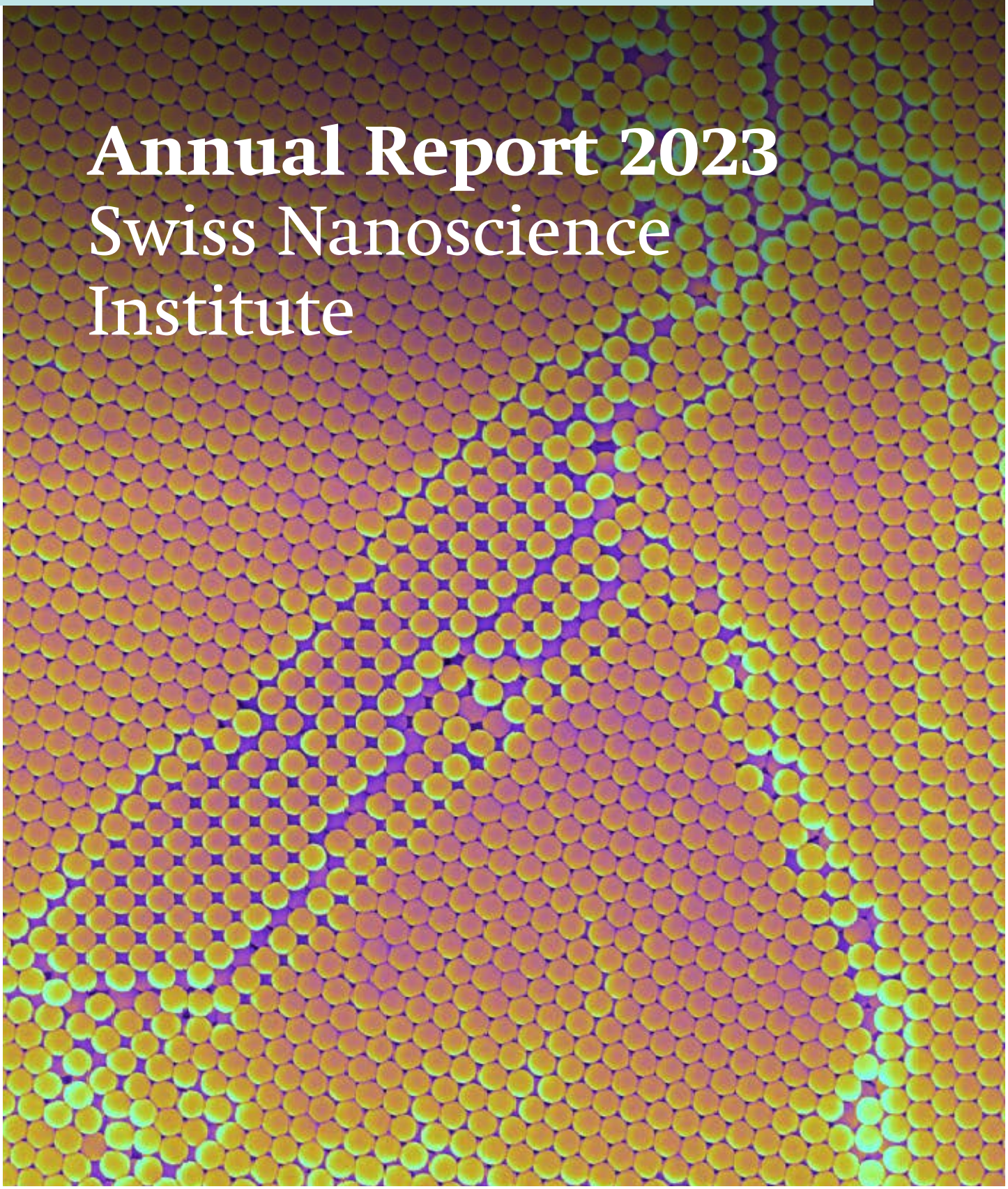
University of Basel

Swiss Nanoscience Institute

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

Annual Report 2023
Swiss Nanoscience Institute



Scientific supplement
Scientific reports from all the Nano-Argovia and SNI PhD School projects from 2023 can be found on our website or by scanning the QR code.

www.nanoscience.ch
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Dear colleagues and nanoenthusiasts,

Once again, the time has come to look back over the past year as part of the Annual Report. This has been my first full year as Director of the SNI, and I've experienced some real highlights in my role.

In 2023, we gave considerable thought to the future of our unique, interdisciplinary network and worked on drawing up a strategy paper. Although the paper will only be published in spring 2024, I can already reveal that we will be focusing on nanoimaging and nanofabrication and strengthening collaboration within our network. We will adapt to changes in external conditions so that we continue to contribute to solving the challenges that our society faces tomorrow through our activities in the areas of research, services and teaching. The sharper focus on our core strengths will help us to position the SNI and equip it for the future – not only with regard to research and education but also in terms of services, expertise and technology transfer.

Another highlight was undoubtedly the Annual Event 2023, which saw SNI members come together in the Canton of Aargau for the first time. Events such as these are vital for our interdisciplinary community, providing an opportunity to learn about each other's work, to make new contacts, and to come up with ideas for joint projects. An occasion such as this is not only important from a research perspective – indeed, our two service units, the Nano Imaging Lab and the Nano Fabrication Lab, also benefit from this exchange of ideas and the opportunity to inform the entire network of their wide-ranging services.

For the two service teams, which together make up the Nano Technology Center, 2023 was a significant year. Following the retirement of Dr. Markus Dürrenberger, the nanoscientist Dr. Marcus Wyss took over as head of the Nano Imaging Lab, and a new member of staff also joined the team, which numbers six people. Likewise, the Nano Fabrication Lab welcomed two new members of staff at the end of the year and began operating a clean room in the new building of the Department of Biosystems Science and Engineering of ETH Zurich in Basel. Accordingly, the Nano Technology Center is even better equipped not only to assist researchers from academia and industry with surface imaging and analysis, as well as micro and nanofabrication, but also to continue expanding its services through its own research.

Research into the nanosciences is and will remain an integral part of the SNI – and we support projects in the areas of both basic and applied science. Two sections of the Annual Report are devoted to the results of research projects that were published by SNI members or carried out by teams as part of the Nano-Argovia program in 2023.

Another key part of our work has always been the training of excellent young scientists, who not only gain valuable specialist knowledge but also learn to look beyond the boundaries of their own research. As scientists, they are therefore ideally prepared to work at the interfaces between different disciplines. Summaries of the dissertations completed at the SNI PhD School in 2023 provide insights into the projects supported by the SNI.

The year also brought highlights in relation to the nanosciences study program. For example, the program coordinator, Dr. Anja Car, received the University of Basel's Teaching Excellence Award for "Service to Teaching" in recognition of her excellent work. Moreover, 2023 was the first year in which nanoscience students completed their master's studies with a major in medical nanosciences. This popular specialization has been available to students since 2021.

The last section of the Annual Report provides examples of various activities that we carry out in order to share our fascination with the natural sciences and nanosciences with the general public and to report on research carried out at the SNI. For example, we've been providing information about the SNI via a redesigned website since the start of 2023 – and we also offered science experiments and craft projects to interested adults, teenagers and children on train journeys.

Through these wide-ranging examples, the Annual Report 2023 provides an overview of the work of SNI members over the last year. We hope you enjoy reading it.

Kind regards,

Professor Martino Poggio
SNI Director

2023 in brief

A successful INASCON
In summer 2023, students and doctoral students of the nanosciences organized the INASCON conference in Basel. The varied program was enjoyed by participants from 15 countries and left visitors with lasting memories of Basel as an exciting research location.
Page 13

First master's graduate in medical nanosciences
Philippe Van der Stappen is the first nanoscience student to complete his master's with the new specialization in medical nanosciences.
Page 14

Wide-ranging research
Five SNI PhD students completed their doctoral dissertations in 2023 while working at the Biozentrum and the Departments of Chemistry, Pharmaceutical Sciences and Physics. One associate doctoral student worked at Empa.
Page 16

Ten-year anniversary
In 2013, the first doctoral students began at the SNI PhD School. To mark this ten-year anniversary, the SNI team organized a special celebration in summer 2023, bringing together numerous current and former doctoral students, as well as project leaders, to share their experiences in a relaxed atmosphere.
Page 21

A varied program
In 2023, there were many opportunities to learn more about the SNI and the nanosciences – on the train, at the Rüeblimärt, at schools, at science festivals, on our new website, or on social media.
Page 56

The Nano Fabrication Lab's new clean room, which began operating in late 2023, is also home to a new electron-beam lithography system.

New clean room in operation
In late 2023, the Nano Fabrication Lab began operating a clean room that is rented by the SNI in the new building of the Department of Biosystems Science and Engineering of ETH Zurich in Basel. The team has grown to four people and is now even better equipped to handle orders relating to micro and nanofabrication.
Page 49

Women in the nanosciences
Many women are passionate about the nanosciences and about their specific roles in this field – whether they are currently studying, working on their doctoral dissertation, conducting research, teaching, or leading research groups. With portraits of some of the women at the SNI, we hope to encourage girls and young women to embark on a career in the natural sciences.
Page 57

Former doctoral student Thomas Mortelmans received the PSI-Impuls Award.

Study program coordinator Anja Car was presented with the Teaching Excellence Award for "Service to Teaching."

Timon Baltisberger received the prize for the best master's thesis in nanosciences at the University of Basel.

New head of NI Lab
In 2023, Dr. Markus Wyss took over from Dr. Markus Dürrenberger as head of the Nano Imaging Lab.
Page 46

New production process for therapeutic nanovesicles
Researchers from the SNI network have developed an innovative method for the efficient production of therapeutic nanovesicles.
Page 25

Investigation of "magic" graphene
Researchers from the SNI network have examined a two-layer graphene device using an atomic force microscope in pendulum mode and demonstrated that the method they used allows fine-tuning of not only current flow but also magnetization in the device.
Page 25

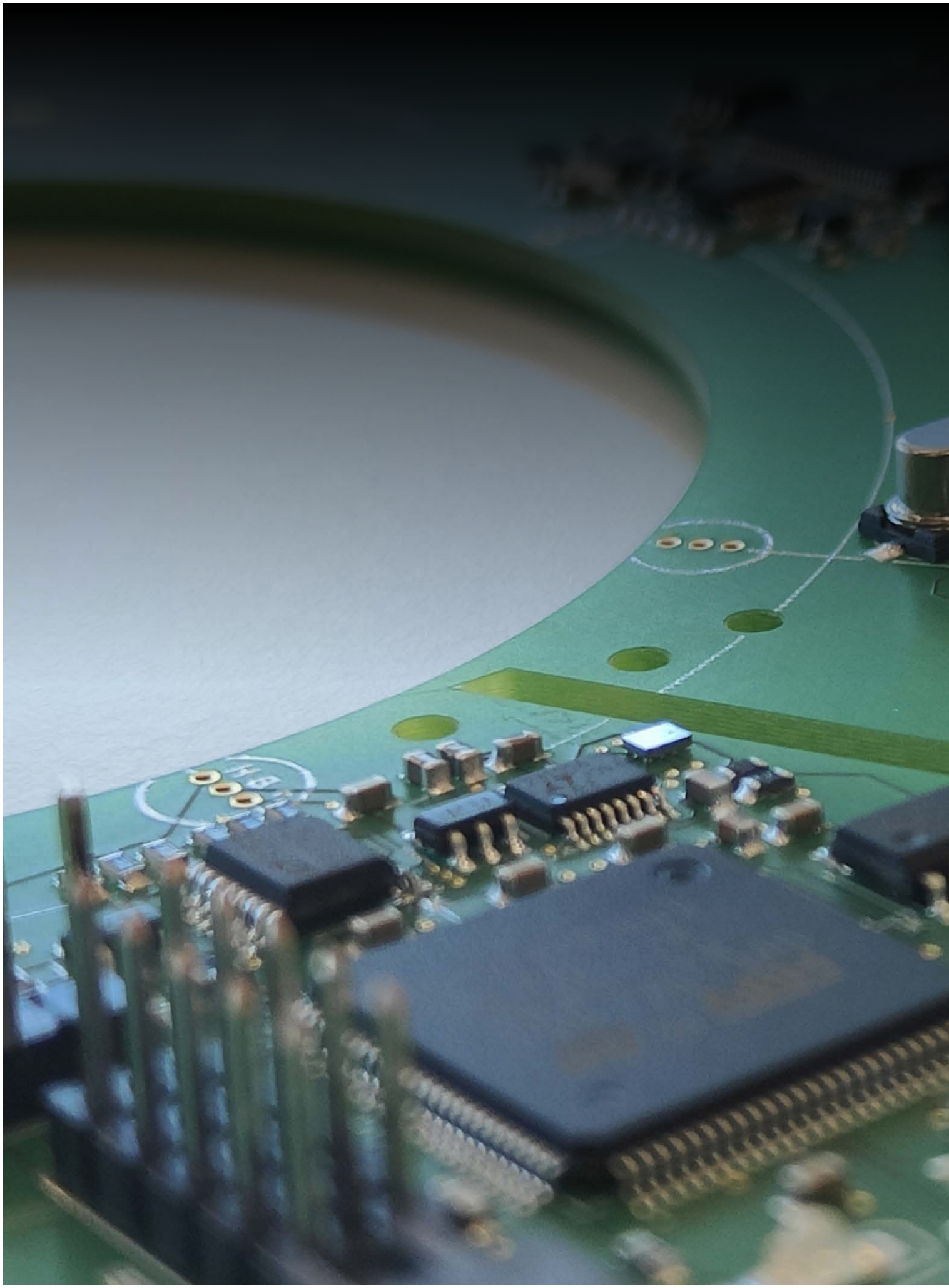
Increased coherence thanks to cooling
A team of researchers has extended the coherence of an electron spin in a gallium arsenide quantum dot to over half a microsecond for the first time. They achieved this by using the electron spin-nuclear spin interaction, thereby causing the spin system to cool down to 100 microkelvins.
Page 26

The SNI Annual Event was held in the Canton of Aargau for the first time. Prizes were awarded to Alessandro Bruno for his excellent poster and Elizaveta Maksimova for her excellent talk.

Under control to the very end
Every day, millions of cells die in our body. Many of them kill themselves. Contrary to what was previously assumed, cells do not simply burst at the end of their lives. Rather, a specific protein serves as a predetermined breaking point for cell membrane rupture.
Page 27

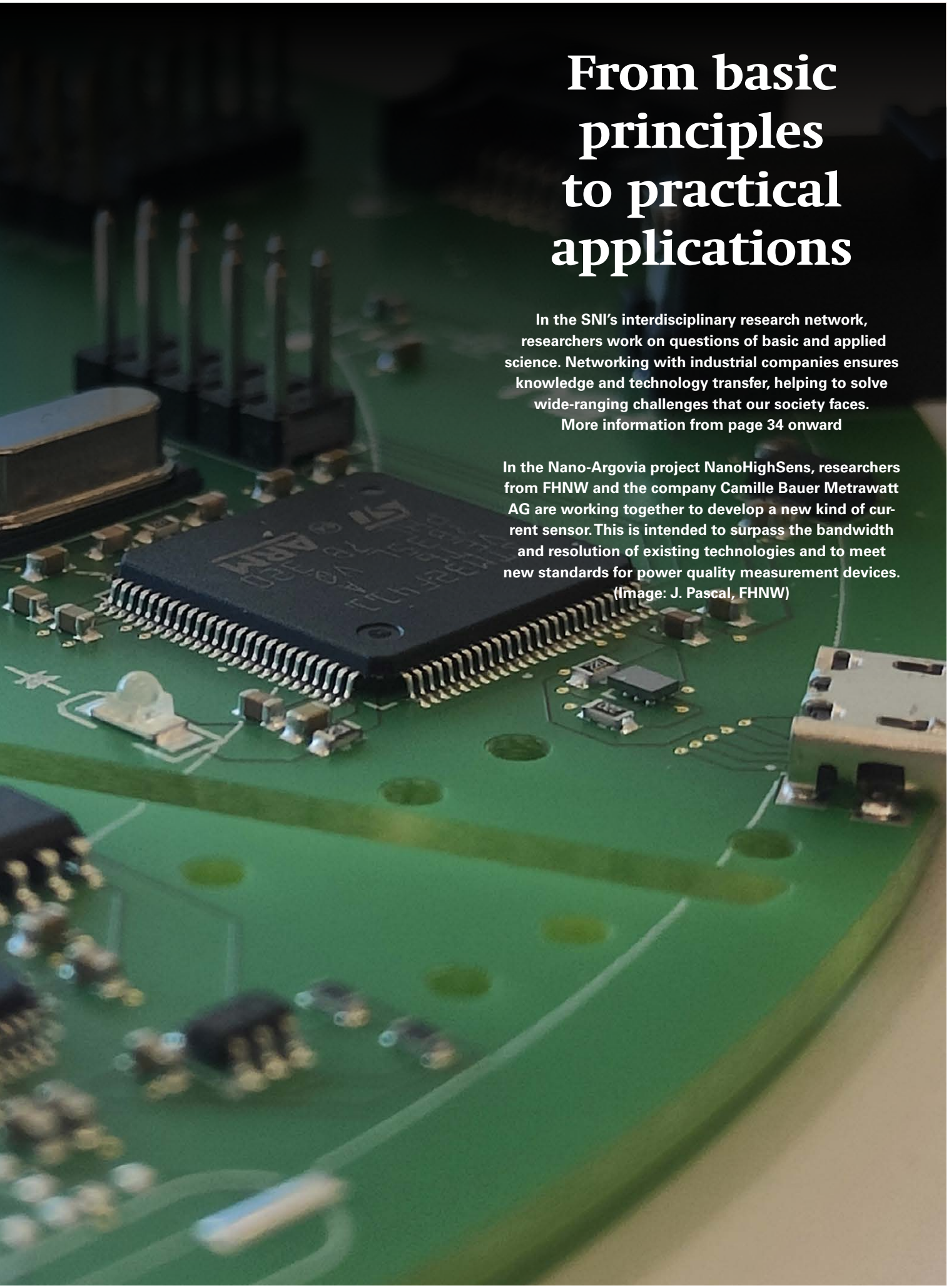
New polymer sample holder
Researchers from the SNI network have developed and tested a new type of polymer sample holder that is ideal for the analysis of crystals at synchrotron and free-electron X-ray laser sources.
Page 28

Electron beam lithography also possible on uneven surfaces
Researchers from the SNI network have developed a new method for applying electron beam lithography to uneven surfaces.
Page 29



From basic principles to practical applications

In the SNI's interdisciplinary research network, researchers work on questions of basic and applied science. Networking with industrial companies ensures knowledge and technology transfer, helping to solve wide-ranging challenges that our society faces.
More information from page 34 onward



In the Nano-Argovia project NanoHighSens, researchers from FHNW and the company Camille Bauer Metrawatt AG are working together to develop a new kind of current sensor. This is intended to surpass the bandwidth and resolution of existing technologies and to meet new standards for power quality measurement devices. (Image: J. Pascal, FHNW)

Swiss Nanoscience Institute: The interdisciplinary center of excellence for nanosciences in Northwestern Switzerland

The Swiss Nanoscience Institute (SNI) at the University of Basel is a center of excellence for nanosciences and nanotechnology and was founded in 2006 on the initiative of the Canton of Aargau and the University of Basel.

The SNI is underpinned by a network of scientists from leading research institutions in Northwestern Switzerland. These researchers work on questions of basic or applied science in relation to the nanosciences and nanotechnology. Moreover, they are involved in educating young nanoscientists who have broad interdisciplinary expertise and are ideally prepared to work at the interfaces between different disciplines.

To drive this interdisciplinary education further, the SNI coordinates Switzerland's unique nanoscience degree program at the University of Basel, which leads students to a bachelor's and a master's degree in nanosciences. The SNI also runs a PhD School, which attracts early career researchers from all over the world.

Support for education and research is also provided by the SNI's Nano Technology Center, which consists of two service units: the Nano Imaging Lab and the Nano Fabrication Lab. With a total of 10 members of staff, the team is available to customers from higher education institutions and companies and supports their research by providing services in the areas of imaging, analysis, and nano and microfabrication.

20%

20% of SNI members are women.

12+5+5

In 2023, 12 students successfully completed their bachelor's program, 5 completed the master's program. Five PhD students successfully defended their theses.

40

In 2023, 40 PhD students were enrolled in the SNI PhD School.

167

167 members belong to the SNI network. (PIs, PhD students, management, voluntary members, Nano Fabrication Lab and Nano Imaging Lab)

49

The SNI supported 49 research projects, 9 in applied research and 40 in the SNI PhD School.

82

In 2023, 56 students were enrolled on the bachelor's program and 26 on the master's program.

80+126

In 2023, 80 clients used the Nano Fabrication Lab`s service. The Nano Imaging Lab received more than 180 orders, which often take several days, from 126 different clients.

14

Fourteen of the 53 PhD students who had completed their PhDs by the end of 2023 work at a federal or research institution.

39

Thirty-nine of the 53 PhD students who had completed their PhDs by the end of 2023 work in industry.

45

In 2023, a total of 45 peer-reviewed papers with participation of SNI members were published in renowned science journals.

10

There are ten partner institutions in the SNI network. These include the research institutions University of Basel, the School of Life Sciences and the School of Engineering at the University of Applied Sciences and Arts Northwestern Switzerland (FHNW), the Paul Scherrer Institute PSI, the Centre Suisse d`Electronique et de Microtechnique (CSEM) in Allschwil, the Department of Biosystems Science and Engineering at the ETH Zurich in Basel, and the technology transfer centers ANAXAM and Swiss PIC. The network also includes the Hightech Zentrum Aargau and Basel Area Business & Innovation.

9 M

In 2023, the SNI had expenditures of approximately CHF 9 million (without building costs) of which CHF 6.4 million were covered by the Canton of Aargau and CHF 2.6 million by the University of Basel.

>5500

The SNI social media channels on Instagram, LinkedIn, X and YouTube have more than 5,500 followers.

The Swiss Nanoscience Institute was founded in 2006 on the initiative of the Canton of Aargau and the University of Basel.

Rooted in the Canton of Aargau and the University of Basel

The SNI was founded in 2006 by the Canton of Aargau and the University of Basel in order to drive forward research and training in the nanosciences and nanotechnology in Northwestern Switzerland.

Nanotechnologies play a key role in research and industry in the Canton of Aargau and are one of the focal areas of the Hightech Aargau program, with which the canton seeks to promote collaboration between companies, higher education and research institutions. Researchers from various disciplines and institutions work together on numerous successful SNI research projects, supporting the strategy in the Canton of Aargau and providing companies from Aargau, Solothurn and the two Basel half cantons with access to new scientific findings and technologies.

In 2023, the SNI spent approximately 9 million Swiss francs, of which some 6.4 million were provided by the Canton of Aargau and 2.6 million by the University of Basel.

The SNI is underpinned by its interdisciplinary network of researchers from leading scientific institutions in Northwestern Switzerland.

Committed members of the network

The Swiss Nanoscience Institute is a network of researchers from different disciplines who participate in various basic scientific or applied research projects. Participating researchers come from the leading scientific institutions of Northwestern Switzerland, including the Departments of Biomedicine, Chemistry, Pharmaceutical Sciences, Physics, Environmental Sciences, and the Biozentrum of the University of Basel, the Schools of Life Sciences and Engineering at the University of Applied Sciences Northwestern Switzerland (FHNW) in Muttenz and Windisch, the Paul Scherrer Institute PSI, the Department of Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel (D-BSSE), the CSEM (Centre Suisse d'Electronique et de Microtechnique) in Allschwil, and the two technology transfer centers ANAXAM and Swiss PIC. The SNI also engages in collaborations with the Hightech Zentrum Aargau in Brugg and with Basel Area Business & Innovation in relation to knowledge and technology transfer.

The SNI trains excellent early career researchers, who are ideally suited for work at the interfaces between different disciplines.

Early career researchers with broad-based knowledge

The SNI's precursor institution set up a bachelor's and master's program in nanosciences at the University of Basel 20 years ago. Students on the bachelor's program first receive a solid grounding in biology, chemistry, physics and mathematics and can then increasingly move into a subject area that suits their personal interests as they progress through this demanding program.

