University of Basel

Swiss Nanoscience Institute

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

Annual Report 2019
Swiss Nanoscience Institute
University of Basel

The Swiss Nanoscience Institute (SNI) is a research initiative of the Canton of Aargau and the University of Basel.

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Cover image: Drug-loaded microparticles from polycaprolactone produced by electrospraying in the Nano Argovia project PERIONANO
F. Costanzo (University of Basel), J. Föhr, O. Germershaus (School of Life Sciences, FHNW)

Contents

Foreword

Dear colleagues, ladies and gentlemen,

Since the Swiss Nanoscience Institute (SNI) was founded, we have begun each year by taking a detailed look at the previous year as we compile our extensive annual report. Rather than just concentrating on the numbers, we tell stories, too – of successful students and doctoral students who have done outstanding work and are now entering the professional world, of young entrepreneurs who have taken the plunge and set up their own companies, and of research projects conducted by members of our interdisciplinary network.

In addition to providing information about new scientific findings, this annual report introduces you to some of the people who make up the SNI. Without the dedication of the SNI's members, students and doctoral students, we would not be able to promote education and research in the nanosciences or conduct research projects with industrial partners to find practical applications for scientific findings.

Learn more about Sebastian Scherb's prize-winning master's thesis, find out where some of our students went to gain additional experience, and obtain an overview of the topics covered by doctoral dissertations completed in 2019. We also provide two examples of potential career paths for graduates of the SNI PhD School.

We also report on some of the activities conducted by Argovia Professors Roderick Lim and Martino Poggio and the PSI titular professors supported by the SNI – Thomas Jung, Michel Kenzelmann and Frithjof Nolting.

In addition, we provide an insight into the research findings published by SNI members in 2019 with examples and an overview of all projects included in the Nano Argovia program in 2019. We briefly describe the successes of four startups that have emerged from the SNI network and report on ANAXAM, a technology transfer center for applied material analysis that opened at the end of 2019.

The SNI's Nano Imaging Lab (NI Lab) will also be involved in projects conducted via ANAXAM. The NI Lab's five members of staff will contribute their expertise in electron and scanning probe microscopy. In this annual report, we reveal how the NI Lab team supports various research projects through their investigations, focusing on two projects in particular.

The NI Lab is a popular port of call for students and groups of visitors – spectacular images of the micro and nano worlds never fail to fascinate and help boost interest in the natural sciences. This is the particular focus of the SNI's communication and outreach team. We have briefly summarized the activities arranged by the small team in the last year to reach the wider public and address specific target groups.

I hope you enjoy this wide-ranging report. In addition to this general section, we have produced a scientific supplement containing reports on all doctoral and Nano Argovia projects supported in 2019. To conserve resources, we have sent a print version of the scientific supplement only to contributors to this edition. You can access the digital version using the QR code on the final page. We will of course be happy to send you a print copy if desired.

