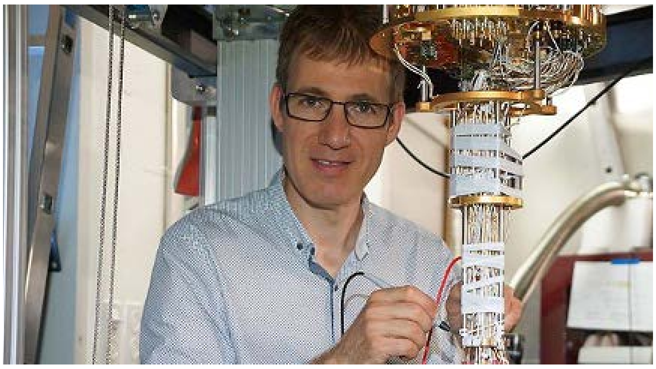
Prof. Marek Basler of the Biozentrum, University of Basel, has been elected as a new member of the renowned European Molecular Biology Organization (EMBO). Basler is now one of a select group of more than 2,000 leading life scientists in Europe and beyond who have so far been honored by EMBO for their outstanding research achievements with this lifetime membership.


Marek Basler has been elected as a member of the European Molecular Biology Organization (EMBO). (Image: Biozentrum, University of Basel)

Further information:
https://www.unibas.ch/en/News-Events/News/Ehrungen-und-Mitgliedschaften/Marek-Basler-newly-elected-EMBO-member.html

Dominik Zumbühl elected American Physical Society Fellow for 2023

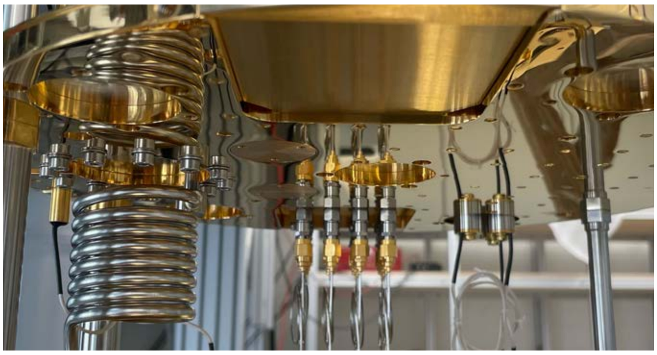
Prof. Dominik Zumbühl, SNI member and director of the NCCR Spin, receives the award “For quantum transport experiments in semiconductor nanostructures at low temperatures studying coherence, spins, and spin-orbit coupling including developing and deploying laboratory instruments”.


Dominik Zumbühl has been elected American Physical Society Fellow for 2023. (Image: NCCR Spin)

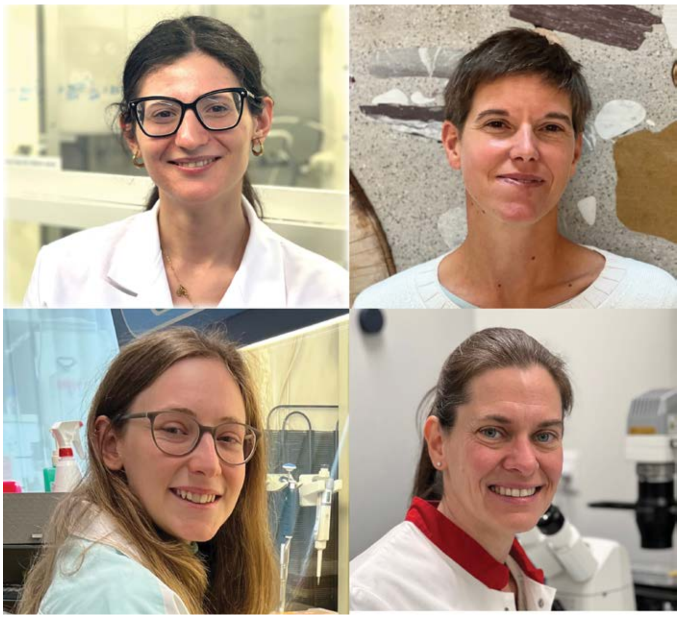
Further information:
https://nanoscience.unibas.ch/en/news/details/dominik-zumbuehl-zum-american-physical-society-fellow-fuer-2023-gewaehlt/

NZZ report: Quantum Computing

An NZZ report published in September takes an in-depth look at quantum computing and highlights both the limitless potential and the risks associated with this ground-breaking technology.



Further information:
https://physik.unibas.ch/en/news/details/nzz-reportage-quantum-computing/



Antonia Ruffo, Sina Saxer, Tamara Utzinger, and Géraldine Guex talk about their careers, their motivation and their fascination for very different scientific topics.

Women in the SNI Network

There are new videos in our series "Who are the women in nanoscience?":

https://nanoscience.unibas.ch/de/outreach/videos/frauen-im-sni-netzwerk/

Antonia Ruffo,
SNI doctoral student at the Paul Scherrer Institut
https://youtu.be/V386tx4PLFA

Sina Saxer,
Research associate at the FHNW School of Life Sciences
https://youtu.be/YzNFfA4CiF8

Tamara Utzinger,
who has just completed her master's in nanosciences at the University of Basel
https://youtu.be/5t6SMUYxaj4

Géraldine Guex
Professor for Oral Implantology, University Center of Dental Medicine Basel (UZB)
https://youtu.be/4nbXd3jKkZ0

What exactly is nano?

We've animated our "Was ist Nano?" brochure, in which you can now find easy-to-understand answers and insights into nanoresearch at the SNI partly illustrated with moving images.

Brochure in German *Was ist Nano?* ("What is Nano?"):
https://sniunibas.relayto.com/e/was-ist-nano-rppx3iftjvkzn?hub=651d6a40795e2

For the first time, members of the SNI network met at Lake Hallwil for their Annual Event.

Annual Event 2023

From September 6 – 8, the members of the SNI network met for the Annual Event – which was held, for the first time, in the Canton of Aargau, specifically at Lake Hallwil.

It was a great conference, with exciting talks and posters on basic and applied research in wide-ranging areas of the nanosciences, as well as opportunities to network and exchange ideas.

Video:
https://youtu.be/f4HHrbnXw88

SNI INSight — Showcasing research and activities of the Swiss Nanoscience Institute

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