Moreover, the students have the opportunity to participate in various research groups and gain insights into applied projects in industry at an early stage in their education.

So far, a total of 285 students have earned a bachelor's degree in nanosciences in Basel, and 216 students have successfully completed the master's program in nanosciences. At the end of 2023, there were 56 students enrolled on the bachelor's program and 26 early career researchers enrolled on the master's program.

The next step for many nanoscience students is a doctorate — and some go on to apply for a project at the SNI PhD School, which was founded in 2012. In 2023, there were 40 doctoral students working on their projects, which were largely interdisciplinary in nature. These students came from all over the world. Five doctoral students successfully completed their dissertation in 2023, while eight new projects were approved and will start in 2024.

Over 70% of the 53 graduates of the SNI PhD School remain in Switzerland after completing their dissertation.

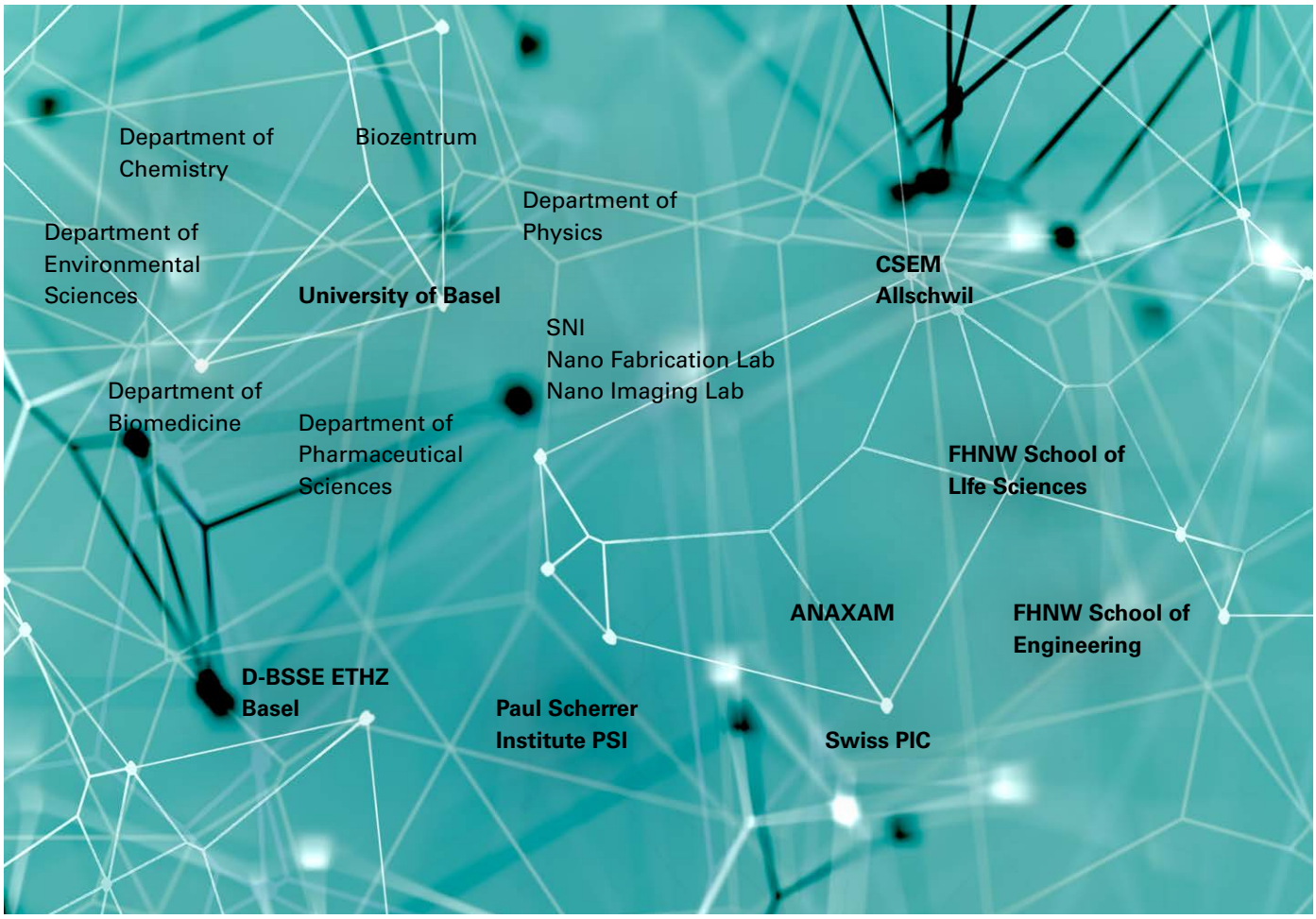
A key contribution to the SNI's visibility

Basic sciences are the foundation of research work at the SNI. As well as the various projects funded as part of the PhD School, the SNI also supports basic scientific research carried out by the two Argovia Professors Rodrick Lim and Martino Poggio, whose work contributes to the SNI's outstanding reputation.

In addition, the SNI supports the research of Professor Patrick Maletinsky, whose research group at the Department of Physics focuses on the development and application of quantum sensors to nanoscale imaging and the investigation of advanced magnetic materials. Outside of the University of Basel, the SNI also supports the three titular professors Thomas Jung, Michel Kenzelmann and Frithjof Nolting, who lecture at the Department of Physics of the University of Basel and lead active research groups at PSI.

Exchange with industrial companies

The SNI supports the transfer of scientific findings and technologies to industry through the Nano-Argovia program. Since the SNI was founded, it has promoted over 100 projects carried out as a collaboration between companies and research institutions from Northwestern Switzerland as part of this successful initiative. In total, nine of these applied research projects were funded in 2023, with four of the partner companies hailing from the Canton of Aargau, while five companies are based in one of the two Basel half cantons. Collaboration with industry is also supported by the two technology transfer centers ANAXAM and Swiss PIC, which also form part of the SNI network.



The interdisciplinary network of the SNI is made up of research groups from the leading research institutions in Northwestern Switzerland. These groups work on basic scientific and applied projects and ensure an excellent standard of research work. (Background image: iStock)

Through its two service units (Nano Imaging Lab and Nano Fabrication Lab), the Nano Technology Center assists researchers with surface imaging and analysis and micro and nanofabrication.

Excellent service from the Nano Technology Center

The SNI is also on hand as a service provider to partners in academia and industry. As part of the SNI since 2016, the Nano Imaging Lab (NI Lab) has a six-person team and offers comprehensive services relating to surface imaging and analysis. In 2022, a second service unit was added in the form of the Nano Fabrication Lab (NF Lab), which initially brought together existing activities and infrastructure from the Department of Physics in order to offer professional and effective services in the promising area of nanofabrication. In 2023, new equipment was purchased and a second clean room went into operation.

Educate and enthrall

It's important to the SNI team not only to train young scientists, conduct excellent research and act as a sought-after partner and service provider, but also to inform the general public about SNI activities and to foster an interest in the natural sciences.

By taking part in science festivals, exhibitions and markets, as well as through laboratory tours and new formats such as "MINT on the move," the SNI staff come into contact with various target groups and provide them with insights into everyday laboratory life and the nanoworld. The SNI also collates information in the form of videos, brochures, media releases and an online magazine, which reach different target groups via various social media channels.

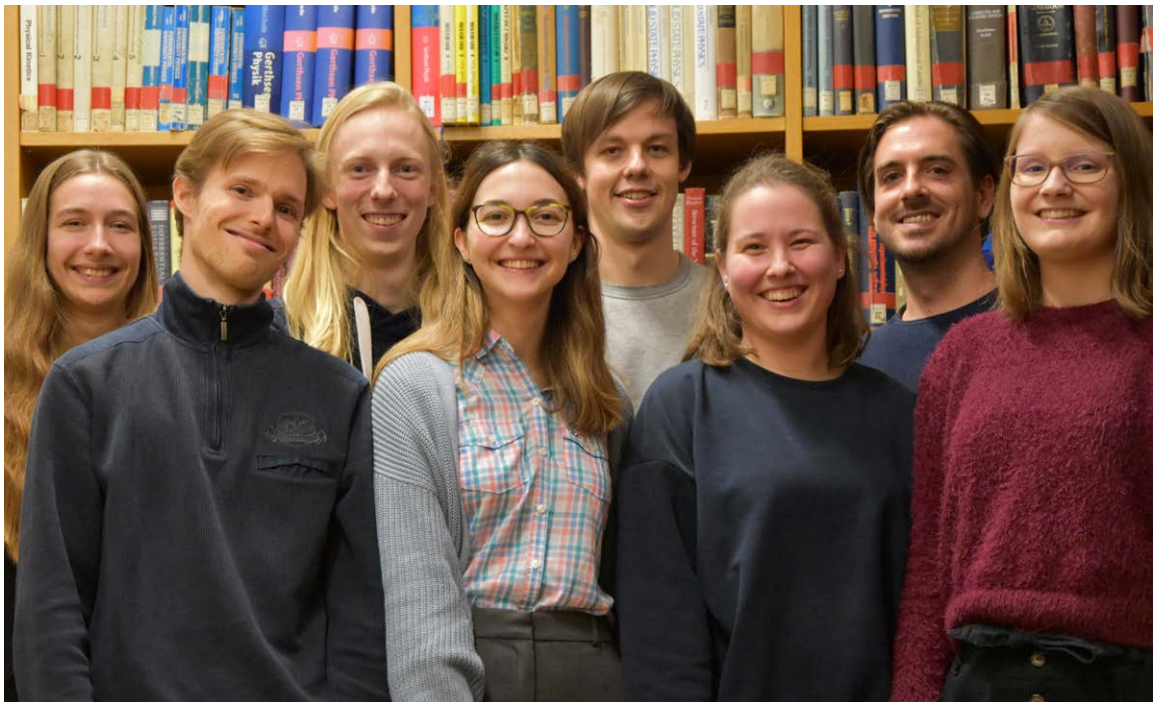
Nanosciences program: An excellent grounding for a career at the interfaces between diverse disciplines

Students on the nanosciences program at the University of Basel receive a broad education in the natural sciences during the introductory level and then become increasingly specialized as they progress through their bachelor's and master's studies.

In the master's program, they can choose between specializations in medical nanosciences, molecular biology, nanochemistry and nanophysics. On top of that, however, they also benefit from an interdisciplinary range of subjects and therefore gain insights into wide-ranging research questions and approaches.

During their studies, the young researchers learn the "language" of the different disciplines. As specialists in their field, they are therefore ideally equipped not only to lead innovative research and development for the benefit of society, but also to operate successfully at the interfaces between different disciplines.

At the end of 2023, there were 56 students enrolled on the bachelor's program and 26 on the master's program. Twelve students successfully completed the bachelor's program and five completed their studies with a master's degree.



Students of the nanosciences and doctoral students from the SNI PhD School organized INASCON 2023.

Twelve months of preparation

Successful collaboration and valuable experience

In August 2023, over 60 students and doctoral students from 26 universities across 15 countries came together in Basel for the International Nanoscience Student Conference (INASCON) 2023. Since its first outing in Silkeborg (Denmark) in 2007, this nanoscience conference has been held in eight different countries. In 2023, Basel hosted the conference for the third time.

The eight-person organizing committee, consisting of students and doctoral students of the nanosciences in Basel, had their hands full ensuring that this event turned out to be a complete success. The young researchers put together a fascinating program featuring well-known speakers, took care of the financing, promoted the event, and carried it out with great professionalism. For everyone involved, it was a busy and eventful time in which they learned a great deal – and helped to ensure that those attending INASCON left with memories of Basel as a livable city and an attractive research location.

Article on INASCON in *SNI INSight:* https://bit.ly/48vy8uE

In August 2023, over 60 students and doctoral students of the nanosciences from 15 countries came together in Basel for INASCON. (Image: P. Dani)

An excellent master's thesis
Timon Baltisberger investigated biofilms

Timon Baltisberger received the prize for the best master's thesis in nanosciences at the University of Basel in 2023.

In his prizewinning thesis, he proved that *Vibrio cholerae* bacteria inside a biofilm are more tolerant to various antibiotics than cultures grown in agitated liquid medium.

The results help to improve our understanding of biofilms, which play a major role in nature and can lead to stubborn infections in humans.

After completing his master's studies in the nanosciences, the young researcher from the Canton of Aargau began his doctoral dissertation at the University of Basel – albeit not, as one might imagine, on a biological/medical topic but rather in quantum physics. Once again, this demonstrates how diverse an education the nanoscience students receive.

Article on Timon Baltisberger's master's thesis: https://bit.ly/3ORDA3a

Video with Timon Baltisberger: https://youtu.be/4zZjnvX-qUQ

"In his master's thesis, Timon paved the way for investigating the effectiveness of antibiotics in bacterial communities."
Professor Knut Drescher,
Biozentrum, University of Basel

Excellent supervision
Anja Car received the Teaching Excellence Award for "Service to Teaching"

The nanosciences program is a challenging one – but time and again, students say they value the familiar atmosphere as well as the excellent supervision they receive.

The coordinator of the program, Dr. Anja Car, was nominated for the Teaching Excellence Awards 2023 for "Service to Teaching," which is awarded by the University of Basel, based on positive feedback from students. Anja Car was selected as the winner by deans of studies at the university and presented with the award, which stands as testament to her extraordinary commitment to the benefit of students, on 25 May, 2023.

Article on Anja Car's career background: https://bit.ly/3UN5MrK

Video with Anja Car: https://youtu.be/mgfWGBSfYCg

"Through her tireless commitment, Anja Car makes a vital contribution to the success of the unique nanoscience degree program. As coordinator, she achieves the extraordinary — from both an organizational and a human perspective."
Professor Philipp Habegger
Dean of Studies,
Faculty of Science,
University of Basel

First master's graduate in medical nanosciences
Philippe Van der Stappen isolated specific cell regions

Since September 2021, the option to specialize in medical nanosciences has been available to nanoscience master's students at the University of Basel. In 2023, Philippe Van der Stappen was the first student to complete a master's degree with a focus on nanomedicine.

For his master's thesis, Van der Stappen received an Argovia Grant to work in Professor Alex de Marco's group at Monash University (Clayton, Australia), where he developed a method for isolating specific regions of a cell. These "subcellular regions" can be used for various subsequent investigations – including to analyze gene expression (transcriptomics) or the entire set of proteins (proteomics).

Article on Philippe Van der Stappen's time abroad: https://bit.ly/42NH3pb

"What makes particularly notable about the specialization in medical nanoscience is the range of lectures covering multiple departments that provide unique insights into everything from molecular medicine to biocompatibility and the analysis of data from imaging techniques."
Philippe Van der Stappen,
Biozentrum, University of Basel

SNI Director Martino Poggio (left) with nanoscience bachelor's graduates of 2023. Having successfully completed the first key step in their scientific careers, the students can now look forward to continuing their studies in this fascinating field as part of the master's program. (Image: A. Car)

At each year's SmallTalk conference, the students present results from the block courses – and design their own flyer for the event.

Insights into various areas
Block courses are a real highlight

When we ask our students about the highlights of their studies, many point to the block courses that students complete in the fifth and sixth semester of the bachelor's program. As part of these courses, they work on their own small-scale projects in different research groups, gaining insights into current research topics, learning about scientific work, and developing contacts with research groups at different institutions. The courses also provide another opportunity for students to identify the subjects they are particularly interested in so that they can then choose the most suitable specializations in the master's program.

In 2023, students had the choice from 45 different block courses at various departments of the University of Basel, the FHNW School of Life Sciences, Empa, EPFL, the PSI and the Adolphe Merkle Institute.

At the end of the sixth semester, the students present results from the block courses at the Small Talk conference, which is organized by the students themselves. Here, each student gives a talk to an interdisciplinary audience and presents another topic in the form of a poster.

SNI PhD School: Looking beyond the boundaries of one's own research

Doctoral students at the SNI PhD School complete their dissertations in research groups at the University of Basel, the Paul Scherrer Institute, the University of Applied Sciences Northwestern Switzerland or the Department of Biosystems Science and Engineering of ETH Zurich in Basel. The students are well integrated into their working groups, where they receive excellent scientific education with a focus on diverse subject areas.

Given the interdisciplinarity of the SNI network, the doctoral students also gain insights into research projects outside of their specialist field — and come into contact with researchers from other disciplines at various SNI events. They receive an overview of wide-ranging projects in basic and applied science that are funded by the SNI and also learn to present their own research to an audience including people who are not experts in the field.

This form of exchange is particularly encouraged at the annual "Nanoscience in the Snow" Winter School and the Annual Event, while interdisciplinary interactions also take place as part of courses developed specifically for the PhD School.

At the end of 2023, a total of 40 doctoral students were enrolled in the SNI PhD School, almost 30% of whom were women. Five doctoral students successfully completed their doctoral dissertations in 2023. Eight new dissertation projects were approved in 2023 and will begin in 2024.

Of the 53 SNI doctoral students who have completed their dissertations so far, 74% were employed in industry at the end of 2023. In addition to that, 26% of former SNI doctoral students are employed at research or federal institutions.

Claudio Alter wrote his doctoral thesis at the Department of Pharmaceutical Sciences. He is continuing his work as a postdoctoral researcher.

David Jaeger wrote his doctoral thesis at the Department of Physics and was employed there as a postdoctoral researcher.

Toshiya Kozai conducted research for his doctoral thesis at the Biozentrum and is now working there as a postdoctoral researcher.

Optimizing gene therapy

In his doctoral thesis, Dr. Claudio Alter explored various methods for effectively and safely delivering genetic material into target cells. This research contributes to the development of gene therapies for treating or preventing certain diseases.

Initially, Alter investigated different gene delivery strategies, including extracellular vesicles, viruses, and lipid nanoparticles (LNPs). He then enhanced the lipid composition of LNPs, incorporating naturally occurring lipids or extracellular vesicles – systems that facilitate gene delivery in organisms. These novel formulations substantially improved the efficacy and potency of LNPs both *in vitro* and *in vivo*. This improvement was primarily due to enhanced cellular uptake and processing in target cells. Furthermore, he investigated the behavior and efficacy of different LNP formulations in animal models. The distribution and circulation observed in zebrafish larvae provide valuable insights into the behavior of LNPs.

Claudio Alter's research has provided a deeper understanding of LNPs, paving the way for the future development of effective and potent gene therapies based on lipid nanoparticles.

Video: https://youtu.be/xR6OzF1z6Sg

Media release: https://bit.ly/49GHfcf

Publication: https://bit.ly/3Ny0QT6

Combining the benefits of two systems

In his doctoral dissertation, Dr. David Jaeger developed an optomechanical platform. The resulting interaction between light and mechanical vibrations has various potential applications, including in highly sensitive sensors or for the generation of quantum states.

The platform is based on an optical resonator, in which light is reflected back and forth with the greatest possible frequency. Within this resonator, researchers position a mechanical structure that can produce the vibrating motion. Thanks to the resonator, the interactions between light and the mechanical element are intensified by several orders of magnitude. This setup can be used not only to accurately measure the movements of the mechanical structure, but even to control the structure using light.

Jaeger implemented the optical cavity using two glass fibers with mirror-coated ends. For the mechanical resonator positioned between the two fibers, he used hexagonal boron nitride (hBN) flakes suspended over holes in a silicon nitride membrane. Given the special properties of the two-dimensional hBN, the resonator absorbs only a small amount of light and ensures long-lasting mirroring.

Publication: https://bit.ly/3RM2tiF

Dynamic structures ensure selective transport

In his doctoral thesis, Dr. Toshiya Kozai studied nuclear pore complexes.

Nuclear pore complexes serve as selective gateways that control the exchange of biomolecules between the cytoplasm and nucleus in eukaryotic cells. These gateways consist of a cylindrical structure in the nuclear envelope with a central channel of about 50 nanometers in diameter in which spaghetti-like proteins, known as disordered proteins, act as a permeability barrier. They selectively allow molecules "tagged" with a transport factor to pass through while preventing the entry of nonspecific molecules.

In his work, Kozai studied the permeability barrier of individual nuclear pore complexes of wild-types and certain mutants using a high-speed atomic force microscope. This microscope can image biomolecules at a resolution of a few nanometers and, because of its speed, can generate a film that reproduces the dynamics of structural changes.

The results demonstrate that the disordered proteins in the central channel exhibit dynamic fluctuations and, together with various transport factors, form a highly dynamic structure. They play a crucial role in the functionality of the barrier and ensure a fast and adaptive response.

Publication: https://bit.ly/3S2iMXw

Joanan López Morales completed his doctoral thesis at the Department of Chemistry at the University of Basel. He is currently a postdoctoral fellow at Roche.

Jacopo Oswald was associate member of the SNI PhD School and conducted research for his doctoral thesis at Empa.

"Attending the interdisciplinary SNI PhD School enriched my perspective significantly, a crucial factor for addressing complex challenges in today's technological landscape."
Dr. Jacopo Oswald,
former associate doctoral student
at the SNI PhD School

Protein variants presented by yeasts

In his doctoral thesis, Dr. Joanan López Morales further improved a valuable tool for protein engineering and the directed evolution of proteins, known as yeast surface display.

In yeast surface display, yeast cells are equipped with specific genes. This allows the yeast cells to form different versions of a protein on the cell surface, which then interact and bind to other cells, proteins or antibodies. The binding allows an automated process to select the yeast cells carrying proteins of interest on their surface.

López Morales developed new systems and proteins with improved properties using yeast surface display as a central technology platform, expanding the range of applications in biotechnology, biochemistry and clinical settings. For instance, he focused on developing a serological immunoassay for the detection of anti-SARS-CoV-2 immunoglobulins in human sera. In another part of his dissertation, he designed a new yeast surface display system in which the copy number of proteins on the yeast cells can be adjusted using a genetic circuit – a long-sought enhancement supporting its use in high-throughput screening. In addition, López Morales designed a strategy for new binding functions and engineered a first-rate non-antibody scaffold with enhanced mechanical properties for immunotherapies.

Publication: https://bit.ly/3GR6IbV

Interfaces between graphene and organic semiconductors

In his doctoral thesis, Dr. Jacopo Oswald focused on interfaces between graphene and different organic semiconductors. The combination of the two-dimensional material graphene, which has special electrical, thermal and mechanical properties, with the adaptable and versatile three-dimensional organic semiconductors promises the development of components for electronic devices that can help to overcome some intrinsic limitations of traditional silicon-based devices.

Oswald focused on investigating the charge transport properties of graphene/organic semiconductor interfaces and the potential for device integration. He first grew graphene on copper foils and then transferred the graphene layers to silicon and various organic materials using the wet transfer technique. By means of characterization techniques such as atomic force microscopy and Raman spectroscopy, in combination with the electrical characterization of the interfaces, he was able to show how organic molecules interact with and influence the electronic properties of graphene. In doing so, he considered both the effect of the molecules on in-plane charge transport in the graphene layer and temperature-dependent charge carrier injection across the vertical heterostructures.

Publication: https://bit.ly/41xs4zl

For Jacopo Oswald, the membership of the SNI PhD School as an associate doctoral student was an enriching experience.

A valuable addition
Associate doctoral students

Doctoral students carrying out research as part of a dissertation project funded by the SNI are members of the SNI PhD School. Particularly interested and qualified doctoral students whose funding comes from other sources can also be incorporated as "associate doctoral students" if their supervisors are members of the SNI network and request their inclusion.

These associate doctoral students become part of the SNI network, attend events organized for the PhD School, and benefit from interdisciplinary exchange.

So far, two doctoral students have taken advantage of the scheme. After Dr. Tamara Aderneuer from the CSEM, Dr. Jacopo Oswald became the first doctoral student from Empa to complete his doctoral dissertation as an associate doctoral student in 2023. Attending SNI courses provided a valuable addition to his education, and he was delighted with this added value. In the future, the SNI plans to further expand the PhD School's associate membership scheme.

In 2023, former SNI doctoral student Thomas Mortelmans received the 2023 PSI-Impuls Award.

Outstanding
PSI-Impuls Award for Thomas Mortelmans

The Paul Scherrer Institute PSI and the PSI-Impuls Association 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 a new kind of 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.