Kind regards,

Christian Schönenberger

Prof. Dr. Christian Schönenberger, SNI Director

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

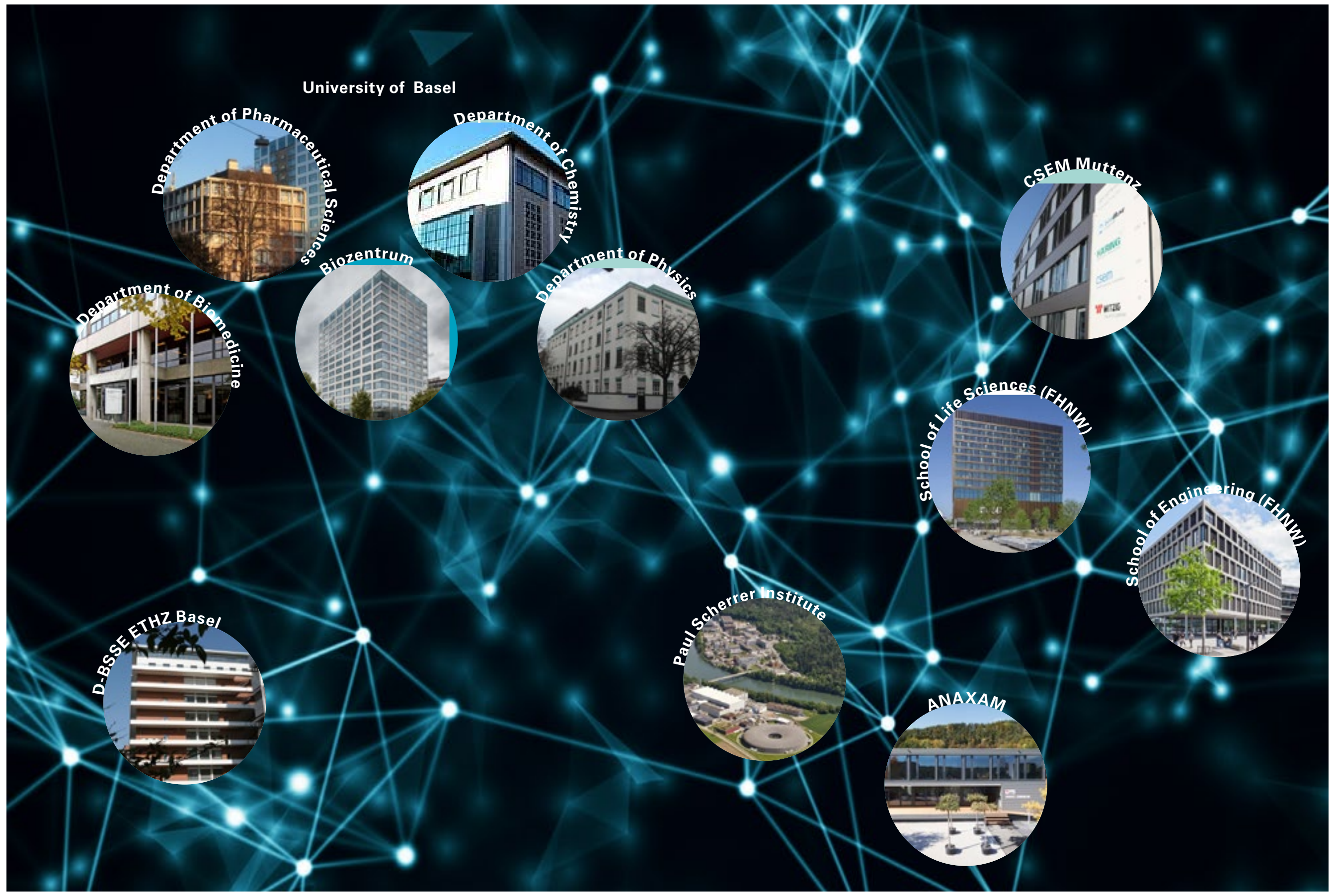
The Swiss Nanoscience Institute (SNI) at the University of Basel is a center of excellence for nanosciences and nanotechnology and was founded in 2006 on the initiative of the Canton of Aargau and the University of Basel. In the SNI network, interdisciplinary teams of scientists conduct basic and applied research that actively supports knowledge and technology transfer to industrial companies from Northwestern Switzerland within the context of the Nano Argovia program. The SNI offers comprehensive imaging services for companies and research institutions through its Nano Imaging Lab. The SNI is a founding member of the new ANAXAM technology transfer center and offers a bachelor's and master's program and a PhD school, providing young nanoscientists with interdisciplinary training. It is also involved in public relations and specifically supports initiatives aimed at generating interest among various target groups for the natural sciences and promoting collaboration between academia and industry.

Commitment from the Canton of Aargau
The SNI was founded in 2006 by the Canton of Aargau and the University of Basel to promote research and training in the nanosciences and nanotechnology in Northwestern Switzerland. Nanotechnologies are highly relevant to research and industry in the heavily industrialized Aargau region. The numerous successful SNI research projects, in which scientists from various disciplines and institutions work together, support the Canton of Aargau's hightech strategy and offer companies from Aargau and the two Basel half cantons access to new scientific findings and technologies. In 2019, the SNI spent a total of 7.19 million Swiss francs, of which 4.68 million were provided by the Canton of Aargau and 2.51 million by the University of Basel.

A diverse, active network
The success of the SNI is based on the interdisciplinary network that has been built up over the years and is constantly attracting new members. This network includes the Departments of Chemistry, Physics, Pharmaceutical Sciences and Biomedicine, and the Biozentrum at the University of Basel, as well as research groups from 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 Muttenz and the newly founded ANAXAM technology transfer center. The wider network also includes the Hightech Zentrum Aargau in Brugg and BaselArea.swiss, which promotes knowledge and technology transfer.

Excellent education for students
The University of Basel has offered bachelor's and master's programs in nanosciences since 2002. At the end of 2019, 53 students were enrolled on the bachelor's program and 47 on the master's program. The students on the bachelor's program receive a solid basic education in biology, chemistry, physics, and mathematics. Over the course of this demanding program, they can choose from a wide range of practical and theoretical courses that allow them to focus on specific topics. Early on in their education, they have the opportunity to participate in various research groups and to gain insights into research projects within industry.