For his doctoral dissertation, which he began in 2018, Mortelmans worked at the Paul Scherrer Institute. After completing the dissertation with top marks, he swapped academia for industry and joined Johnson & Johnson, where is currently working as a Device Scientist.

Article: https://bit.ly/3YOrYRh

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

Video on the SNI PhD School: https://youtu.be/9dqX_vimmcY

In short videos, Annika Huber and Antonia Ruffo talked about their research and motivation.

Women in the nanosciences
Role models from the PhD School

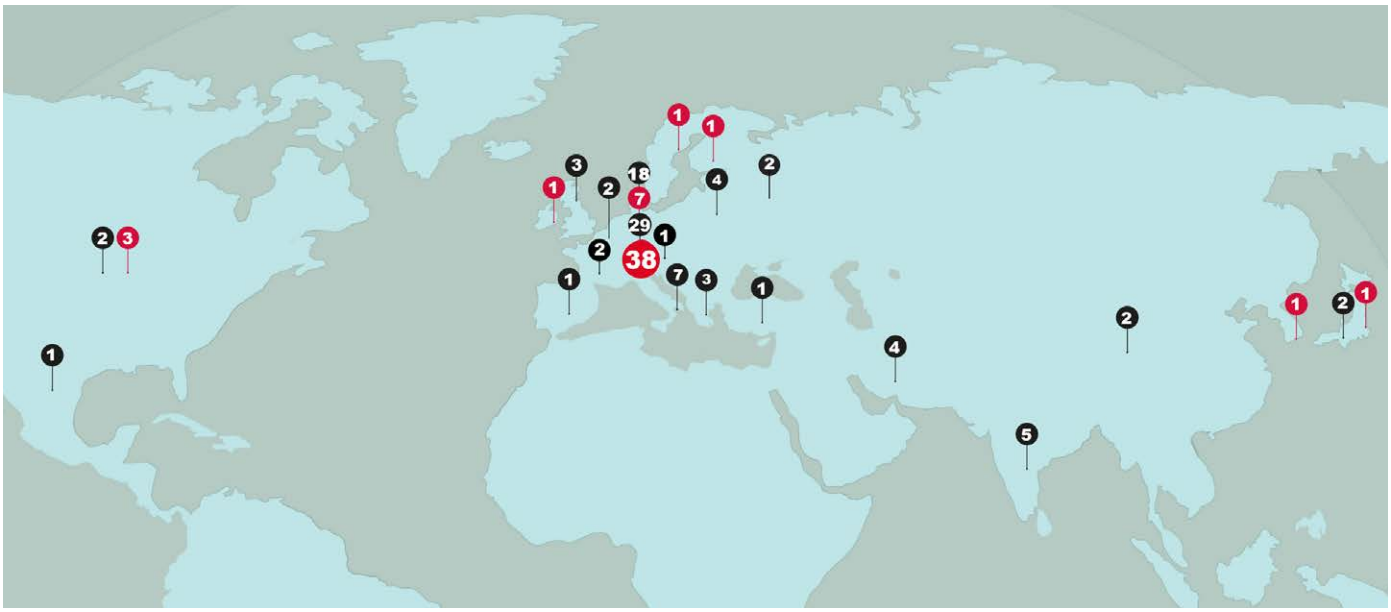
By the end of 2023, two female doctoral students from the SNI PhD School have participated in the video series "Who are the women in nanoscience?," which was launched by the SNI.

Annika Huber from the Department of Chemistry at the University of Basel is working to develop a nanomaterial that could one day be used in a gas sensor. At the Paul Scherrer Institute, Antonia Ruffo is researching the development of a non-invasive method for measuring the temperature in fuel cells.

Having both followed their own career pathways, the two young women are very much enjoying their current research work and serve as role models for other young women with an interest in the natural sciences in general and the nanosciences in particular.

Videos:

Annika Huber: https://youtu.be/8JxTRe8rRPo
Antonia Ruffo: https://youtu.be/V386tx4PLFA



Overview of the origin of SNI doctoral students enrolled to date (in black) and the countries in which the current graduates were employed at the end of 2023 (in red).
The figures indicate the respective number of the nanoscientists per country. Of all 89 doctoral students enrolled to date, 33% (29 PhD students) came from Switzerland. Of the 53 graduates, 72% (38 graduates) remained in Switzerland after finsihing their PhD theses. (Background image: Designed by Freepik)

At the Annual Event 2023, Alessandro Bruno won the prize for the best poster. Elizaveta Maksimova captivated the audience with an excellent lecture and received the prize for the best talk.

"The SNI Annual Event was a real highlight of the year for me. I was selected to give a talk on my results after the first year of my doctorate. Winning the prize for the best talk was not only unexpected but also a great honor. The experience really boosted my self-confidence!"
Elizaveta Maksimova
Doctoral student from the SNI PhD School and winner of the best talk award at the Annual Event 2023

Special events

Excellent opportunities for interdisciplinary exchange

In 2023, we celebrated the 10th anniversary of the SNI PhD School, which provided another excellent opportunity for an exchange of ideas between members of our network. To mark this occasion, current doctoral students and alumni together with numerous project leaders and members of staff spent a wonderful few hours together as they enjoyed a boat trip on the Rhine. The event was an all-round success and an opportunity for participants to see how doctoral students who completed their theses years ago are still connected with the SNI, have fond memories of their time here in Basel, and continue to maintain the relationships they built.

In January, the doctoral students who are currently carrying out research as part of the SNI all met in Unterwasser for the SNI Winter School "Nanoscience in the Snow." The coordinator of the SNI PhD School, Dr. Andreas Baumgartner, had assembled a varied program of talks from project leaders and doctoral students. Likewise, the Annual Event – which was held in the Canton of Aargau for the first time, at Lake Hallwil – also provided an opportunity for members of the SNI PhD School to discuss and present their research to other scientists from the network in the form of talks and posters.

The doctoral students learn to give presentations such as these professionally as part of a course on rhetoric and communication that they all take once as part of their studies. The course teaches them to present their scientific findings clearly and confidently to an interdisciplinary audience. It is provided specially for SNI doctoral students by the science journalist and communication expert Atlant Bieri.

In spring 2023, the SNI team also organized an information and networking event for SNI doctoral students at Novartis Pavillon. At this event, the students gained an insight into the work of various Novartis employees as well as information and tips on prospective applications to the global pharmaceutical company.

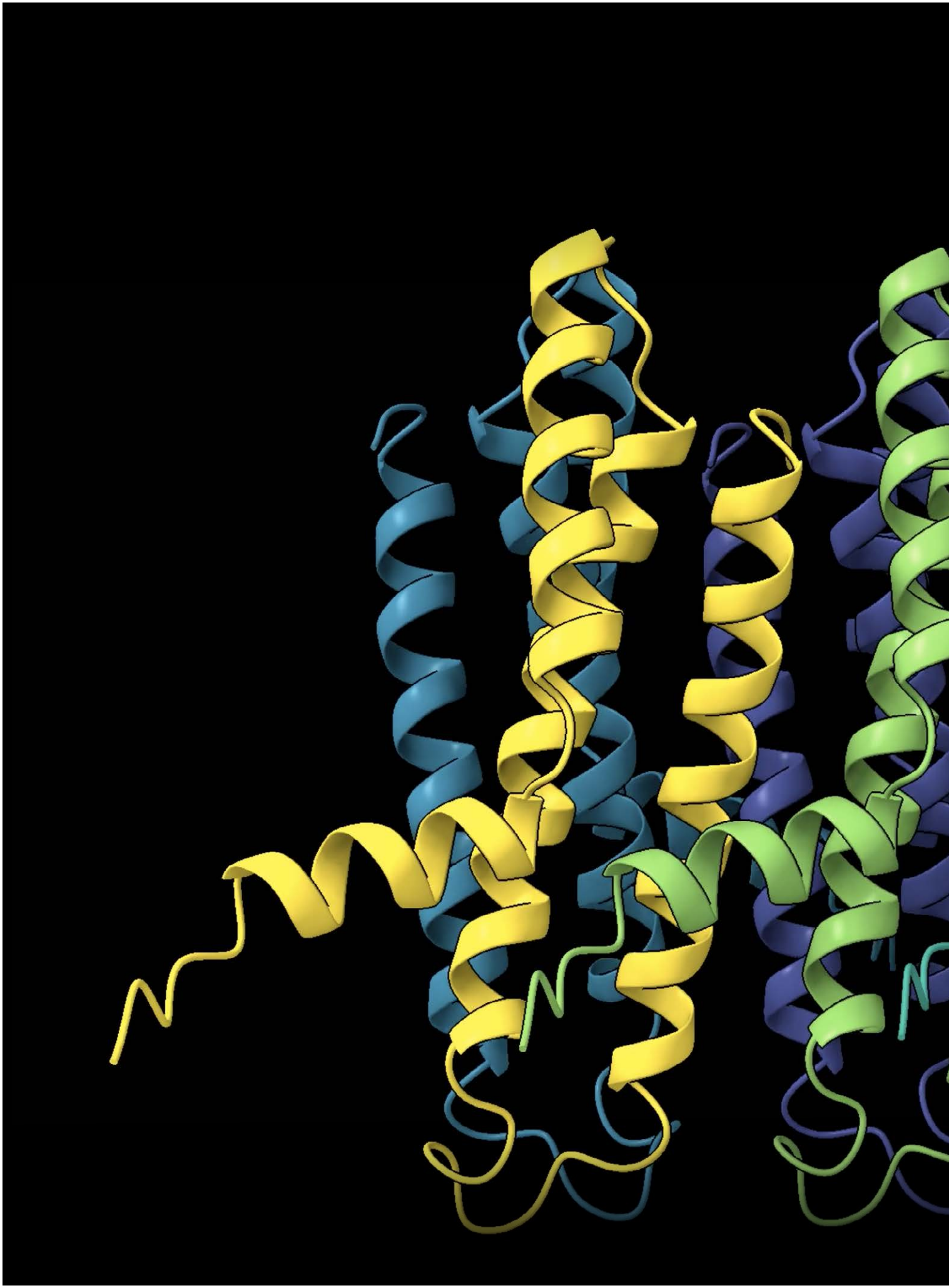
"What I've always valued about the SNI is its cutting-edge research in wide-ranging disciplines and that this work is interlinked in a very appealing manner. With that in mind, I was thrilled to talk to current SNI doctoral students and staff about their research activities at the anniversary celebration. For me, however, my personal highlight was to see former PhD colleagues again and talk to them about my experiences outside the world of research."

Dr. Arne Barfuss
Team Leader for Product Development and Power Semiconductors, Robert Bosch GmbH

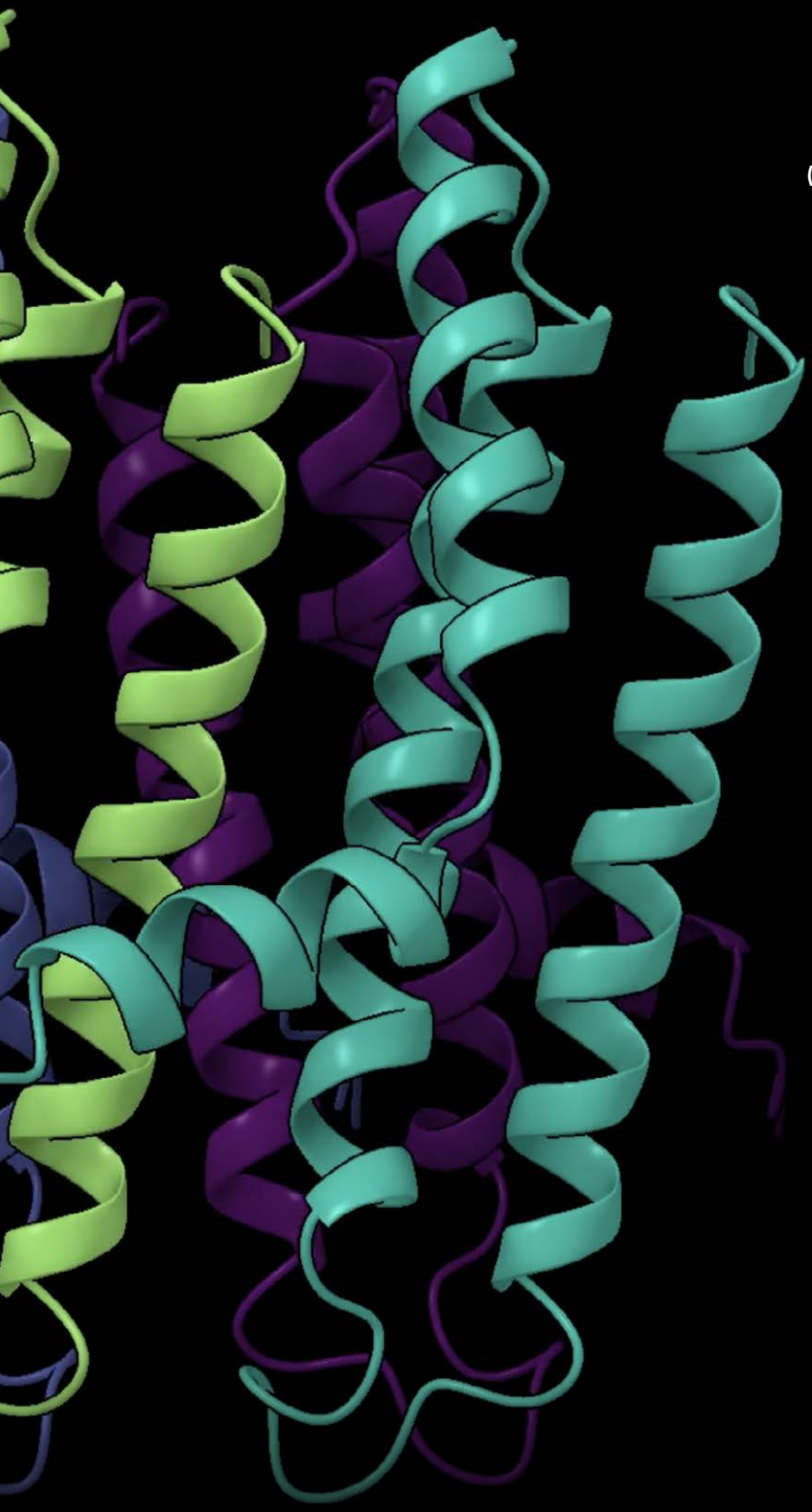
"The rhetoric course with Atlant Bieri was very informative and encourages you to think about exactly how to communicate things. It's very helpful both for presentations and for job interviews!"

Josh Zuber, doctoral student at the SNI PhD School

As part of the SNI PhD School's 10th anniversary celebration, current and former doctoral students together with project leaders met for an inspiring exchange of ideas on the Rhine.



A better understanding of cell death



Cells do not simply burst at the end of their lives. Rather, the protein ninjurin-1 provides breaking points for cell membrane rupture.
More information on this research on page 27.
(Image. M. Degen Biozentrum, University of Basel)

Research: Varied and high-quality

The basis of innovations often lies in exploring fundamental scientific principles. Understanding how systems work is the first step toward potential applications. Accordingly, basic research plays a vital role at the Swiss Nanoscience Institute.

A wide range of research fields are addressed within the SNI network. Most projects revolve around understanding quantum physical phenomena and biomedical questions. Above all, researchers in the SNI network focus on making the nanoworld "visible" and on producing nanoscale structures and materials.

In 2023, researchers from the SNI network published 45 publications in respected journals. A small selection of these publications is presented here to provide insights into the wide-ranging subject areas and results obtained. The various research findings help us learn to understand the special laws that rule the nanoworld, paving the way for various applications.

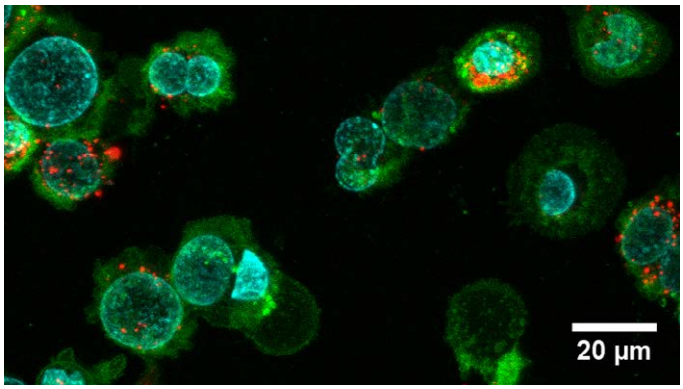
New production process for therapeutic nanovesicles

Researchers at the University of Basel have developed an efficient method for the preparation of therapeutic nanovesicles, thereby fulfilling a key prerequisite for industrial production. The method also paves the way for research into areas such as immunotherapy treatments for cancer.

Video: https://youtu.be/xR6OzF1z6Sg

Media release: https://bit.ly/49GHfcf

Original publication: https://www.nature.com/articles/s42003-023-04859-2



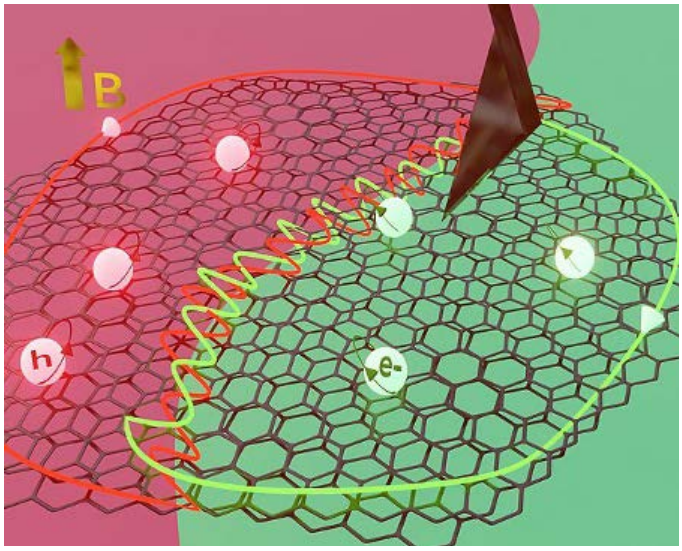
The extracellular vesicles (red) produced using the new technique are absorbed *in vitro* by immune cells (green; nucleus in turquoise) and can therefore influence an organism's immune response. (Image: C. Alter, Department of Pharmaceutical Sciences, University of Basel)

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.

Media release: https://bit.ly/49mDcSJ

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



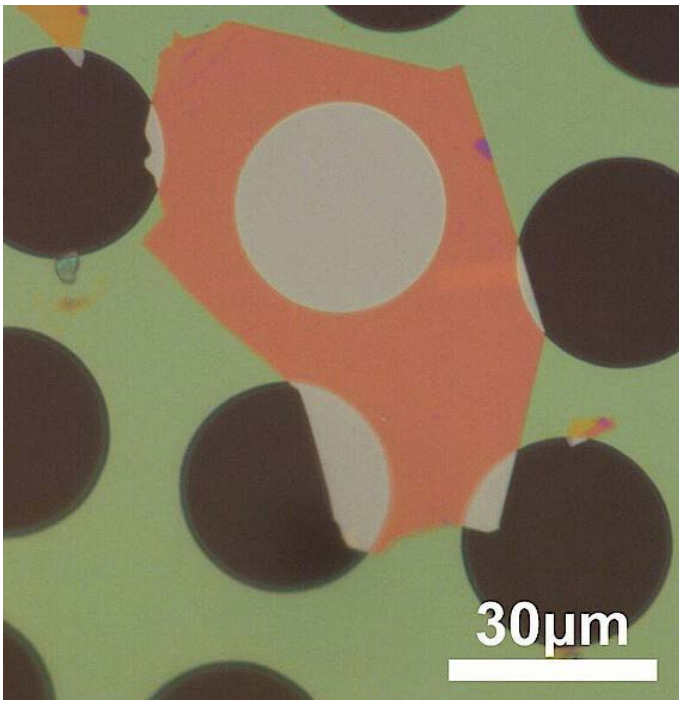
The two graphene layers are twisted relative to one another by the magic angle of approximately 1.1°. Depending on how many electrons a single cell is filled with, the graphene exhibits different electrical and magnetic properties. Measurements can be made using the oscillating tip of an atomic force 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)

Promising combination

Researchers from the SNI network have fabricated a tiny optomechanical device consisting of a two-dimensional, free-hanging hexagonal boron nitride (hBN) layer suspended above holes in a silicon nitride membrane. The tiny hBN drum can be excited and then begins to vibrate, acting as a mechanical resonator.

SNI post: https://bit.ly/3V7ivGb

Original publication: https://pubs.acs.org/doi/10.1021/acs.nanolett.3c00233

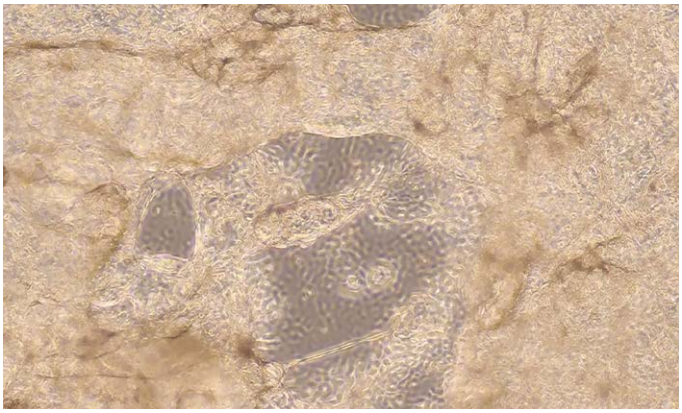


A two-dimensional boron nitride layer is suspended above holes in a silicon nitride membrane. The device could be used as an optomechanical sensor. (Image: D. Jaeger, Department of Physics, University of Basel)

Bioink for various tissues

3D-printed artificial biological tissues can be used as models for pharmacological tests. Researchers from the SNI network have been investigating the optimal conditions for the printing process and subsequent tissue regeneration. They have now presented a new, cost-effective hydrogel that is suitable for use as a "bioink" and can be adapted for the printing process of different tissue types and conditions.

Original publication: https://www.mdpi.com/2313-7673/8/1/27



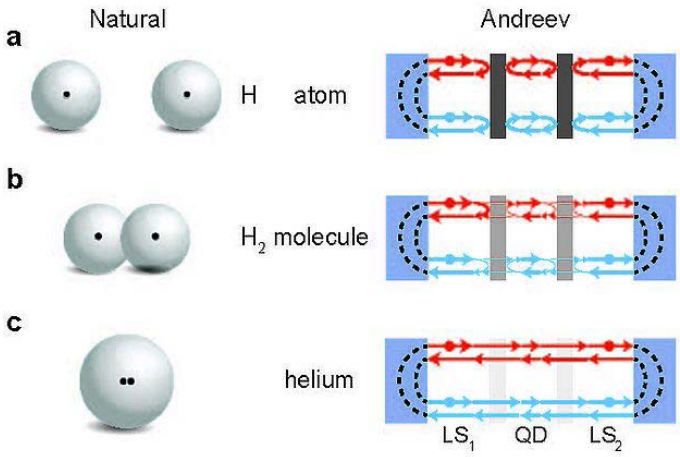
The researchers use a hydrogel as "bioink" for heart muscle cells. (Image: F. Züger, FHNW)

"Andreev chemistry" on a nanowire

Researchers from the SNI network 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 provide important insights for the development of new quantum states.

Media release: https://bit.ly/4764gor

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



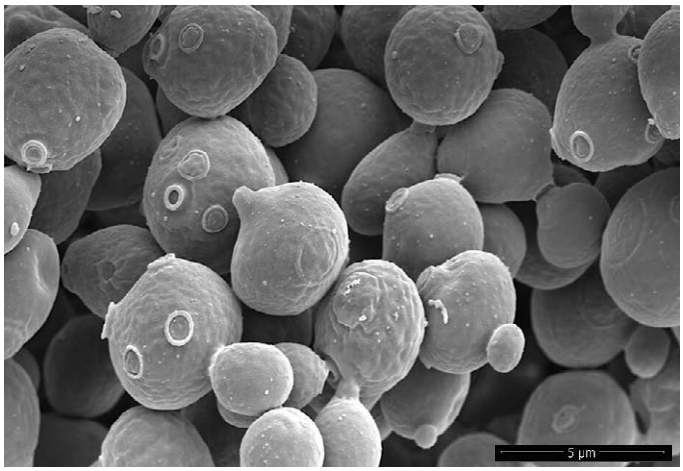
a) Andreev atoms: At high barriers, single, independent Andreev bound states are formed — analogous to two single hydrogen atoms.
b) Andreev molecules: If the barriers between the segments are reduced, coupled Andreev bound states are formed — analogous to a hydrogen molecule.
c) Andreev helium: At very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

Method to improve yeast cell display

Researchers from the SNI network have developed a method to improve what is known as yeast surface display – a fundamental tool for protein engineering and targeted protein evolution.

SNI post: https://bit.ly/3wmRq7n

Original publication: https://pubs.acs.org/doi/full/10.1021/acssynbio.2c00351



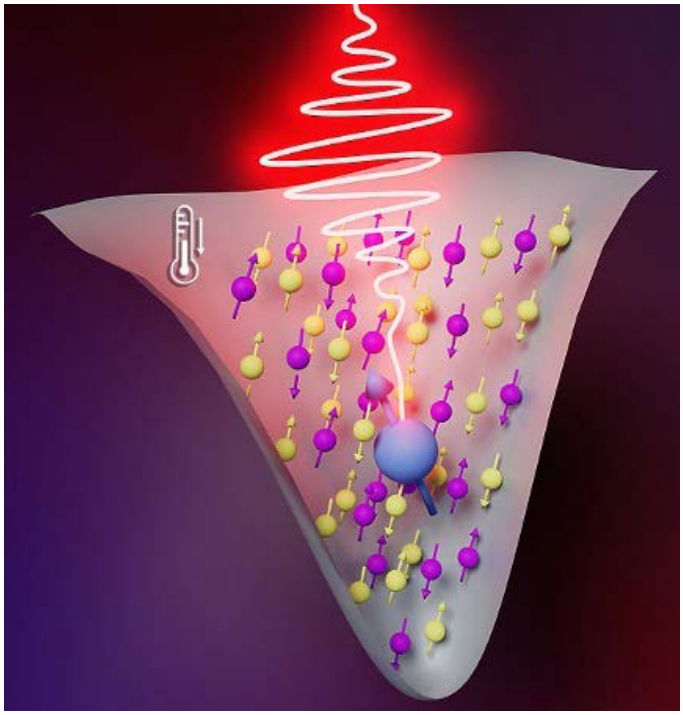
Genetically modified cells of baker's yeast (*Saccharomyces cerevisiae*) synthesize proteins of interest on their cell walls using yeast surface display, a tool that enhances engineering and directed evolution of proteins. (Image: © M. Oeggerli/Micronaut, supported by University Hospital Basel and the Biozentrum of the University of Basel)

Increased coherence thanks to cooling

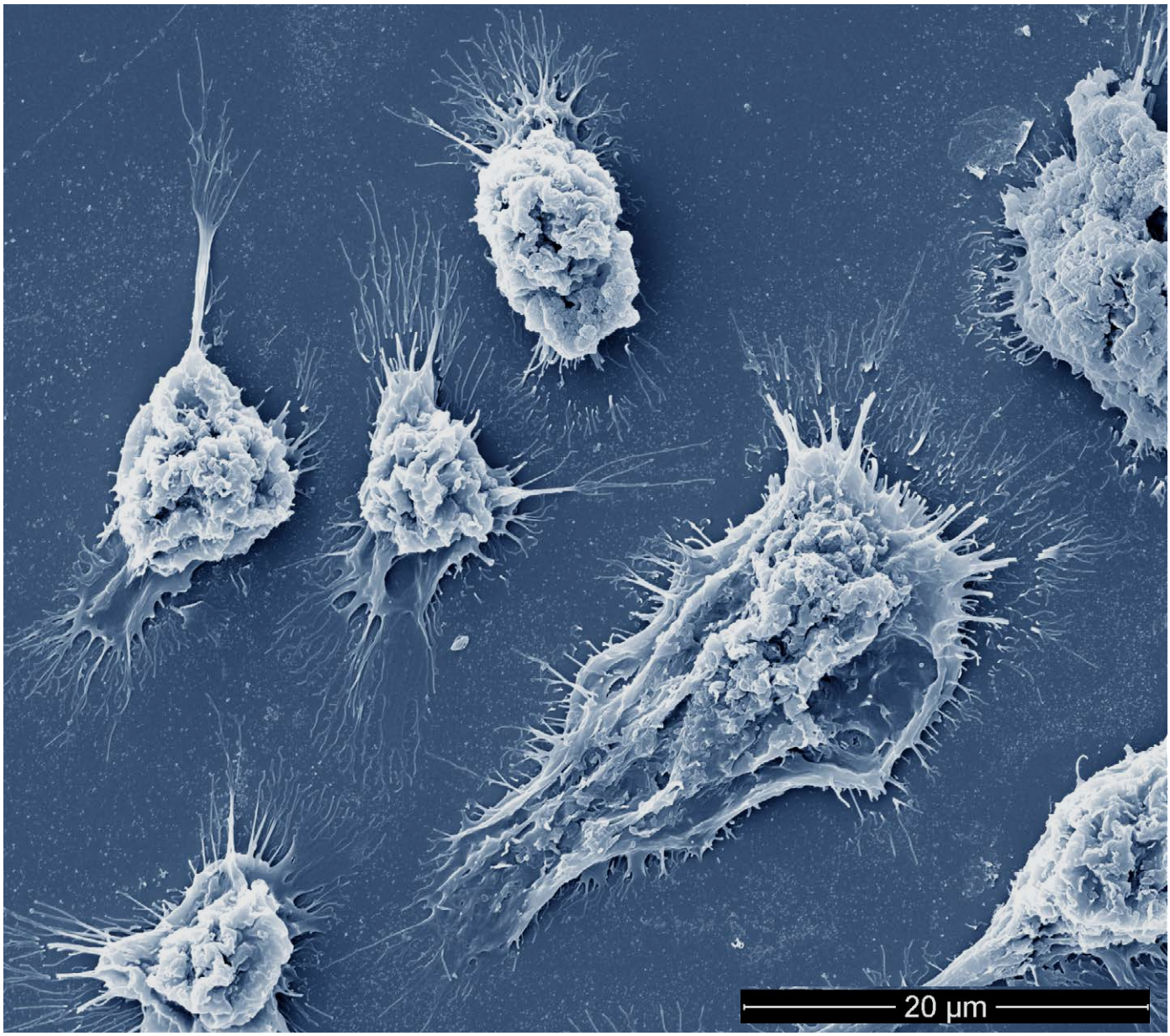
A team of researchers from the SNI network has increased the coherence of an electron spin in a gallium arsenide quantum dot to over half a microsecond for the first time. The scientists achieved the more than 150-fold increase in coherence time by using the electron spin-nuclear spin interaction, which causes the spin system to cool down to 100 microkelvins.

SNI post: https://bit.ly/3uwGrrC

Original publication: https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.131.210805



By drastically reducing the fluctuations of the nuclear spins, it is possible to increase the coherence time of the electron in the quantum dot. (Image: Department of Physics, University of Basel)



Scanning electron micrograph of dying cells. (M. Degen (Biozentrum) and Nano Imaging Lab (Swiss Nanoscience Institute, University of Basel))

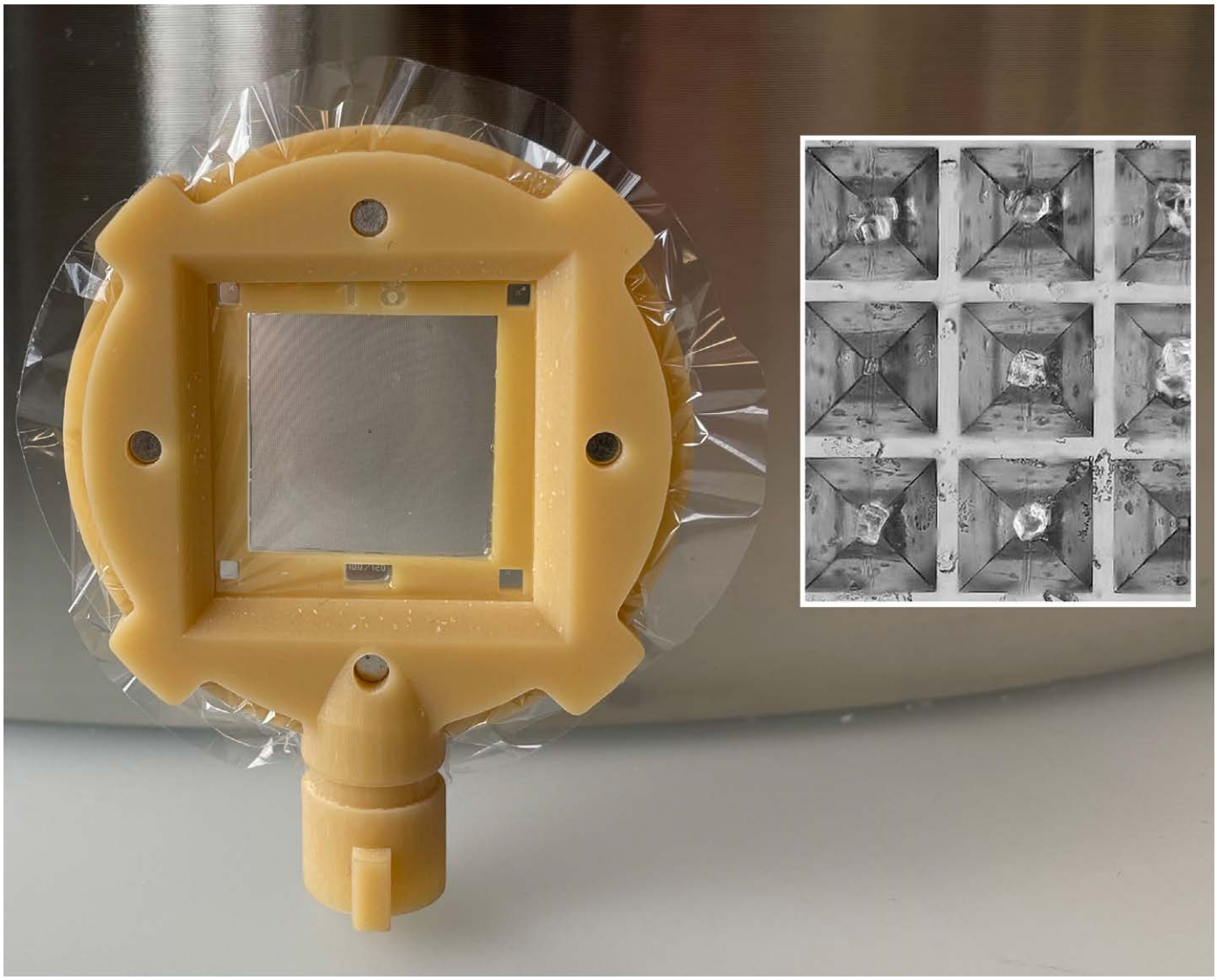
Under control to the very end – how our cells kill themselves

Every day, millions of cells die in our body. Contrary to what was previously assumed, cells do not simply burst at the end of their lives. Rather, a specific protein serves as a breaking point for cell membrane rupture. Researchers from the SNI network have now been able to elucidate the exact mechanism at the atomic level.

Video: https://youtu.be/Smvc06udcS0

Media release: https://bit.ly/42RfwDC

Original publication: https://www.nature.com/articles/s41586-023-05991-z



The polymer carrier is mounted in a sample holder. The 2 x 2 cm^2 membrane contains 26,000 pyramidal cavities. The inset shows protein microcrystals aligned within the 100 µm sized cavities (black-and-white image). (Image: Paul Scherrer Institute)

Novel polymer sample holder

Researchers from the SNI network have developed and tested a new type of polymer sample holder that is ideal for studying crystals at synchrotron and X-ray free-electron laser sources. The crystals are applied to the transparent microstructured polymer membrane of the sample holder, allowing their position to be precisely determined prior to analysis. This work lays the foundation for developing a process for low-cost mass production of the sample holder.

Original publication: https://journals.iucr.org/m/issues/2023/06/00/zf5021/

Electron beam lithography also possible on uneven surfaces

Researchers from the SNI network have developed a new method for applying electron beam lithography to uneven surfaces. They are working with a floating resist that enables uniform coating. This method will help the researchers place electrical contacts on the tip of an atomic force microscope cantilever and thus produce highly sensitive probes for studying electric and magnetic fields.

Video: https://youtu.be/UBcYtnmA9Hc

SNI post: https://bit.ly/42RgtMc

Original publication: https://doi.org/10.1063/5.0127665

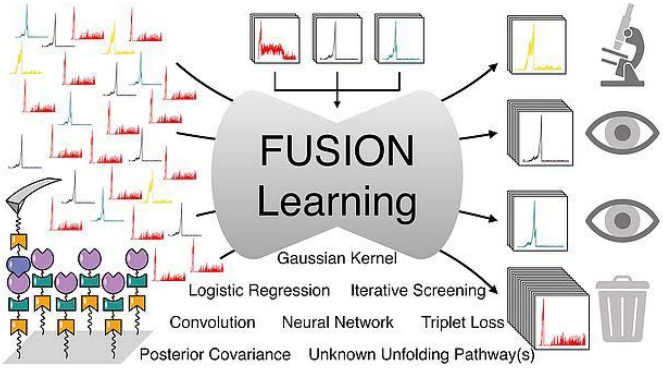
The developed method will help the researchers place electrical contacts on the tip of an atomic force microscope cantilever and thus produce highly sensitive probes for studying electric and magnetic fields.

Better classification with machine learning

Researchers from the SNI network have presented a new machine learning technique specifically designed to enhance the analysis of protein unfolding using atomic force microscopy (AFM) data. The method is characterized by the fact that the program used repeatedly analyzes the data and thereby allows more precise and efficient data classification.

SNI post: https://bit.ly/3UQ4QTA

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



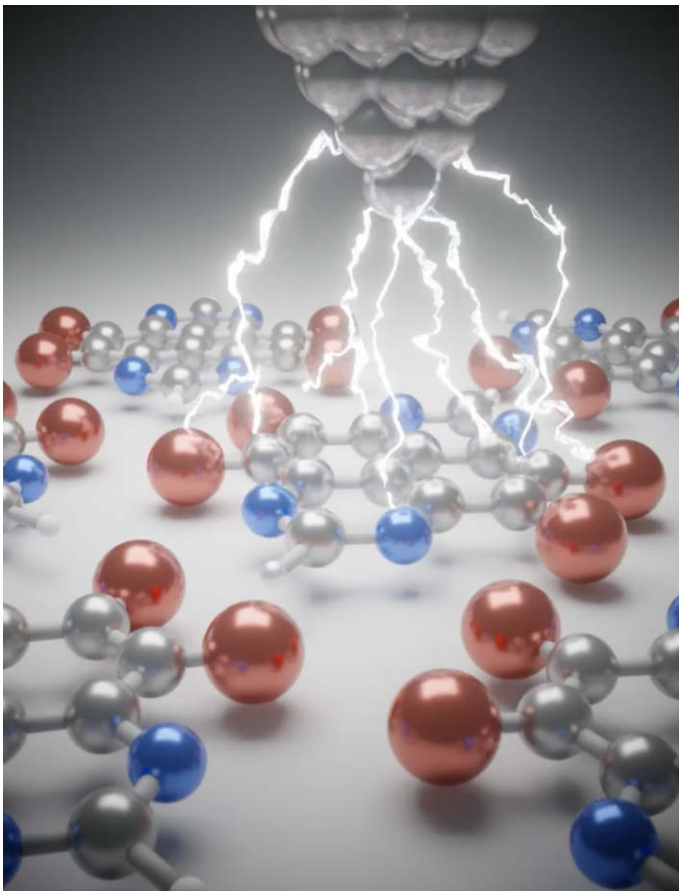
Machine learning enhances the classification of unfolding patterns in proteins. (Image: V. Doffini, Department of Chemistry, University of Basel)

Vibrations of molecules visualized and studied

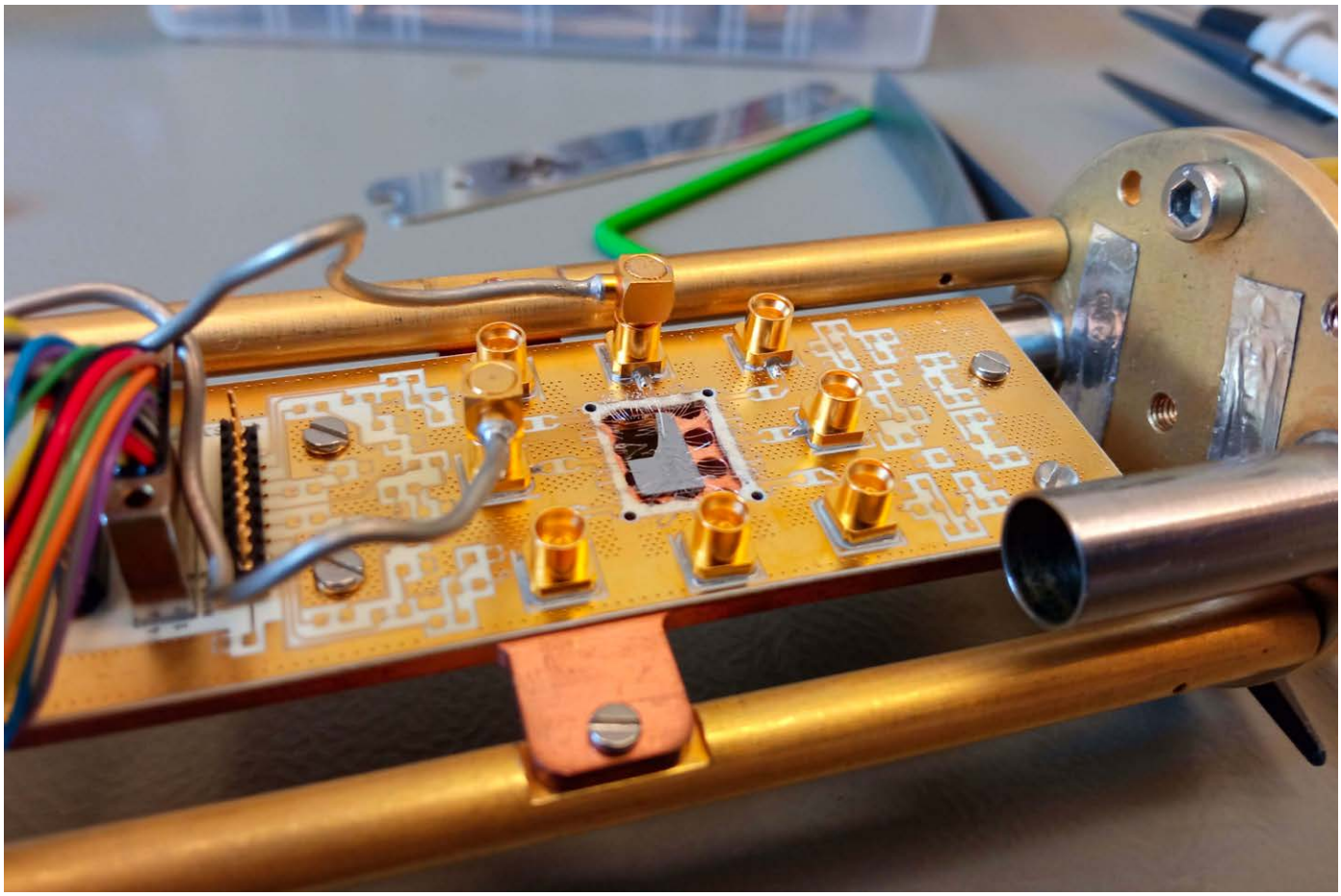
Researchers from the SNI network have developed a new method for imaging the vibration of molecules. The scientists studied a specific pyrene molecule on a silver surface using a scanning tunneling microscope (STM). Understanding molecular vibration is of crucial importance in a wide range of areas in molecular electronics and spintronics and in the development of quantum computers, for example, since vibrations affect transport properties and spin dynamics.

SNI post: https://bit.ly/3UPtBzf

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



TBTAP molecules on a silver surface are initially negatively charged. If a positive voltage is applied to the tip of an STM and this is then 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)



The researchers cooled the circuit board with a semiconductor sample (chip in the center) to milli-Kelvin temperatures in order to investigate the properties of the photon storage devices. (Image: J. Ungerer, Department of Physics, University of Basel)

Photons survive difficult conditions

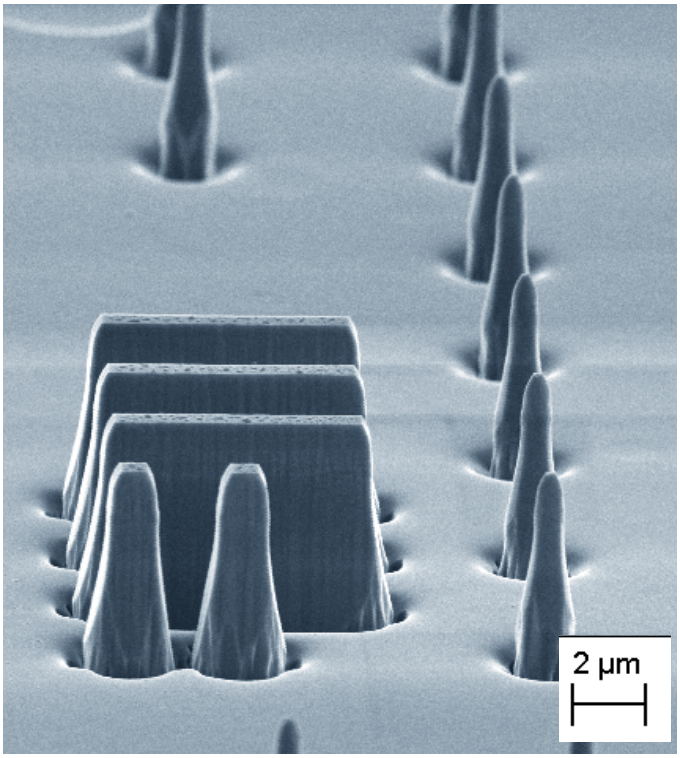
SNI physicists have investigated whether and how long microwave photons survive under adverse conditions. They found that special photon memories can be produced with sufficient quality even in close proximity to oxides, which are widely used in semiconductor technology. The photon memories, known as resonators, can therefore be used as sensors for quantum effects in semiconductor structures.

Original publication: https://doi.org/10.1140/epjqt/s40507-023-00199-6

Candidate for quantum sensing under extreme conditions

Researchers from the SNI network have presented a robust and scalable approach to using negatively charged silicon-vacancy (SiV) centers in diamond nanostructures. These vacancy centers, in which a silicon atom is placed between two vacancies in the diamond lattice, are promising candidates for quantum sensing based on single electron spins at very low temperatures and in strong magnetic fields.

Original publication: https://pubs.acs.org/doi/10.1021/acs.nanolett.3c03145



The researchers embed near-surface silicon vacancy centers in diamond nanopillars. (Image: J. Zuber, Department of Physics, University of Basel)

Method for measuring charge in quantum dots

Researchers from the SNI network have presented an approach to studying the charge configuration of quantum dots formed in germanium nanowires with a silicon cladding. For this, they use a special superconducting resonator based on niobium-titanium nitride and couple it with a double quantum dot in the germanium-silicon nanowire.