A variety of topics at the PhD School
To promote the further training of young scientists and a wide spectrum of basic scientific research, the SNI initiated a PhD School in 2012. Within the SNI PhD School, each doctoral student is supervised by two members of the SNI network. The doctoral students' interdisciplinary education is further enhanced by participation in internal scientific events such as the Winter School "Nanoscience in the Snow", the Annual Meeting and various courses developed specifically for the PhD School. In 2019, 38 doctoral students were enrolled, seven of whom have completed their doctoral theses. Eight new projects were approved that will start in 2020.



The success of the SNI is based on the interdisciplinary network of leading research institutions in Northwestern Switzerland. (Background image: Shutterstock)

Leaders in their field
Basic sciences form the foundation of research work at the SNI. In addition to the various projects funded as part of the PhD School, the SNI also supports the basic scientific research performed by Argovia professors Rodrick Lim and Martino Poggio. Their work contributes to the SNI's outstanding international reputation.

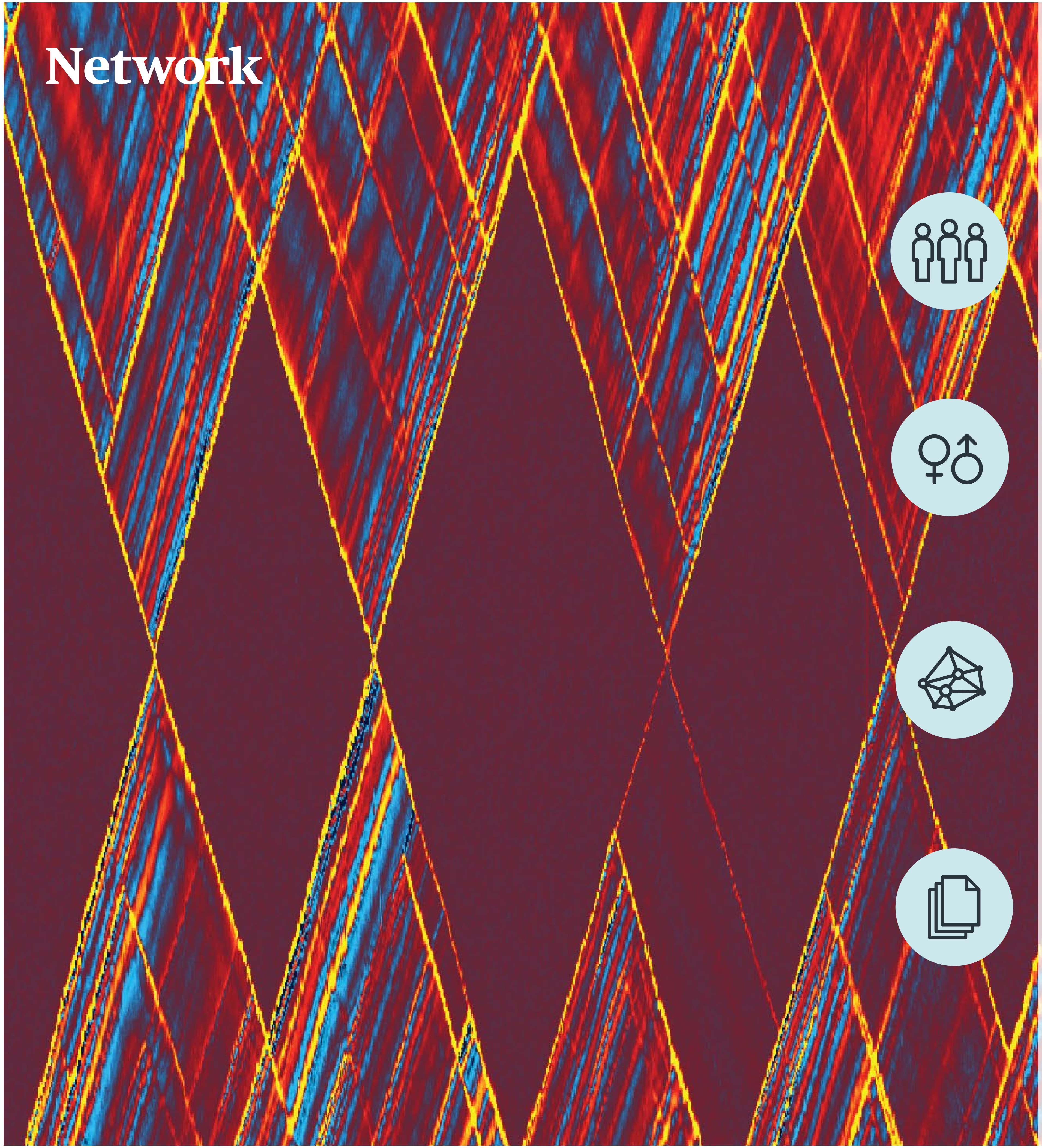
In addition to the Argovia professors, the SNI supports three titular professors: Professor Thomas Jung teaches and researches in the Department of Physics at the University of Basel and leads a team at the PSI. Professors Frithjof Nolting and Michel Kenzelmann also lecture at the Department of Physics and are active with their research groups at the PSI.