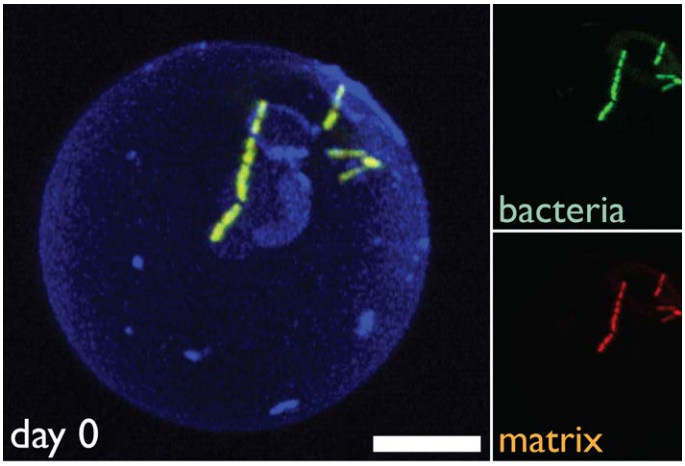
Original publication: https://iopscience.iop.org/article/10.1088/2633-4356/ace2a6

Artificial cells made from polymer and biomolecule building blocks

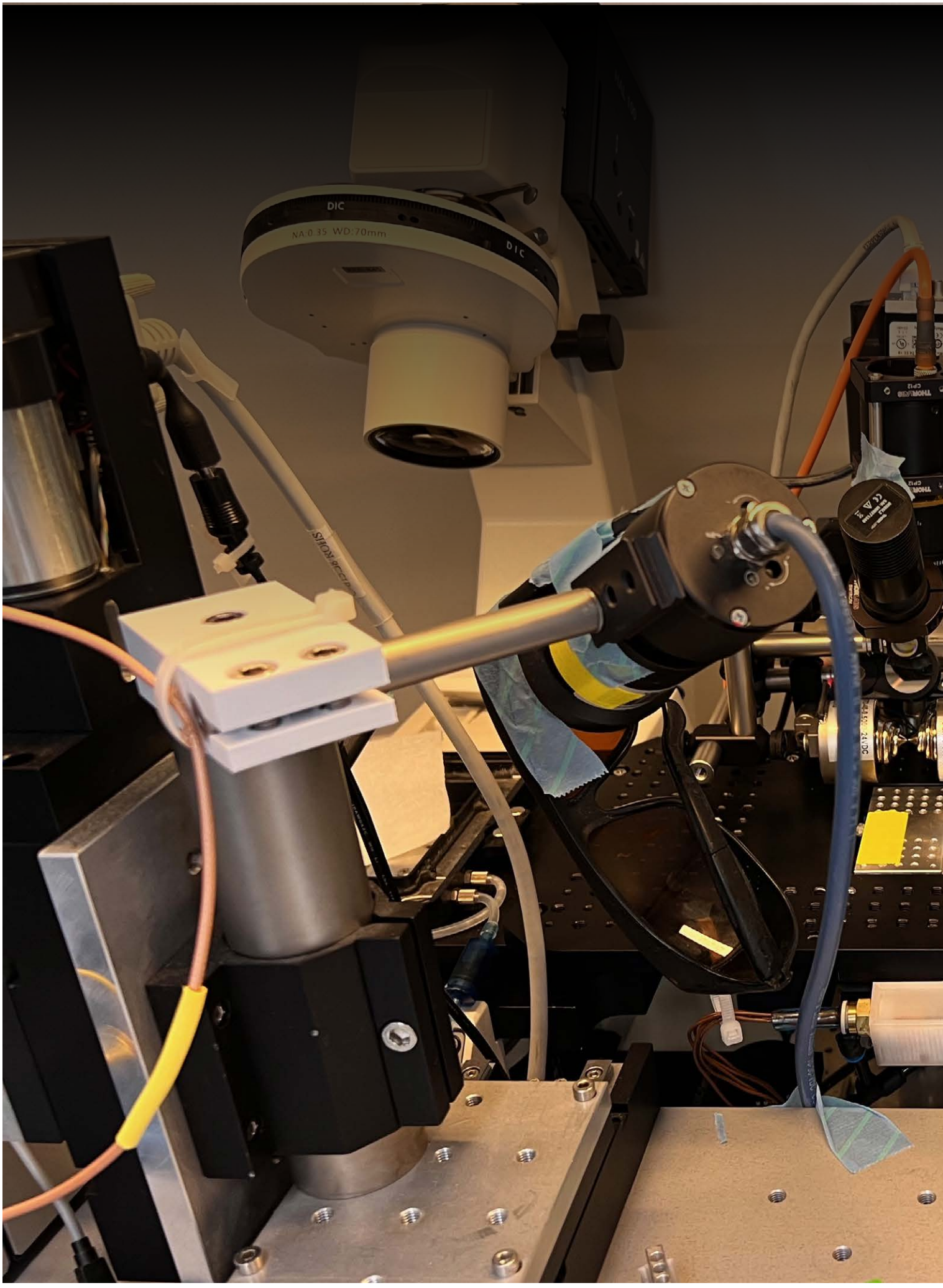
Artificial organelles and cells built from a multitude of synthetic building blocks in combination with biomolecules serve as tools for gaining a better understanding of fundamental biological processes and open up new ways of producing multifunctional systems. Researchers from the SNI network describe artificial compartments of this kind whose scaffold consists mainly of polymers. Polymers are of particular interest due to their chemical diversity and the possibility of adjusting the properties of their assemblies such to allow biomolecules to preserve their integrity and activity when inserted/encapsulated inside. The researchers apply such advanced compartments to provide a controlled and confined space for high throughput screening of bacteria and evaluate the efficacy of antibiotics.

Original publications: https://onlinelibrary.wiley.com/doi/epdf/10.1002/advs.202305837

https://onlinelibrary.wiley.com/doi/full/10.1002/advs.202307103



Researchers are investigating the effectiveness of antibiotics against bacteria that are trapped in a polymer vesicle. (Image: Reproduced under terms of the CC-BY 4.0 license. Copyright 2023 Advanced Science published by Wiley-VCH GmbH)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Innovation through collaboration

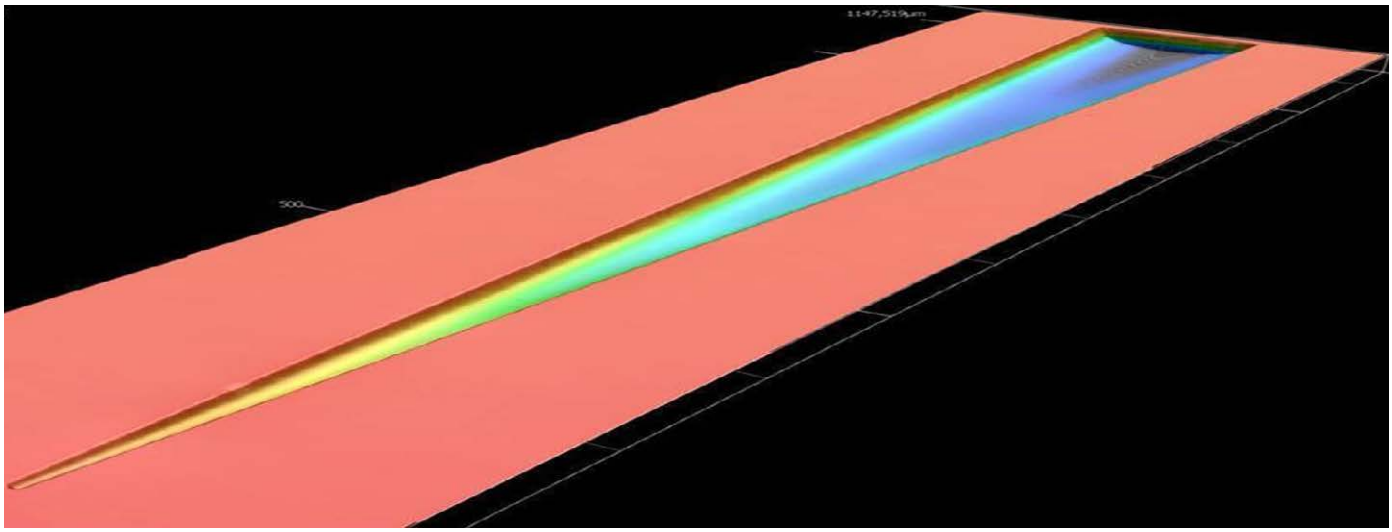
As part of the Nano-Argovia program of the SNI, interdisciplinary teams from research institutions work closely with industrial partners from Northwestern Switzerland. Networking with companies ensures knowledge and technology transfer, helping to solve wide-ranging challenges facing society.
More information from page 34 onward

Several projects supported by the SNI have contributed to the development of the cryoWriter, which enables the efficient preparation of biological samples for cryo-electron microscopy. In collaboration with the start-up cryoWrite, the researchers are testing new modules to increase the functionality.
More information on page 41

Nano-Argovia program: Knowledge and technology transfer with companies from Northwestern Switzerland

Constant exchange between academic institutions and industry is a vital part of promoting innovation at companies. The SNI supports this process of knowledge and technology transfer through its Nano-Argovia program, which has existed since the SNI was founded. This successful program has enabled the SNI to support over 100 projects so far with companies from Northwestern Switzerland, paving the way for numerous nanotechnology applications.

In 2023, nine projects were funded as part of the Nano-Argovia program — five new ones and four that had begun in 2022. Four of the industrial partners were from the Canton of Aargau, five hailing from one of the two Basel half-cantons. Participating as academic partners in 2023 were mainly the University of Applied Sciences and Arts Northwestern Switzerland in Muttenz and Windisch and the Paul Scherrer Institute. Likewise, colleagues from CSEM Allschwil, the University of Basel and the ANAXAM Technology Transfer Center also contributed their expertise to the success of Nano-Argovia projects.



Example of a half capillary — a pointed funnel structure with a concave (hollow) design. (Image: PSI)

Smooth mirrors for X-rays

In the Nano-Argovia project CAPOFOX, an interdisciplinary team has been working on the further development of lithographic methods for the production of micro-optical components made from polymers. These so-called capillary optics are elongated, cylindrical mirrors that focus light on a point by reflection. As they are intended to be suitable for both ultraviolet and X-rays, the mirrors must have a very low surface roughness.

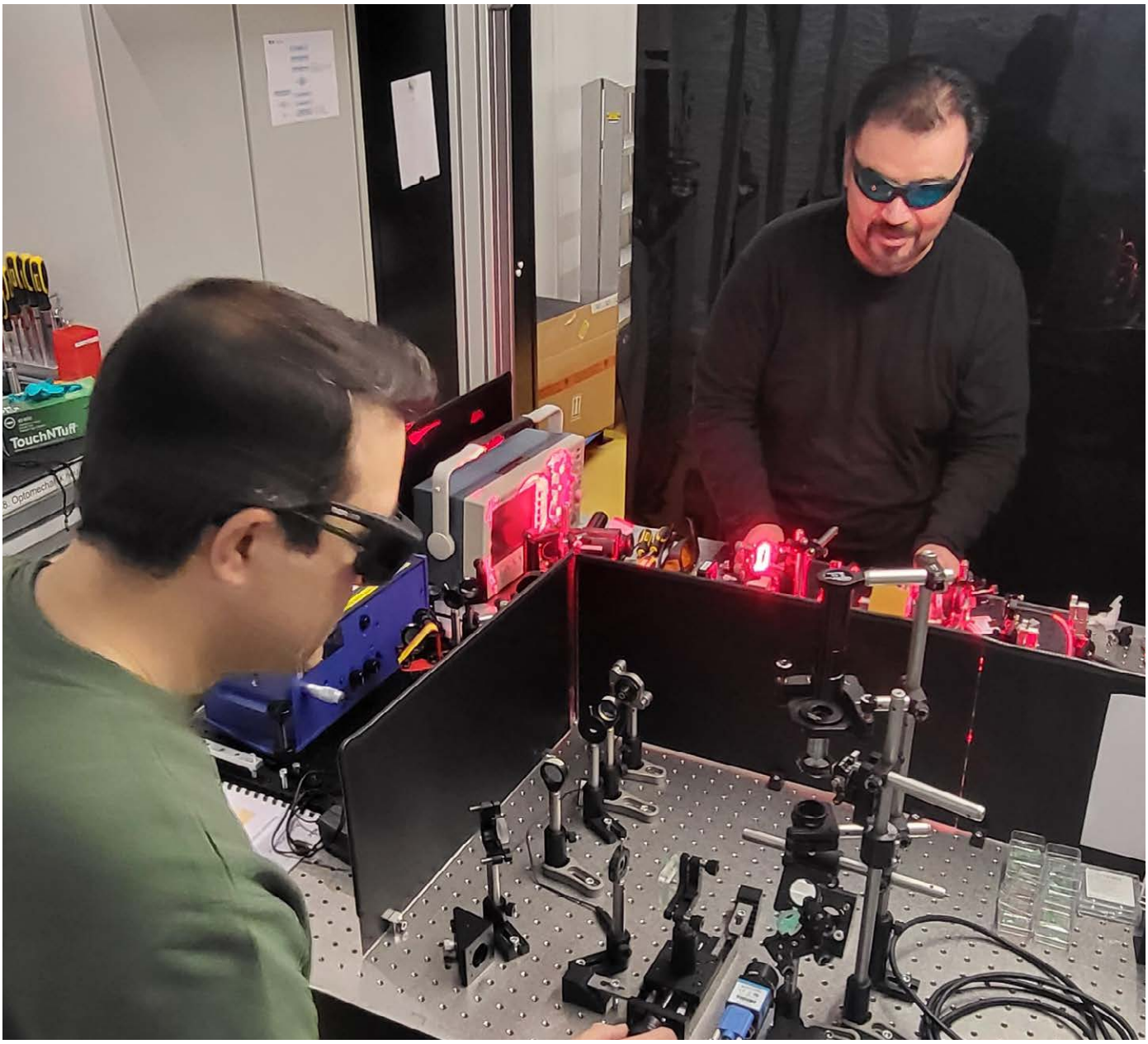
The researchers combined tool-, laser-, design- and material-related aspects in order to develop a method that leads to an elongated three-dimensional structure of the polymers. They initially concentrated on the production of stepless, semi-cylindrical indentations and on developing the basis for measuring nanoroughness using various methods.

Cooperation with: XRnanotech // Paul Scherrer Institute // FHNW School of Life Sciences

Project description: https://bit.ly/3ThvoMr

"The CAPOFOX project brings together outstanding expertise in the preparation and examination of ultrasmooth surfaces. The chosen methodology is innovative and is also remarkable due to its numerous high-impact future applications. We're very much looking forward to accompanying and supporting these developments."

Dr. Florian Döring,
CEO and founder of XRnanotech



Maurizio Gullo and Bojan Resan are working on the optical tweezer setup and the new red diode pumped alexandrite laser. (Image: FHNW Windisch)

Efficient femtosecond laser as optical tweezer for 3D printing of cells

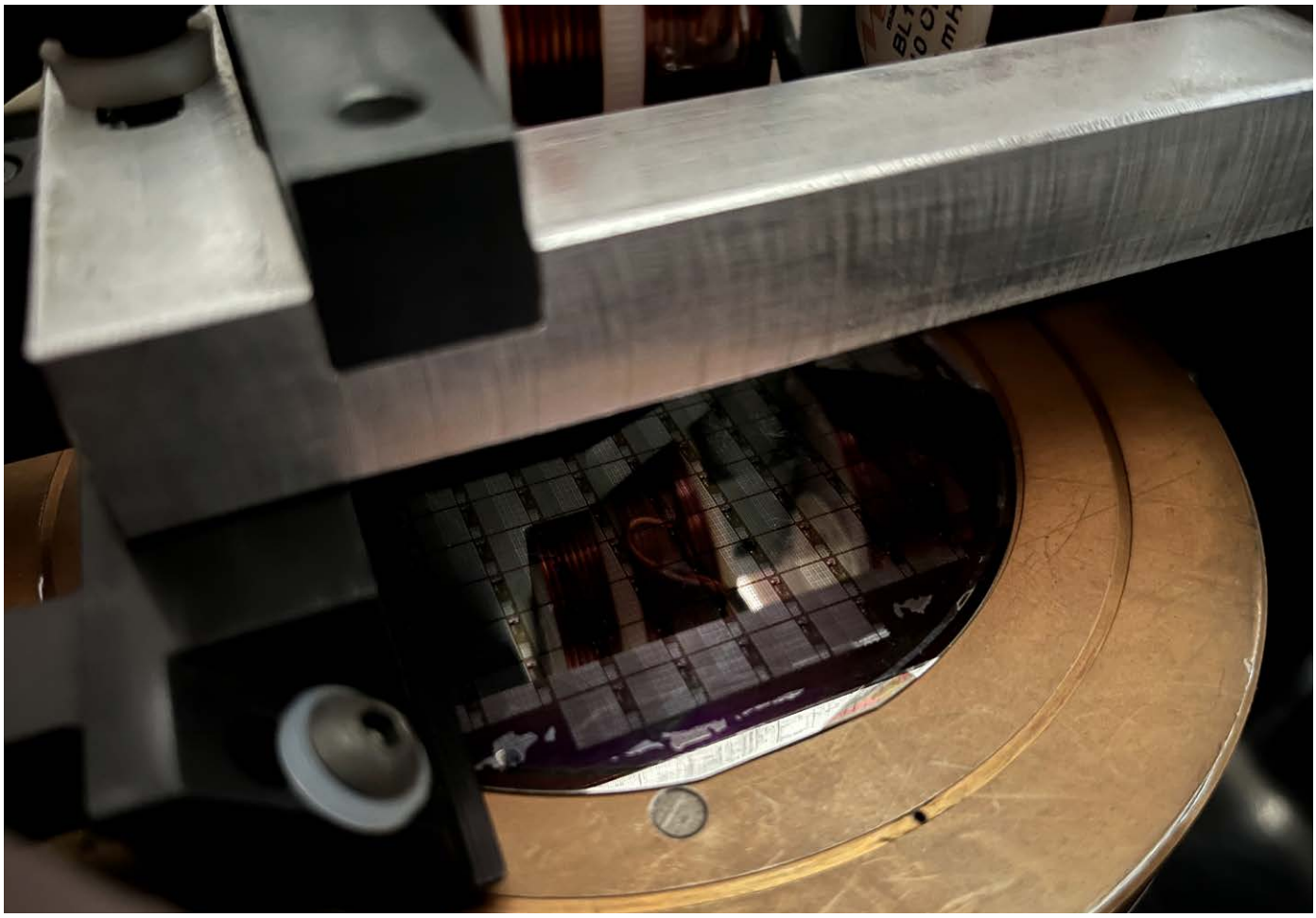
In the Nano-Argovia project NanoFemto Tweezers, researchers have started to develop optical tweezers that can be used to assemble different cell types, including neurons, in a tiny area. The interdisciplinary team is using femtosecond lasers and nano-optical elements to build these optical traps (tweezers).

They plan to use a 3D printer to build organ systems from different cell types on a micrometer surface (body-on-chip) – for example, to be able to study the effects of drugs on different organ systems on a chip.

Cooperation with: TLD Photonics AG // FHNW School of Engineering // FHNW School of Life Sciences

Project description: https://bit.ly/3l6gAKd

"The Nano-Argovia project NanoFemto Tweezers allows us to investigate and commercialize one of our novel lasers for multiple new applications — optical tweezers, multiphoton imaging and micro-scale 3D printing of biomedical tissues."
Stephan von Wolff,
CEO, TLD Photonics AG



In the Nano-Argovia project NanoHighSens, researchers have started to develop a novel current sensor. The researchers are using an array of eight small magnetometers positioned around the current conductor, each based on 100 magnetic tunnel junctions. (Image: FHNW Muttenz)

"The NanoHighSens project is an essential basic building block for a holistic energy efficiency assessment taking into account the power quality footprint."
Max Ulrich,
Managing Director, Camille Bauer Metrawatt AG

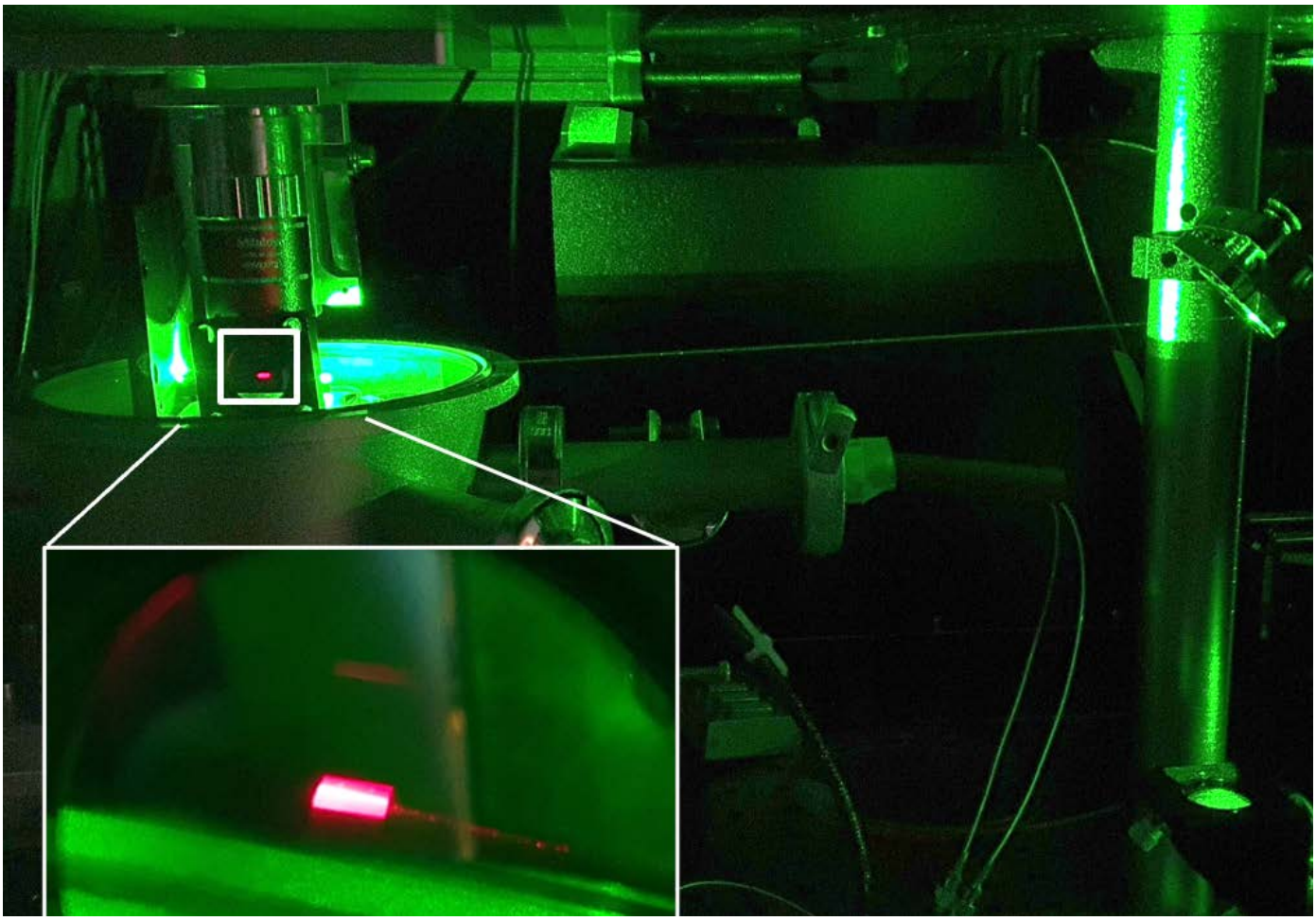
Novel current sensor fulfilling the latest quality standards

In the Nano-Argovia project NanoHighSens, researchers have started to develop a novel current sensor that aims to outperform existing technologies in terms of bandwidth and resolution and is expected to meet new standards for power quality measurement devices.

The researchers are using an array of eight small magnetometers positioned around the current conductor, each based on 100 magnetic tunnel junctions (MTJs). These are arranged over an area of 100 µm x 100 µm. The good resolution with an improved signal-to-noise ratio compared with conventional devices results from the fact that the respective measurements are based on an average of 100 magnetic field measurements. In the first year of the project, the interdisciplinary team tested various magnetic tunnel junctions as well as different approaches to the design of the new current probe architectures.

Cooperation with: Camille Bauer Metrawatt AG // FHNW School of Life Sciences // FHNW School of Engineering

Project description: https://bit.ly/48ru0uQ



In the Nano-Argovia project QSBI, researchers plan to use nitrogen vacancy centers in diamonds to optimize magnetic encephalography. (Image: PSI)

Quantum sensor for diagnostics in the brain

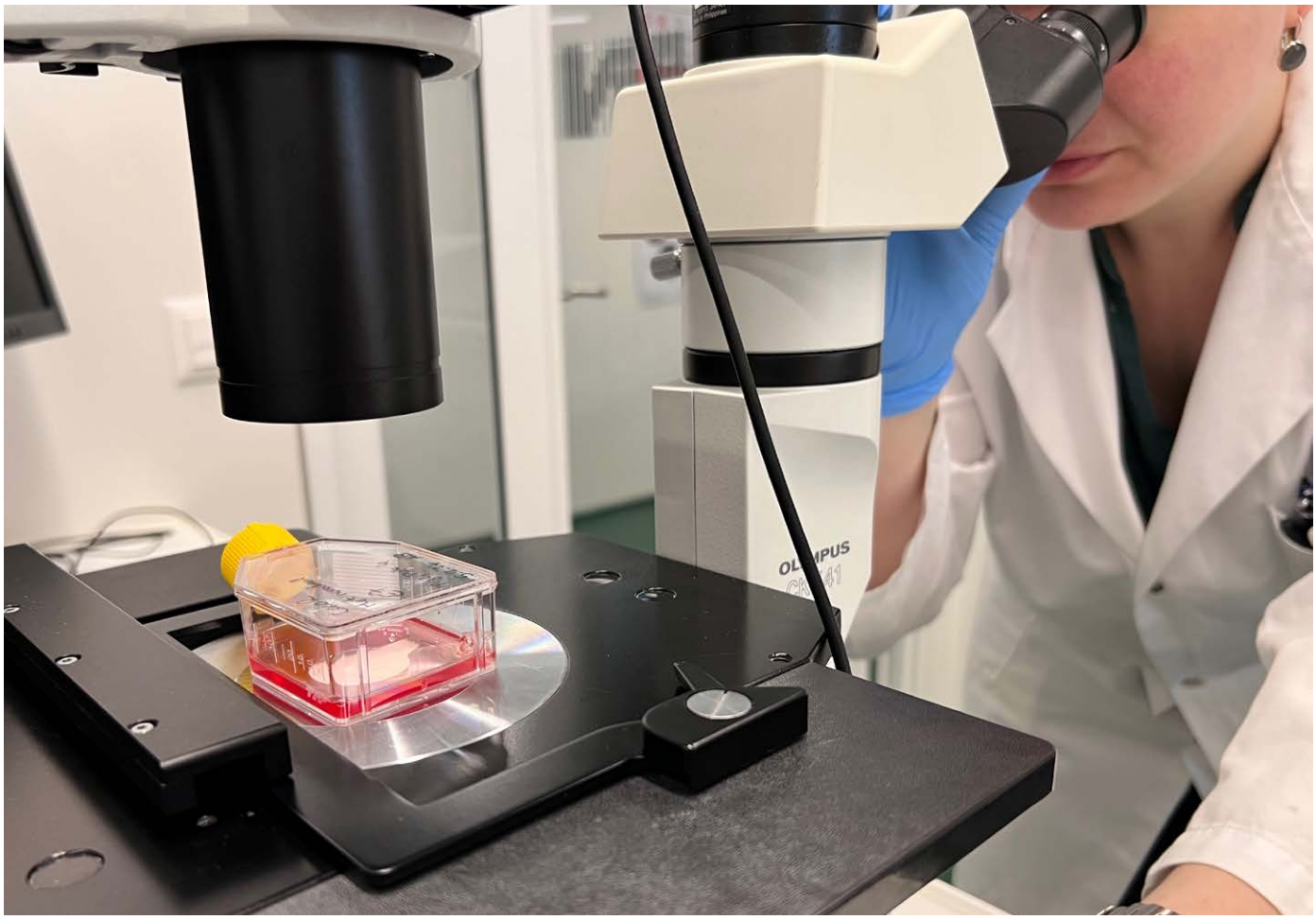
In the Nano-Argovia project QSBI, an interdisciplinary research team has started to investigate the use of quantum sensors based on nitrogen-vacancy (NV) centers in diamonds to study brain activity. The NV centers can be used to detect the weak magnetic fields of the brain. The team plans to use the project to optimize the existing method of magnetoencephalography and to develop an algorithm so that a three-dimensional map of brain activity can be created from the measurement data.

The researchers are in the process of improving the signal-to-noise ratio of the signals generated by the NV centers by applying a nanopattern of photonic crystals on the diamond surface. They have also started to develop machine learning algorithms that can process the data and eventually lead to the reconstruction of a 3D brain activity map with high accuracy and robustness.

Cooperation with: Qnami AG // Paul Scherrer Institute // CSEM Allschwil

Project description: https://bit.ly/47BuEFD

"We believe that due to their combination of robust operation, easy logistics and high sensitivity, NV diamond magnetometers will revolutionize biomagnetism."
Dr. Tobias Sjölander,
Quantum Engineer at Qnami AG



Researchers in the SmartCoat project are using innovative nanoparticles to transport small interfering RNA into cancer cells.

"The ongoing project with FHNW and PSI is a cornerstone of the innovation of Palto Therapeutics."
Dr. William L. Wishart,
Director, Palto Therapeutics Inc.

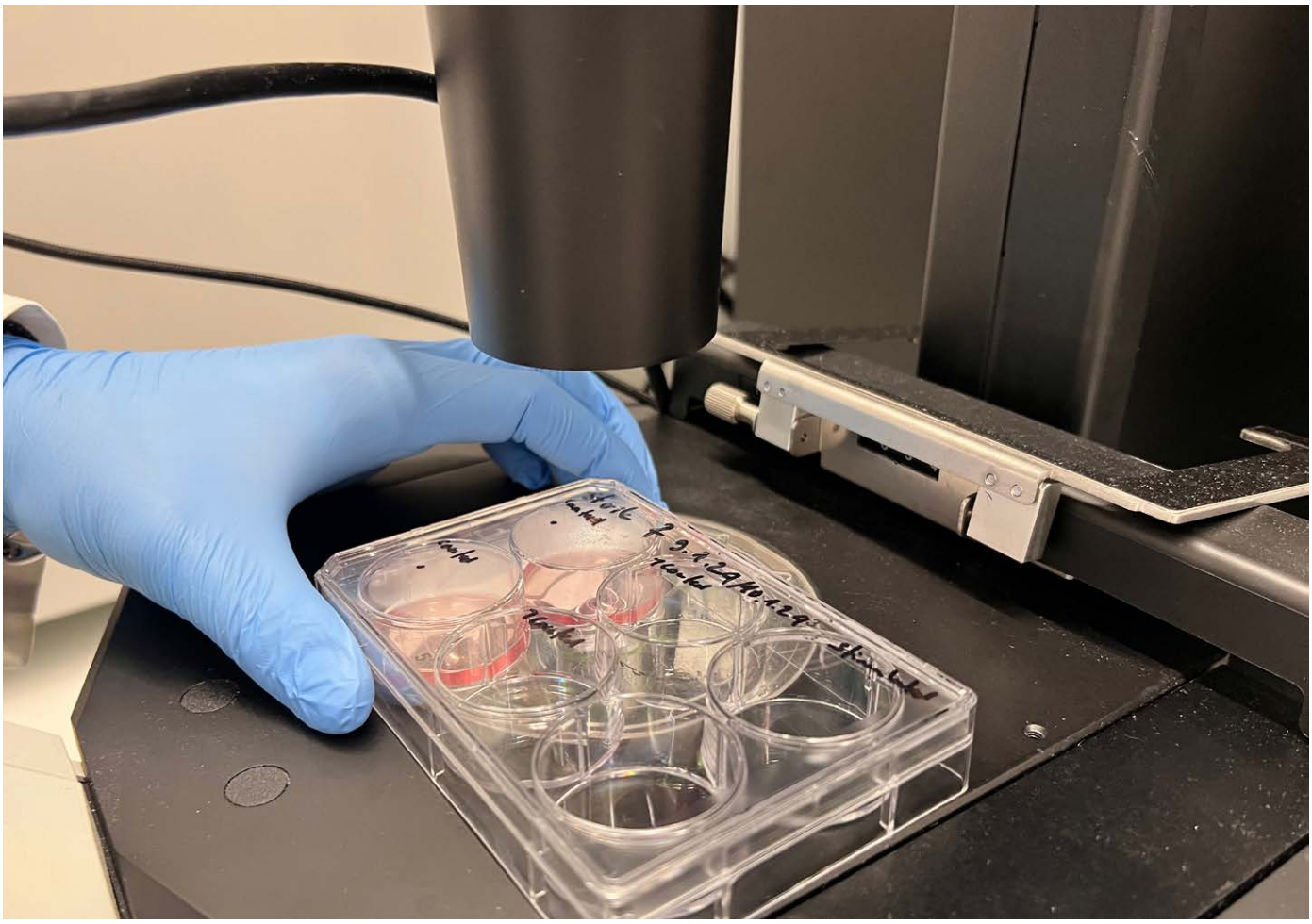
Innovative approach to the treatment of cancer

In the Nano-Argovia project SmartCoat, researchers have started to investigate a novel method for shuttling RNA-based therapeutics specifically to tumor cells in order to downregulate specific genes that drive proliferation and malignancies in cancer. They are using innovative nanoparticles (SmartCoats) to transport small interfering RNA (siRNA) that can knock out specific genes. RNA interference is a natural process through which a disease-causing gene can be eliminated in a highly specific manner. This mechanism enables precise and personalized treatment of various life-threatening diseases, including cancer.

The SmartCoats protect the siRNA from enzymatic degradation and from interactions with immune cells during circulation in the body. Their specific design also ensures that the siRNA is taken up only by targeted cancer cells. These cancer cells have specific structures (shuttling receptors) on their surface that enable binding and subsequent uptake of the SmartCoat-siRNA complexes into the cell. In this way, the RNA fragments only enter the degenerated cells and can exert their regulatory effect there.

Cooperation with: Palto Therapeutics AG // FHNW School of Life Sciences // Paul Scherrer Institute

Project description: https://bit.ly/4bR9s1Z



Researchers in the Nano-Argovia project B7H3 Nanobody PC are using cell cultures to investigate a new method for imaging and treating malignant tumors.

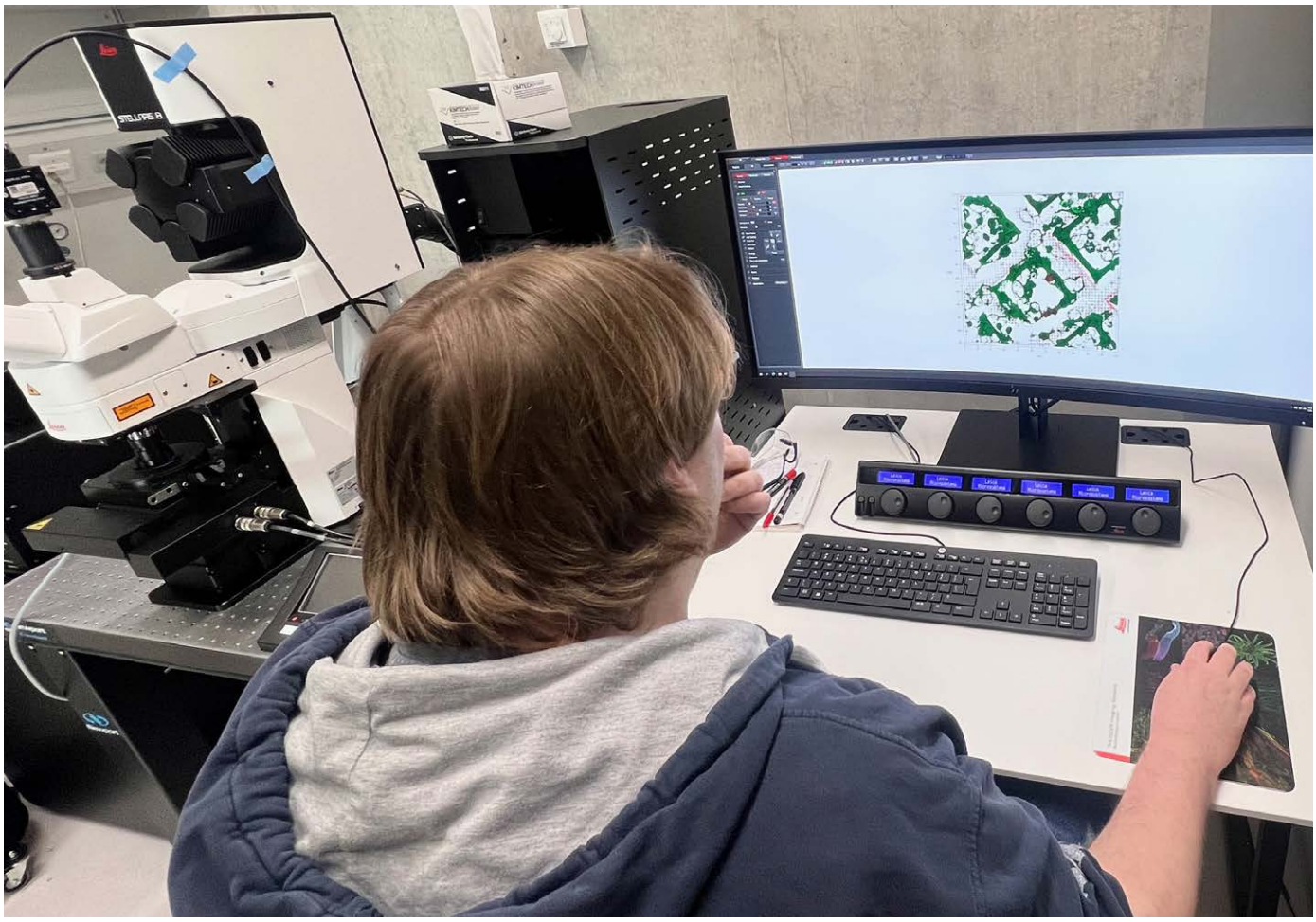
New approach to combating cancer

In the Nano-Argovia project B7H3 Nanobody PC, researchers have come closer to their goal of developing a new method for imaging and treating malignant tumors. The approach is based on the use of a so-called nanobody-polymer conjugate. This is a combination of a cell-specific nanobody, which acts very similarly to antibodies but is much smaller and which binds specifically to certain cancer cells, and a polymer that can be loaded with different compounds. The nanobody-polymer conjugate will be designed to cross the blood-brain barrier and then bind to the specific target molecule on the surface of cells of malignant brain tumors. Depending on the active substance that is bound to the nanobody-polymer conjugate, cancer cells in the brain may be combated or imaged. A radioactively labeled nanobody is currently in initial cell culture trials, and various test polymers for conjugation have been developed.

Cooperation with: CIS Pharma AG // FHNW School of Life Science // Paul Scherrer Institute // University Children's Hospital Zurich (without funding from the SNI)

Project description: https://bit.ly/3IrxFGd

"Even though there is still a long way to go: I am positive about the results regarding nanobody production and radioactive labeling, and we are looking forward to the first coupling attempts with the new polymer carriers."
Dr. Christian Geraths,
CSO at CIS Pharma AG



Andri Fränkl from Thomas Braun's laboratory looks at shock-frozen cells that have been prepared on a grid for electron microscopy using the cryoWriter system.

"The Nano-Argovia program offers companies in Northwestern Switzerland a unique opportunity to evaluate the latest technologies with experts from the academic environment. This is precisely in the area between fundamental research and product development, where the know-how is often not (yet) available in a company.
Dr. Patrick Frederix,
CEO, cryoWrite

Imaging before shock freezing

In the Nano-Argovia project FuncEM, researchers are developing an extension module to the cryoWriter. The cryoWriter flash-freezes tiny quantities of samples – with no loss of material and in a fully automated process – before the samples are examined using cryo-electron microscopy. The planned extension module should enable the researchers to analyze the "living" samples immediately before the freezing process. With the help of the optics developed so far, the interdisciplinary team has succeeded in creating 3D structures of the samples, which provide important information about sensitive parts of the complex protein architecture. The researchers initially focused on the investigation of thin cilia, which also play a crucial role in numerous diseases. The upstream light microscopic examination provides relevant information about the functionality of the cilia examined.

Cooperation with: cryoWrite // Biozentrum, University of Basel // Paul Scherrer Institute

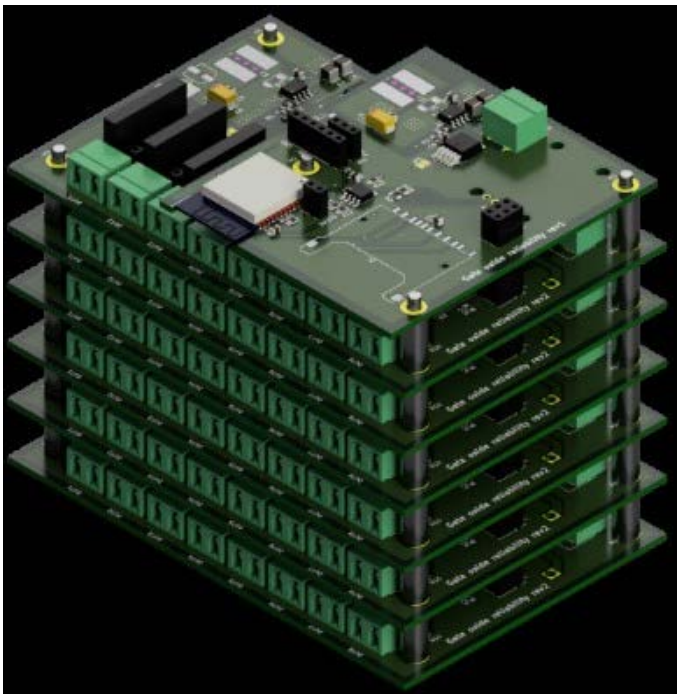
Project description: https://bit.ly/3K62L0A

On the way to more robust power semiconductors

In the Nano-Argovia project CRONOS, an interdisciplinary team of scientists has investigated how cosmic radiation affects power semiconductors designed for high electrical currents and voltages. The researchers irradiated the power semiconductors with protons and neutrons in a controlled manner while simultaneously applying an electrical voltage. They then carried out stress tests focusing on specific very thin layers in the semiconductors (gate oxide layers) that prevent electrical leakage currents. The researchers gained important information about the damage that physical processes can cause. Their data will support the development of more robust power semiconductors.

Cooperation with: SwissSEM GmbH // FHNW School of Engineering // ANAXAM

Project description: https://bit.ly/3xfcxpv



In the Nano-Argovia project CRONOS, an interdisciplinary team of scientists has investigated how cosmic radiation affects power semiconductors. (Image: FHNW Windisch)

"The Nano-Argovia project CRONOS creates ideal conditions for advancing and improving the development of power semiconductors in collaboration with experts in material analysis."
Dr. Roger Stark,
Head of Test Laboratory, SwissSEM Technologies AG

Altered phases

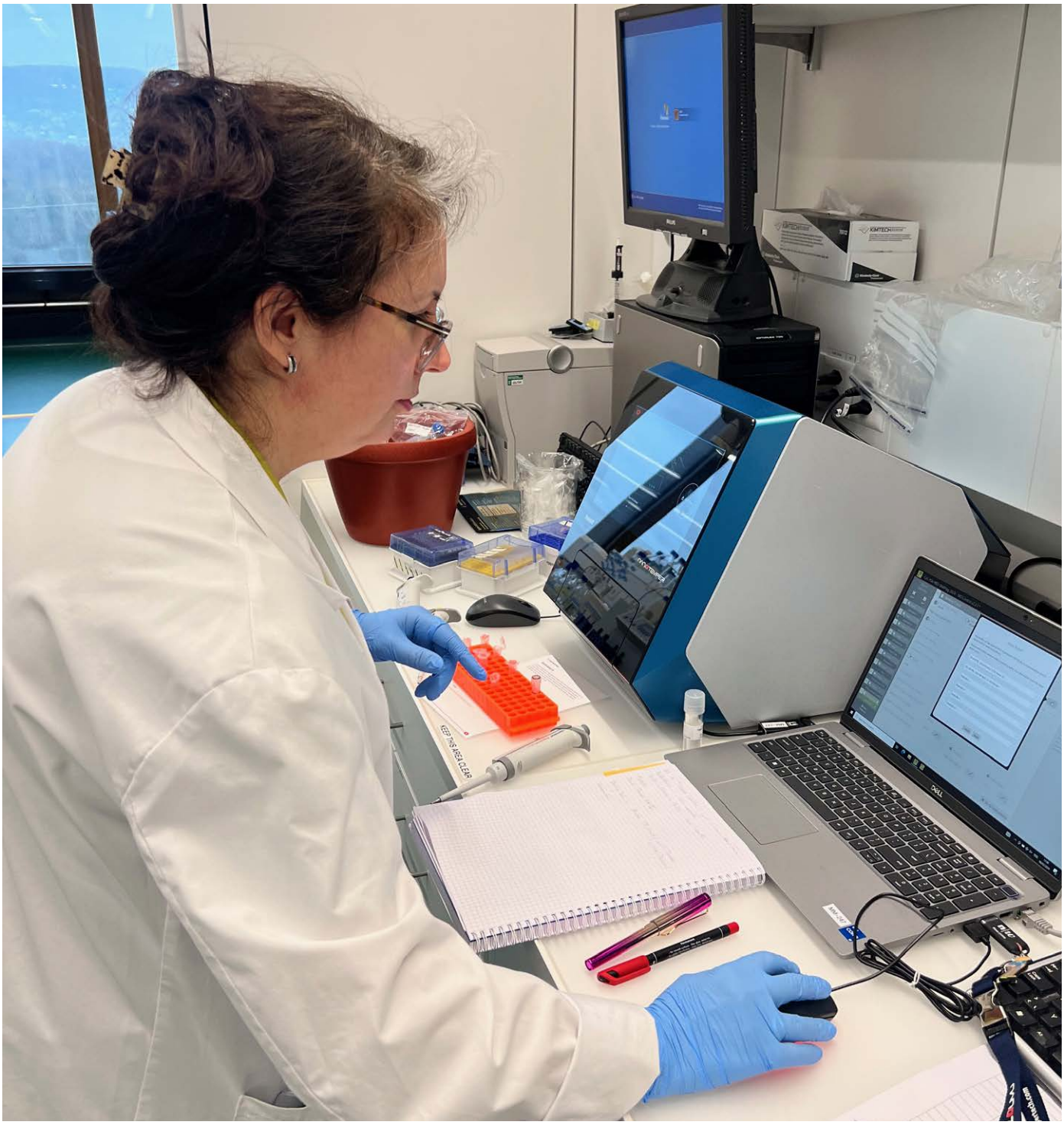
In the Nano-Argovia project META-DISPLAYS, researchers have been developing a phase retarder that can be used as a component in foldable and rollable screens to specifically alter and control the propagation of light. This is possible thanks to tiny nanostructures on the phase retarder's surface that change the phases of the electromagnetic field emitted by the light source. The researchers have now been able to reduce the retarder's thickness, making it suitable for foldable and rollable screens. They also succeeded in meeting other requirements such as high transmission and color neutrality.

Cooperation with: Rolic Technologies Ltd // CSEM Allschwil // Paul Scherrer Institute

Project description: https://bit.ly/3Xw9YtE

In the future, greater use will be made of flexible screens. (Image: Rolic Technologies)

"A metasurface device will allow Rolic to strengthen its competitive advantage as a material supplier to the display industry."
Dr. Richard Frantz,
Head of Development, Rolic Technologies Ltd



The Nano-Argovia program supports interdisciplinary applied research projects in collaboration with industrial companies from Northwestern Switzerland. Here, an employee of the FHNW School of Life Sciences is investigating the use of certain nanoparticles in the fight against cancer.

Valued support

Employees of the Nano Technology Center support scientific projects and conduct research themselves. They are also involved in helping students with their Matura theses. For example, the Nano Imaging Lab team made it possible to study insect wings using scanning electron microscopy.

In addition to the Nano Imaging Lab, the Nano Fabrication Lab, which was founded in 2022, is also part of the SNI`s Nano Technology Center. The two service units provide comprehensive services for customers from industry and academia in the field of imaging, processing and analyzing surfaces as well as micro- and nanofabrication. (Image: NI Lab, SNI, University of Basel)

Nano Technology Center: Support and in-house research at the highest level

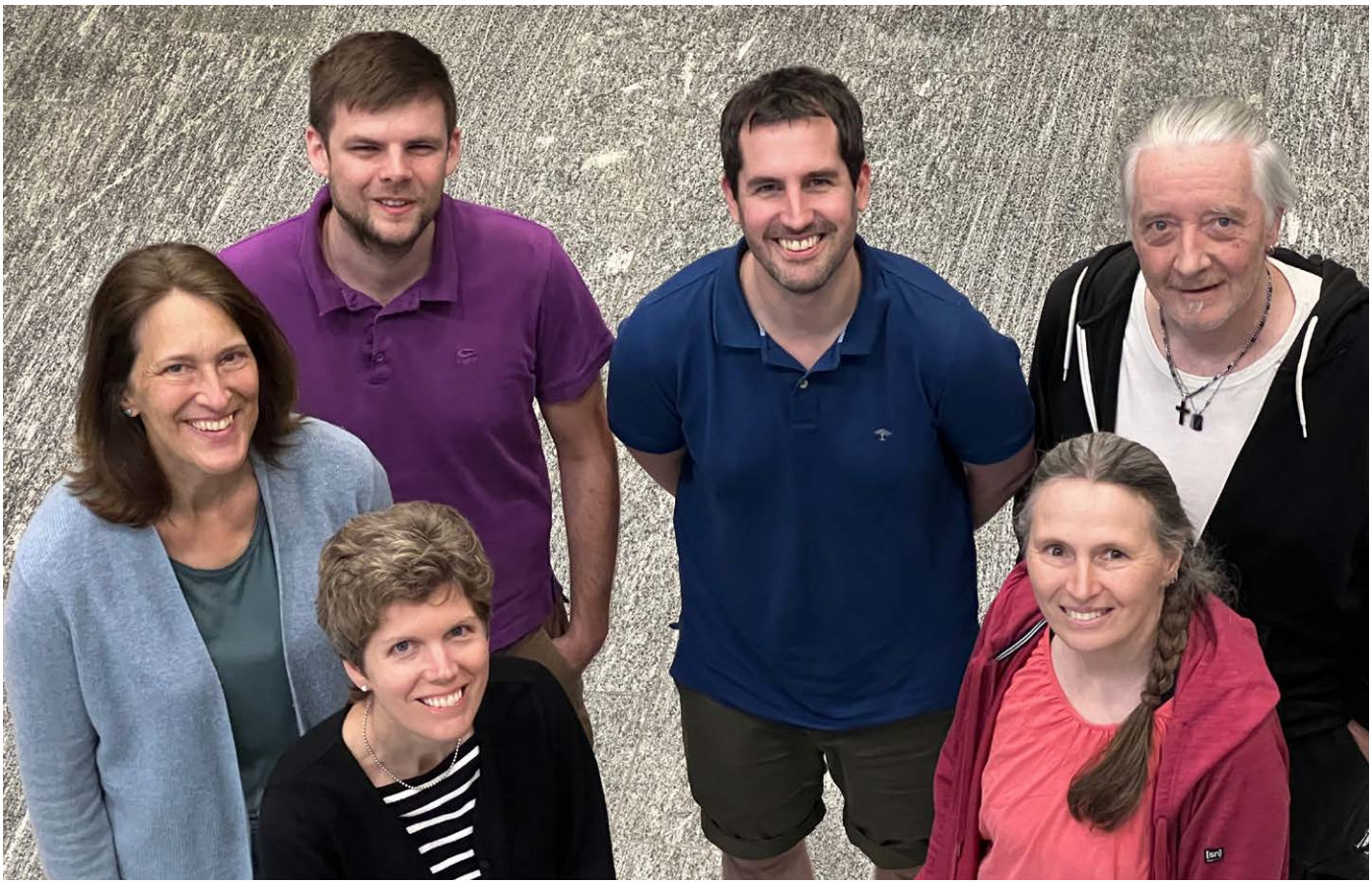
After its founding in 2022, the Nano Technology Center went on to make valuable contributions to research and education in the SNI network in 2023. The Nano Fabrication Lab (NF Lab) and Nano Imaging Lab (NI Lab), which both form the Nano Technology Center, complement one another perfectly. They are available to provide services both to partners from the network and to external customers. As well as enhancing their range of services through their own research activities, the two labs also participate in teaching and outreach activities of the SNI.

The year 2023 brought far-reaching staffing changes at the Nano Imaging Lab, with the retirement of the long-standing head of the lab, Dr. Markus Dürrenberger, who handed over the reins to the nanoscientist Dr. Marcus Wyss, as well as the arrival of the physicist Dr. Alexander Vogel as a new member of staff.

The lab's six-person team handled a total of 183 orders from 126 different customers in 2023. Not only research groups from the SNI network but also external companies profited from the detailed analyses provided by the NI Lab staff. Various groups of visitors also enjoyed fascinating tours of the NI Lab, whose microscopes deliver fascinating images of the micro and nanoworld and therefore allow impressive insights into the world of tiny structures and objects.

In 2023, the Nano Fabrication Lab continued its mission to pool the infrastructure from the Department of Physics that is needed for micro and nanofabrication, to establish organizational measures with a view to improving efficiency and safety in clean room operations, and to pave the way for expanding the equipment and a second clean room. The year 2023 also saw the services of the NF Lab used by nine different research groups from the University of Basel, with a total of 80 users, as well as considerable growth in the lab's staff. In November, the two technicians Juri Herzog and Xavier Wildermuth joined the team, which now numbers four people.

Nano Technology Center: https://nanoscience.unibas.ch/en/services/



Since June 2023, the six-person team of the Nano Imaging Lab (from left to right: Susanne Erpel, Alexander Vogel, Monica Schönenberger, Marcus Wyss, Evi Bieler and Daniel Mathys) has been led by the nanoscientist Marcus Wyss.

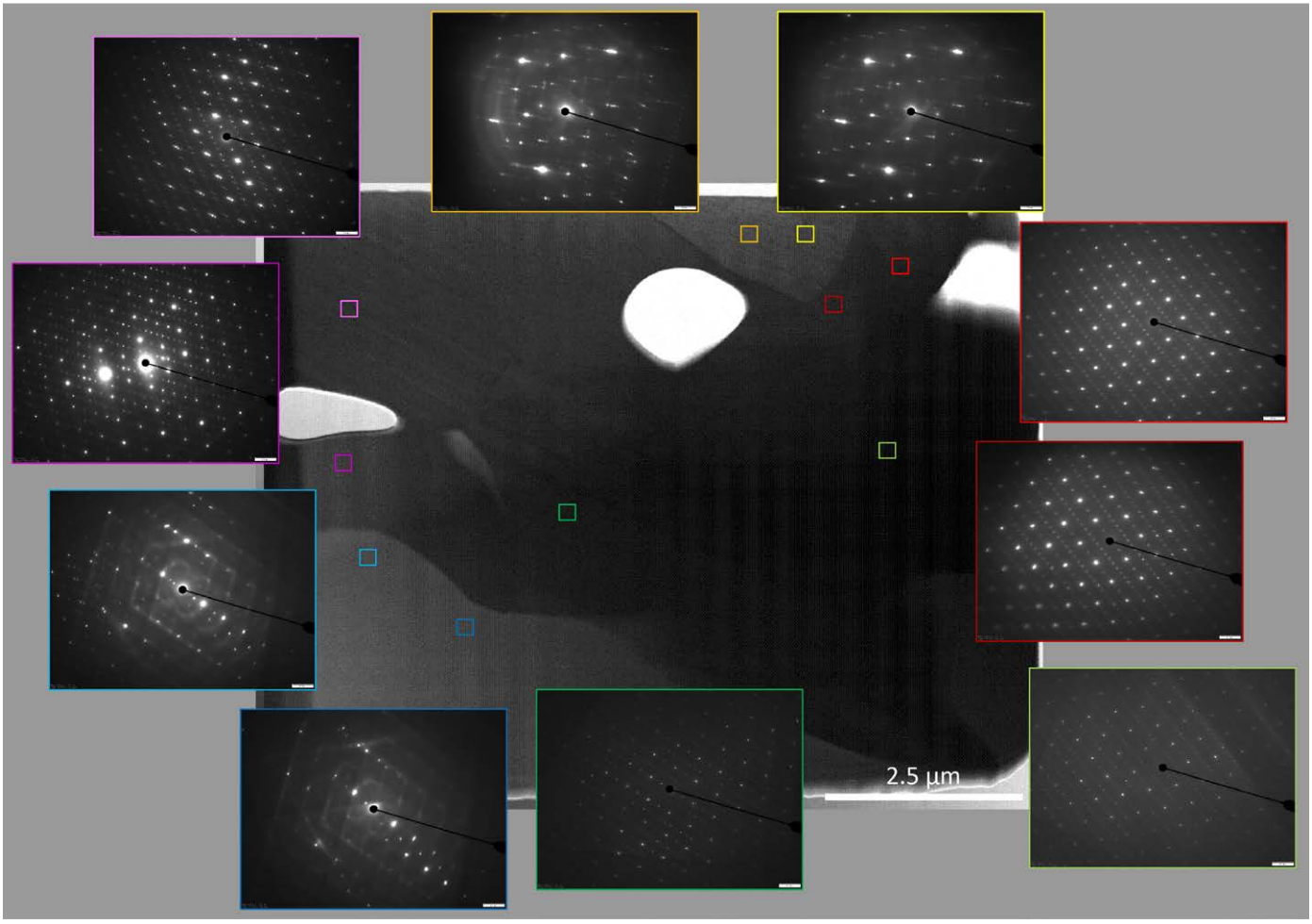
"The Nano Imaging Lab's contribution in the field of electron microscopy offers ANAXAM an important addition to our analytical expertise in the field of neutron and synchrotron analysis."
Dr. Christian Grünzweig,
CEO ANAXAM

Nano Imaging Lab
Valuable partners for research and education

In 2023, the team of the Nano Imaging Lab supported numerous research projects in the material sciences – including in collaboration with the ANAXAM Technology Transfer Center and the companies Artidis AG (Basel (BS)), Tiefbohrbär GmbH (Rothrist (AG)), Solvias AG (Kaiseraugst, AG) and mz partner GmbH (Neudorf (LU)).

There was also a productive collaboration with the University of Genoa and the start-up ELDICO Scientific, in which the NI Lab contributed analyses of gold-magnesium layers. In this interdisciplinary project, researchers are investigating gold and magnesium layers that have been fused together at high pressure and temperature. In the process, various phases with different stoichiometric compositions emerge at the interface between the two metals. The project participants hope to identify a new composition of magnesium and gold with novel properties that could be of interest for various applications.

In this project, the NI Lab used a focused ion beam (FIB) to cut lamellas out of the interfaces as well as EDX analysis to determine the precise composition of these lamellas and to measure the two-dimensional crystal structures of the different phases. With its newly developed electron diffractometer, the partner company ELDICO Scientific delivered additional three-dimensional structures so that the researchers now have access to precise information regarding the composition and structure of the interfaces.



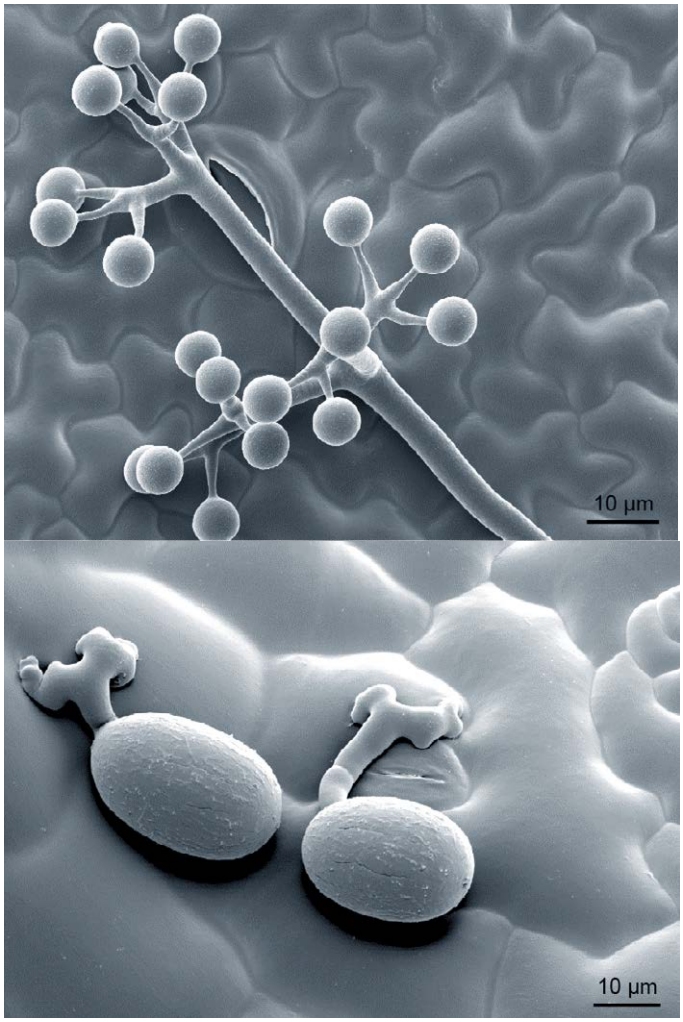
Electron microscope image of a lamella cut from the gold-magnesium boundary layer. The contrast difference reveals areas with different stoichiometric compositions of gold and magnesium. The researchers captured electron diffraction patterns in different regions. (Image: Nano Imaging Lab, SNI, University of Basel)

In another collaboration, in this case with the group led by Professor Richard Warburton of the Department of Physics at the University of Basel, the NI Lab assisted with analyses of quantum dots as a source of individual photons and created an interface between the emitted photons and stationary spin memories. In a recently published study, in which the researchers succeeded in extending the coherence of an electron spin in a quantum dot for over half a microsecond for the first time, the NI Lab assisted the physicists with microscopic examinations of the quantum dots.

The NI Lab has played an active role in trinational research projects relating to viticulture for many years – and the year 2023 saw the launch of the WiVitis project, which is approved for a period of three years and seeks to preserve and promote sustainable viticulture. Research groups from Germany, France and Switzerland are exploring how to deal with pests, climate change, and the resulting extreme weather events. The NI Lab's key contribution to the project are scanning electron microscope images of shock-frozen grape vines, as these analyses are an ideal way of visualizing plant structures without causing damage and therefore allow the research teams to obtain valuable information on the plants' state of health.

As well as assisting with numerous research projects, the staff of the NI Lab also carry out research of their own. This allows them to expand the range of services available to customers in the future. For example, having incorporated a gas injection system onto one of the electron microscopes, the NI Lab team is now able to apply gold to various surfaces. In one

project, the NI Lab staff assisted an SNI doctoral student at the Biozentrum by fabricating gold tips on cantilever probes to which proteins bind and can then be analyzed. Likewise, there are also plans for the fabrication and characterization of electrically conductive nanoscale gold contacts that are suitable for wide-ranging applications.



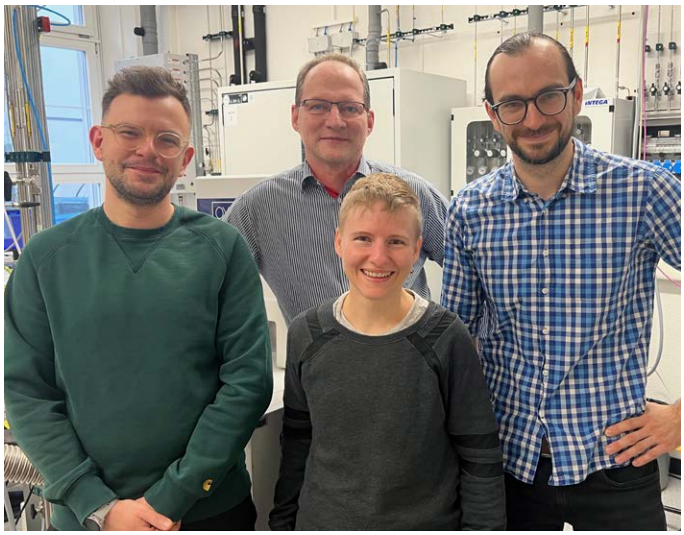
Scanning electron microscope images from shock-frozen vine leaves infected with downy mildew and powdery mildew.
(Images: Nano Imaging Lab, SNI, University of Basel)

Nano Fabrication Lab
Specialists in tiny structures

In 2023, the team of the Nano Fabrication Lab continued in its efforts to pool the equipment of various working groups at the Department of Physics, to improve safety and efficiency for users, and to digitalize the laboratories that form part of the NF Lab.

In addition, the NF Lab acquired new equipment, including an electron beam lithography system. The staff are still working on installing the device, but it will soon be available for researchers to fabricate structures measuring less than 10 nanometers. Above all, the new machine will be used by customers from the field of quantum computing.

In another significant new purchase, the NF Lab acquired a metal evaporator – a device that can be used to vaporize various metals and then oxidize them under controlled conditions, allowing the production of extremely thin metallic and oxide layers with no defects. This capability is primarily required by researchers for the production of Josephson junctions, in which a non-superconducting material is sandwiched between two superconducting layers.

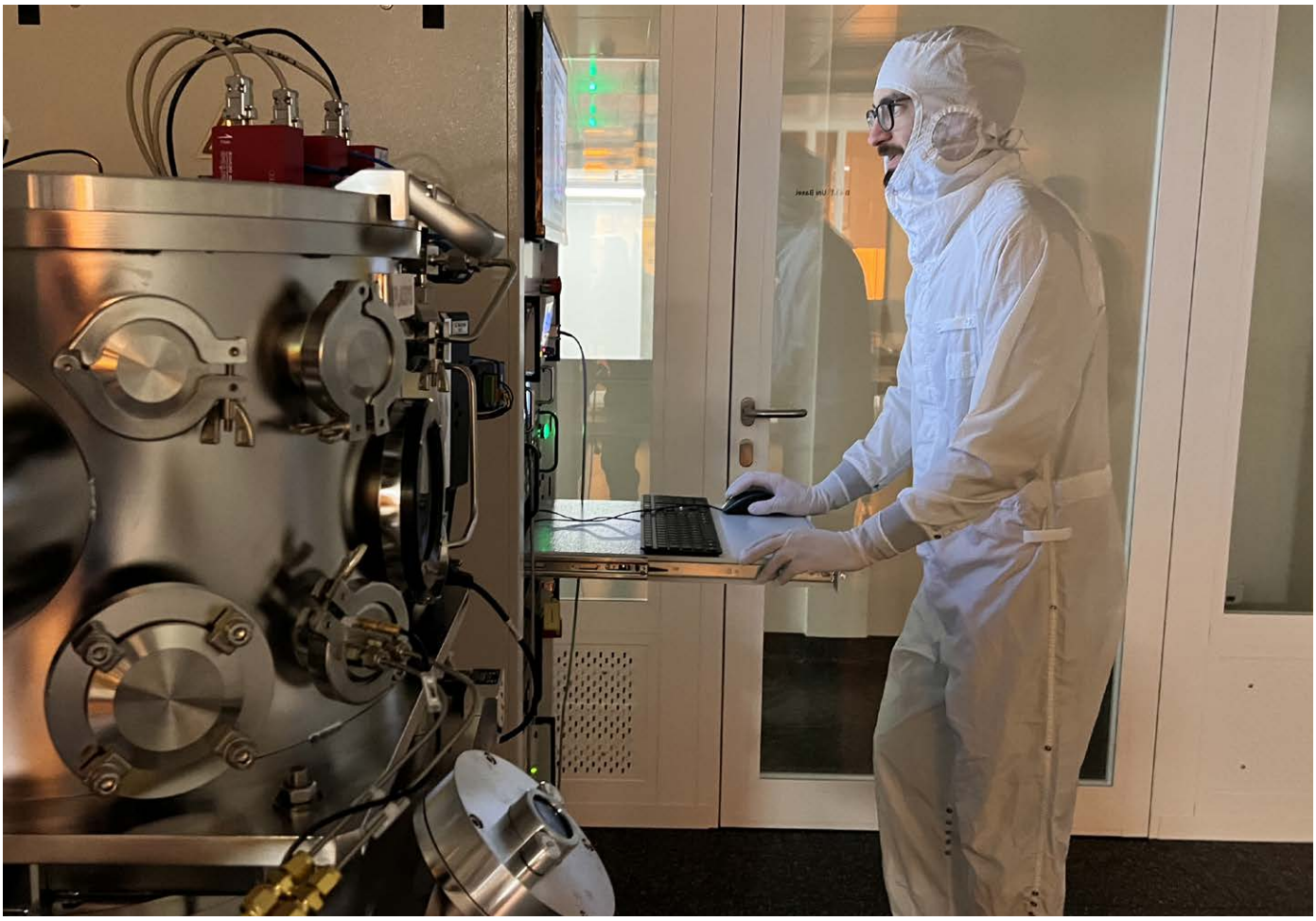


In November 2023 Xavier Wildermuth and Juri Herzog joined the Nano Fabrication Lab team. From left to right: Xavier Wildermuth, Arnold Lücke, Juri Herzog and Gerard Gadea.

The two devices are located in the new, second clean room, which forms part of the Clean Room Facility Basel (CRFB). This will considerably expand the services available to customers of the NF Lab. Currently, the SNI is renting the new clean room in the building of the Department of Biosystems Science and Engineering of ETH Zurich in Basel, whose construction was completed in 2023.

Until now, the main users of the NF Lab's facilities came from the Department of Physics at the University of Basel and the start-up Qnami, which emerged as part of the SNI network. With the team now numbering four people and since the expansion of the clean room capacities, the services of the NF Lab will also be available to further academic and industrial customers in the future.

"The NF Lab is the working horse of our research: It is where we fabricate our nanoscale devices on which we explore quantum physics. We are happy about the effort of the team to make the fabrication of samples proceed more smoothly and safely."
Prof. Andrea Hofmann
Department of Physics, University of Basel



The newly acquired metal evaporator is located in the new clean room, which the SNI has rented in the new building of the Department of Biosystems Science and Engineering of ETH Zurich in Basel.

Education
Joint activities

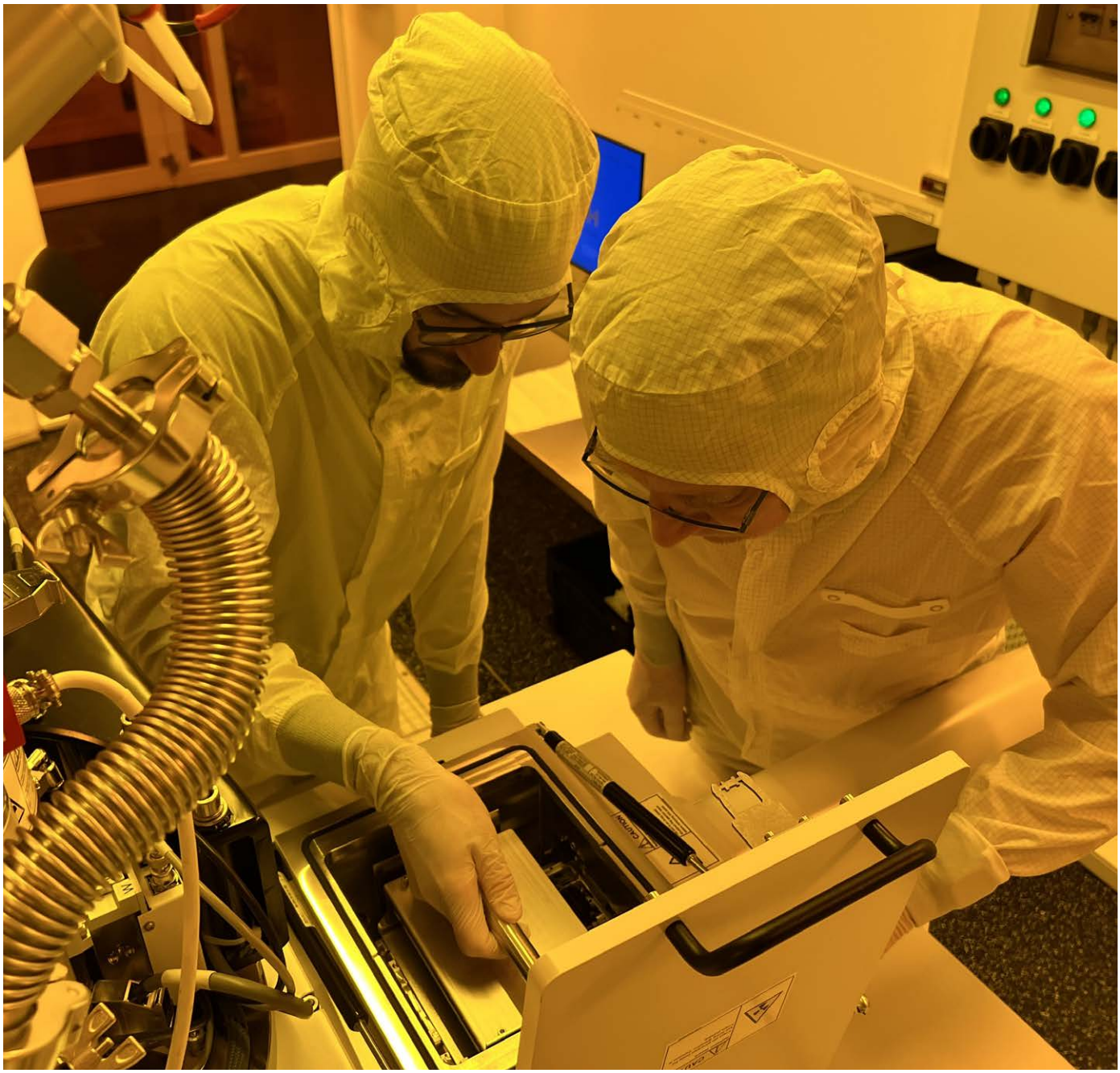
The two groups that make up the Nano Technology Center are also involved in teaching and public relations.

In 2023, the two group leaders, Dr. Gerard Gadea and Dr. Marcus Wyss, offered their first lecture course for bachelor's students of nanosciences and physics. Students on the course receive an introduction to the subject matter as well as an excellent overview of the practical work relating to electron and scanning probe microscopy as well as micro and nanofabrication, thereby complementing their theoretical knowledge.

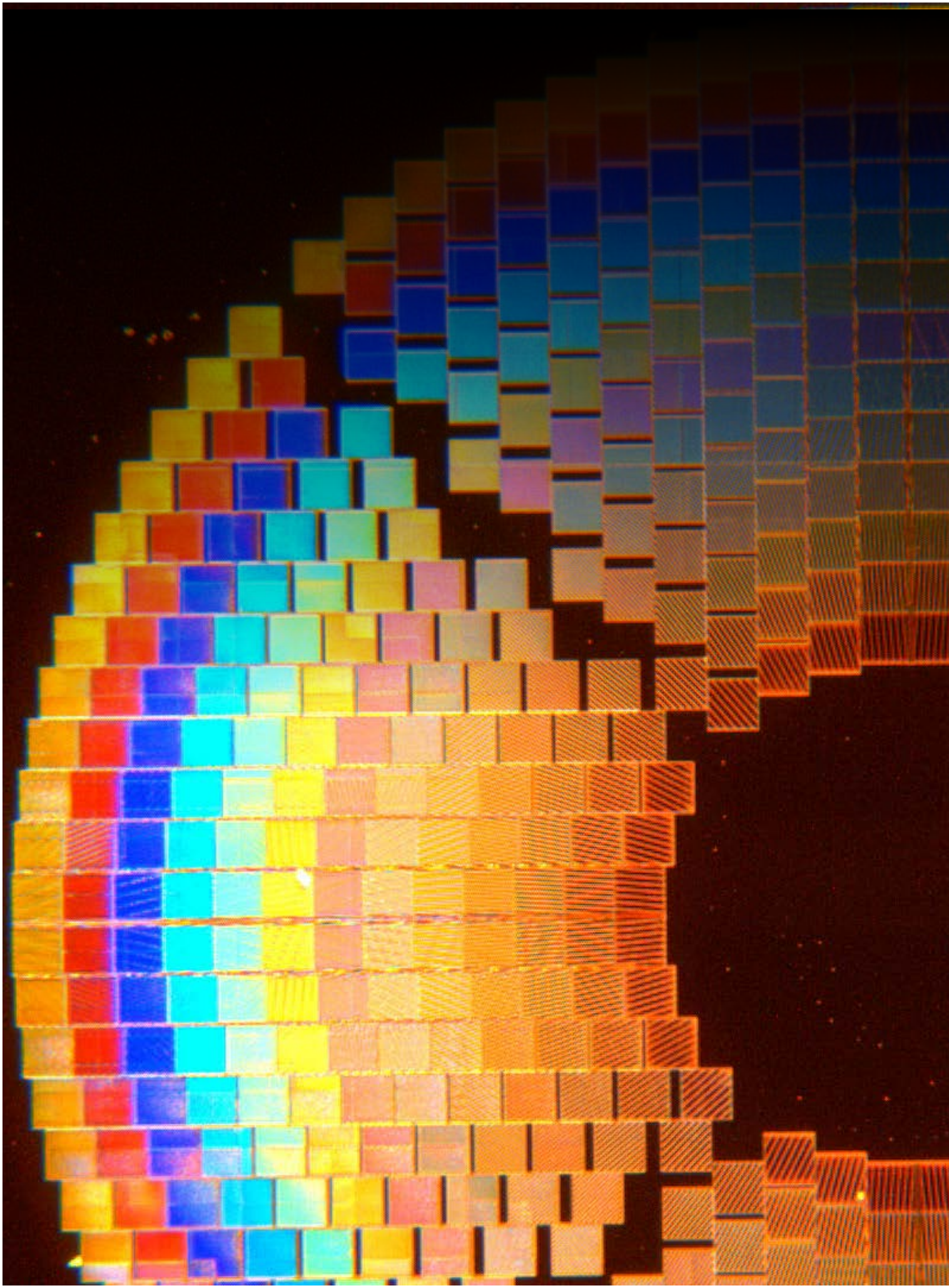
Interns and visitors were welcomed to both the NF Lab and the NI Lab in 2023. By taking part in tours and interactive visitor programs, they gained an insight into various activities relating to the imaging of the micro and nanoworld as well as various techniques for producing tiny structures.

In 2023, the Nano Imaging Lab not only welcomed school classes but also supported five high-school students who needed scanning electron microscope (SEM) analyses and images for their Matura projects. Providing this kind of support is very time-consuming but represents an investment in the future. After all, a broader understanding of the micro and nanoworld drives greater acceptance of nanosciences and nanotechnology.

"For me, working on the scanning electron microscope was a highlight of my Matura thesis. "
Tim Zimmerli on the support from Evi Bieler and Monica Schönenberger from the Nano Imaging Lab



Gerard Gadea and Arnold Lücke testing the new electron beam lithography system.



Tiny and beautiful

Once a year, the SNI invites members of the network to submit the most beautiful images they've obtained from the nano and microworld for a chance of winning the Nano Image Award. The SNI team uses these "works of art," which can only be seen using microscopes, to encourage an interest in the nanoworld.

One of the winning images in 2023 was that of an X-ray condenser viewed under an optical microscope. The condenser's complex geometry diffracts visible light and reveals a spectrum of brilliant colors, with each hue representing a specific wavelength. With a diameter of 2 mm and lines with a width of down to 50 nm, the device was developed by researchers at PSI for an X-ray microscope at the Hereon research center in Germany.
(Image: Peng Qi, Joan Vila-Comamala, Di Qu, Paul Scherrer Institute)

Network: Collaboration across boundaries between disciplines and institutions

What makes the SNI so special is its interdisciplinary network, which includes researchers from various departments of the University of Basel (Biomedicine, Chemistry, Physics, Pharmaceutical Sciences, Environmental Sciences, and the Biozentrum), as well as members of research groups at the Schools of Life Sciences and Engineering at the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) in Muttenz and Windisch, the Paul Scherrer Institute PSI, the Department of Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel (D-BSSE), the CSEM (Centre Suisse d'Electronique et de Microtechnique) in Allschwil, and the technology transfer centers ANAXAM and Swiss PIC. The wider network also includes both the Hightech Zentrum Aargau in Brugg and Basel Area Business & Innovation, which work to promote knowledge and technology transfer.

Essential for collaboration

Exchange of ideas at the Annual Event and Nano-Tech Apéro

Regular events are essential for researchers from different research institutions to develop new ideas for projects and collaborate effectively. Each year since the SNI was founded, its management has therefore organized the Annual Event for all members of the network. In 2023, the event was held in the Canton of Aargau for the first time, specifically at Lake Hallwil.

Whereas all researchers from the network can present their work at the Annual Event, the focus at the annual Nano-Tech Apéro is on applied research. In 2023, this event was held at Switzerland Innovation Park Basel Area Allschwil. In addition to the fascinating talks, visitors also enjoyed guided tours of ELDICO Scientific, a start-up that developed within the SNI network, and of the neighboring Swiss Tropical and Public Health Institute (Swiss TPH).

Video of Annual Event: https://youtu.be/f4HHrbnXw88

SNI events provide researchers from different institutions and disciplines with an opportunity to exchange experiences and develop new ideas for projects.

Excellent

Prizes and awards for researchers from the SNI network

In 2023, prizes were awarded to numerous researchers from the SNI network.

Among them was the head of the Nano Technology Center, Professor Ilaria Zardo, who received the Emmy Noether Distinction from the European Physical Society (EPS) in the mid-career category. As a physicist, Zardo received the award for her contributions to the methodology of characterizing nanoscale materials and the consequent discovery of their new functional properties.

Professor Christoph Gerber received the Albert Einstein World Award of Science 2023. He was awarded this prize by the World Cultural Council in recognition of the fundamental nature and broad applicability of his research in nanoscale science.

Professor Dominik Zumbühl was elected as an American Physical Society Fellow in 2023 in recognition of his quantum transport experiments in semiconductor nanostructures at low temperature, which sought to investigate coherence, spins and spin-orbit coupling.

Professor Marek Basler from the Biozentrum of the University of Basel was elected as a member of the prestigious European Molecular Biology Organization (EMBO).

Professor Jonathan de Roo was awarded an SNSF Starting Grant in 2023 to support his research into recyclable sponges with programmable structures made from metal-oxo clusters.

Dr. Markus Dürrenberger, the former head of the Nano Imaging Lab, was granted honorary membership of the SNI for his outstanding services to microscopy.

Further information: https://bit.ly/3Oew16m

Ilaria Zardo, Christoph Gerber, Dominik Zumbühl, Marek Basler, Jonathan de Roo and Markus Dürrenberger are among the researchers from the SNI network who were honored in 2023.

Fit for the future

Developing a strategy

In 2023, the SNI team worked on developing a strategy for the next 10 years. As well as the SNI management, this process involved experts from the SNI network and from various European nanocenters, as well as the members of the SNI Executive Committee.

In spring 2024, the results of this process will be published in a strategy paper to serve as a guide for the SNI's future development. Key topics include focus areas, collaboration, adaptation and impact.

Communication and outreach: Sharing our fascination with the natural sciences

Many of the research topics that play a role within the SNI are complex and not always easy to understand. The challenge for the communication and outreach team of the SNI is therefore to provide information on the nanosciences, nanotechnology and the work of the SNI in a clearly comprehensible and attractive form for various target groups. Events involving personal interaction are also vital, as are print materials and the dissemination of news via social media.

In 2023, the SNI team took part in established events such as the TecDays, visits by and to school classes, and the Science Days at Europa-Park Rust (Germany). In addition, however, they also tested new formats with a view to reaching people who previously had little contact with the natural sciences.

Social media and the website, which was redesigned in 2023, are also playing an increasingly significant role in the SNI's communications. Key topics include news on research projects, awards, portraits and events. These themes are often brought to life in short videos that are produced in house. At the end of 2023, the SNI had more than 5,500 followers – including individuals and organizations – across its LinkedIn, X, Instagram and YouTube channels.

Always something new
SNI team tests new formats

Some of the events in which the SNI participates have formed part of the outreach team's program for many years. For example, visits to and by school classes, as well as the TecDays organized by SATW, are well-established features and provide an opportunity to show pupils the exciting challenges that nanoscience researchers are facing with the help of a clear, interactive program. Likewise, the annual Science Days at Europa Park Rust also form part of the SNI's "standard program," bringing together children and adults who are interested in experiments and learning about the natural sciences in their spare time.

In 2023, however, the SNI also tried out two activities with new formats in order to address target groups that we have not been reached in the past. For one of these activities, two members of SNI staff were on board of several Treno Gottardo rail services operated by SOB. Setting themselves up in the family area of the trains, they offered passengers the chance to take part in experiments and craft projects all about light as part of a project entitled "MINT on the move." In another new format, students from Oberrhein high school in Weil am Rhein (Germany) were asked to draw details of equipment in laboratories at the Department of Physics as part of the "Change of Perspective" project. These drawings were then presented – along with explanations – in an exhibition both at the Department of Physics and at the school.

At the start of 2023, the newly designed SNI website also went live, providing extensive information on the various activities of the SNI as well as current news and events. Posts on the SNI's various social media channels generally link to longer articles on the site.

Further information:

YouTube channel: https://bit.ly/3u9XLjv

LinkedIn: https://bit.ly/3rbYP4s

X: https://twitter.com/SNIunibas

SNI website: www.nanoscience.ch

Experiments to perform at home: https://bit.ly/42N6zer

Video series on women in the nanosciences: https://bit.ly/48NNHya

"The special thing about the experiments on the train was that people really had time to listen to us and learn about the nanosciences."
Dr. Kerstin Beyer-Hans, outreach manager at the SNI and initiator of the project "MINT on the move"

In the "Change of Perspective" project, our pupils benefited from links with academia and learned about the potential for a fascinating interface between the worlds of art and science.
Dr. Tanja Reinhardt-Albiez
Principal Oberrhein high school, Weil am Rhein

As part of "MINT on the move," passengers could take part in science experiments and craft projects in collaboration with the SNI staff.

At the Rüeblimärt in Aarau, numerous visitors expressed an interest in the SNI's activities.

An animated version of the online magazine *SNI INSight* seeks to present news about the SNI in a more attractive form for readers.

A video series on women in the nanosciences features examples of various nanoscience careers.

Financial report

The Swiss Nanoscience Institute (SNI) was founded by the University of Basel and the Canton of Aargau in 2006. Then, as now, the goal was to establish a center of excellence for the nanosciences and nanotechnology in Northwestern Switzerland, to advance nanoscience research, and to support knowledge and technology transfer to industry, as well as to deliver an excellent education for early career researchers.

It all starts with basic research

As innovations are founded on a fundamental understanding of phenomena in the nanoworld, the SNI invests in wide-ranging research into questions of basic science. On the one hand, this is achieved by funding the two Argovia Professors Rodrick Lim and Martino Poggio, both of whom have contributed to the SNI's excellent reputation with their research groups since the early years of the institute. Through their participation in national and international collaborations, the two Argovia professors together received over CHF 1.9 million in funding for their research in 2023. The SNI also supports the work of Professor Patrick Maletinsky (University of Basel) as well as three titular professors at the Paul Scherrer Institute: Thomas Jung, Michel Kenzelmann and Frithjof Nolting. In total, the professors received funding of some CHF 1.7 million in 2023.

Basic science is also the field of research pursued by most doctoral students at the SNI PhD School, which was founded in 2012. The 40 doctoral students who formed part of the PhD School in 2023 work at various institutions within the SNI network – but they all earn their doctorates from the Faculty of Science at the University of Basel. In total, the outgoings for the PhD School ran to some CHF 2 million in 2023.

A focus on knowledge and technology transfer

With the Nano-Argovia program, which has existed since the Swiss Nanoscience Institute was founded, the SNI supports knowledge and technology transfer to industry. This program sees industrial companies from Northwestern Switzerland work with at least two academic partners from the SNI network to explore novel lines of applied research at an early stage. In 2023, the SNI launched nine new Nano-Argovia projects with total funding of some CHF 1.4 million. Project partners contributed almost CHF 0.8 million via public research funding instruments (e.g. Innosuisse, Swiss National Science Foundation and EU funding) and funding from the research institutions themselves. The industrial partners contributed around CHF 1.1 million to the various lines of research in the form of in-kind services.

Continued expansion of the Nano Technology Center

In 2023, the SNI achieved further milestones in the expansion of the Nano Technology Center, which is becoming increasingly established as a service center of the SNI. The Nano Technology Center includes the Nano Imaging Lab, which was founded in 2016, and the Nano Fabrication Lab, which was founded in 2022. The two service units provide customers from industry and academia with comprehensive services in the area of imaging as well as in micro and nanofabrication.

In 2023, the Nano Fabrication Lab received large new instruments that will play a key role in its micro and nanofabrication services. This followed an investment of CHF 0.5 million in the new equipment by the SNI. Such investments are only possible thanks to reserves, which also meant that necessary repairs could be carried out quickly on microscopes in the event of

The following table shows the outgoings for 2023 by item of expenditure according to the financial report of the University of Basel of 26 February, 2024:

Expenditure 2023 in CHF

		Univ. Basel	Canton AG	Total
Management	Personnel and operational costs	92'973	260'364	353'337
	Overhead	—	650'000	650'000
Infrastructure	Infrastructure equipment	27'034	1'130'944	1'157'978
Know-how & Techtransfer	Personnel and operational costs	23'980	136'481	160'461
	Nano-Argovia projects	—	1'370'119	1'370'119
Outreach & PR	Personnel and operational costs	95'231	77'742	172'973
Support	Professors Univ. Basel	569'664	1'064'013	1'633'677
	PSI professors		53'366	53'366
Nano Curriculum	Bachelor and master programs	293'846	236'494	530'340
Nano Technology Center	Nano Imaging/Nano Fabrication	652'582	303'741	956'323
SNI PhD School	Personnel and operational costs	802'779	1'204'399	2'007'178
Total expenditure 2023 in CHF		**2'558'090**	**6'487'662**	**9'045'752**

malfunctions. In total, the Nano Technology Center's budget ran to almost CHF 1 million in 2023. Other purchases with a view to equipping the Nano Technology Center for the future were also approved in 2023, but long delivery times will mean that they are not included in the cost accounting until 2024.

Study and outreach as further cornerstones of our work

The SNI contributes over CHF 0.5 million to the interdisciplinary degree program in nanosciences at the University of Basel. In 2023, 56 bachelor's and 26 master's students took advantage of this educational program – the only one of its kind in Switzerland – in which early career researchers receive a broad grounding in the natural sciences and are therefore ideally equipped to work at the interfaces between different disciplines.

The work of the SNI team also includes raising awareness of the degree program and informing the public about nanosciences and the activities of the SNI in general. To this end, staff take part in various events and establish their own formats for dialog with the general public. Increasing importance is also placed on publishing information about the SNI on social media. Events such as the Annual Event and the Nano-Tech Apéro provide essential occasions for an internal exchange of ideas. Here, SNI members have the opportunity to get to know one another, discuss their research and generate new ideas. In total, the costs for public relations and internal events come to less than CHF 0.2 million.

Essential investments in the future

Modern infrastructure is vital in order to remain competitive in the nanosciences and nanotechnology. Accumulated reserves allow the SNI to support infrastructure measures in research groups and at the Nano Technology Center. In addition to procurements in the service sector, the SNI also contributed CHF 0.5 million to the acquisition of a state-of-the-art electron microscope at the Biozentrum. In total, the SNI invested almost CHF 1.2 million in new infrastructure in 2023.

Further investments in research infrastructure were planned in 2023, but long delivery times mean they will not appear in the financial report until 2024. The SNI Executive Committee approved further infrastructure investments of around CHF 1 million at its first meeting of 2024. This ensures that the SNI's reserves are put to sensible use and will help to equip the SNI and associated research groups for the future.

In the last line of the SNI's annual statement, some CHF 5.6 million are shown as "SNI assets per 31 December 2023, in CHF." This balance does not take account of commitments already made in previous years, including new equipment for the Nano Technology Center and investments in infrastructure for research groups. In addition, there is always a proportion of funding for Nano-Argovia projects that has not been spent yet. A significant part of this funding consists of reserves for ongoing doctoral dissertation projects, as doctoral students at the SNI PhD School are funded for a contract period of 48 months.

We would like to extend our sincere thanks to the Finance department at the University of Basel for its valuable collaboration throughout the year and for its efficient financial reporting. A huge thanks also goes to the Cantons of Aargau, Basel-Stadt and Baselland. Their ongoing commitment is what makes it possible for the SNI to train excellent early career researchers, generate new scientific insights, and support companies with innovative projects as we work toward building a better future.

The following table shows the income statement of SNI funds as of 31 December, 2023:

SNI annual statement in CHF

	Univ. Basel	Canton AG	Total
Grants	2'827'284	5'140'000	7'967'284
Investment income	16'009	1'068	17'077
Income	**2'843'293**	**5'141'068**	**7'984'361**
Expenditure	**2'558'090**	**6'487'662**	**9'045'752**
Annual balance 2023	**285'204**	**(1'346'594)**	**(1'061'390)**
SNI assets per 01/01/2023	**1'704'344**	**4'923'761**	**6'628'105**
Annual balance	285'204	(1'346'594)	(1'061'390)
SNI assets per 31/12/2023 in CHF	**1'989'548**	**3'577'167**	**5'566'715**

Organization

Argovia Board
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Prof. Dr. C. Bergamaschi, President FHNW
Prof. Dr. G.-L. Bona, former Director Empa
Dr. W. Riess, former IBM Department Head & Coordinator Binnig & Rohrer Nanotechnology Center
Prof. Dr. C. Rüegg, Director Paul Scherrer Institute

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C. Wirth, General Manager SNI (HR, finance, administration)
Prof. Dr. I. Zardo (Nano Technology Center and Department of Physics)

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Dr. A. Car (Curriculum Nanosciences)
Dr. K. Beyer-Hans (Communications, outreach)
Dr. G. Gadea (Nano Fabrication Lab)
S. Hüni (Communications, outreach)
Dr. C. Möller (Communications, media contact, social media)
Dr. M. Wegmann (Outreach, communications, social media)
Dr. M. Wyss (Nano Imaging Lab)

Curriculum Nanosciences
Dr. A. Car (Study coordinator)
S. Chambers (Administration)

Nano Imaging Lab
Dr. M. Dürrenberger (Head until 31.05.2023)
Dr. M. Wyss (Head since 01.06.2023, TEM, FIB-SEM)
E. Bieler (SEM)
S. Erpel (SEM, TEM)
D. Mathys (FIB-SEM, Image coloring)
Dr. M. Schönenberger (AFM, LSM)
Dr. A. Vogel (TEM, FIB-SEM)

Nano Fabrication Lab
Dr. G. Gadea (Head)
J. Herzog (since 01.11.2023)
A. Lücke (financed by Department of Physics)
X. Wildermuth (since 01.11.2023)

Lists of members and projects 2023

Principal Investigators and associated members
https://bit.ly/4c6klYb

PhD students
https://bit.ly/4c2yzyM

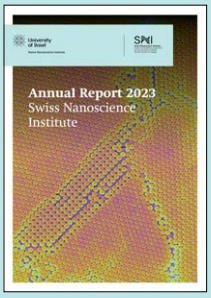
SNI PhD School projects 2023
https://bit.ly/3uZQOUU

Nano-Argovia projects 2023
https://bit.ly/4bVfoa2

Further information

If you would like to know more about the Swiss Nanoscience Institute, please visit our website (www.nanoscience.ch) or follow us on LinkedIn, X, Instagram or YouTube. There we regularly post news from the network.

Scientific supplement
Scientific reports from all the Nano-Argovia and SNI PhD School projects from 2023 can be found on our website or by scanning the QR code.
https://bit.ly/3TrNwTL



Title image: Microspheres
Microspheres were prepared from styrene via emulsion polymerization by students in the practical training in polymers at FHNW. The spheres (Ø approx. 0.25 µm) form hexagonally ordered assemblies when dried on the sample holder. The image was taken with an electron microscope. The spheres were originally white and the image was colored using Adobe Photoshop. (Image: V. Hollenstein, L. Martinez and S. Saxer, FHNW Muttenz)

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Scientific supplement