Strong connections to practical application
The transfer of academic findings to industry plays an important role at the SNI and is supported by the Nano Argovia program. In 2019, six new projects were approved and seven projects were extended from the previous year. Eight of the partner companies came from the Canton of Aargau, and five were from the two Basel half cantons. Collaboration with industry is also promoted through the new ANAXAM technology transfer center. ANAXAM provides companies throughout Switzerland with access to state-of-the-art analysis methods.

Services in demand
The SNI is also on hand as a provider of various services for partners in academia and industry. At the heart of these services is the Nano Imaging Lab (NI Lab), which has been part of the SNI since 2016. The NI Lab's five members of staff have a wealth of experience in electron and scanning probe microscopy and can provide comprehensive imaging services thanks to the lab's outstanding equipment and their expertise. The SNI also supports the excellently equipped workshops for technology, electronics, and mechanics in the Department of Physics. Research institutions and industrial companies can access both the expert knowledge of the staff and the outstanding technical resources of the SNI and affiliated departments.

Sharing the fascination with others
For the SNI, it is important to keep the public informed of its activities and to involve them in its fascination with the natural sciences. For example, the SNI team participates in science festivals and exhibitions and provides schools and groups of interested visitors with an insight into everyday laboratory life. The annual Nano-Tech Apéro promotes contact with industrial companies. A digital magazine, press releases, website, social media channels along with a range of brochures support these activities and allow the SNI to report on its outstanding research findings and activities.

Network



156

156 members belong to the SNI network.

21

21% of the SNI members are women.

9

There are nine partner institutions in the SNI network. These include the research institutions University of Basel, the School of Life Sciences at the University of Applied Sciences Northwestern Switzerland (FHNW), the School of Engineering at the FHNW, the Paul Scherrer Institute (PSI), the Department of Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel, the Centre Suisse d'Electronique et de Microtechnique (CSEM) in Muttenz, and the technology transfer center ANAXAM. The network also includes the Hightech Zentrum Aargau and BaselArea.swiss.

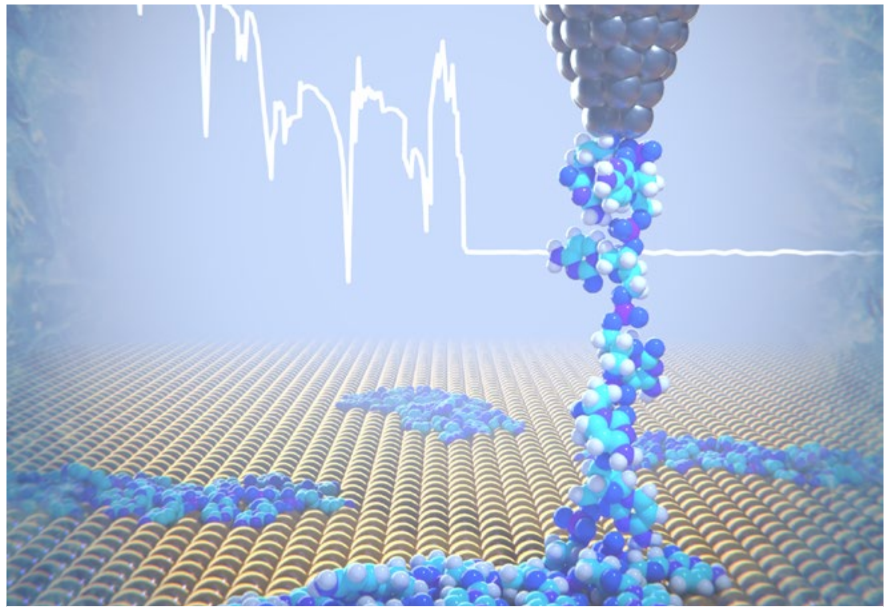
66+187

SNI members published 66 scientific papers based on SNI projects and presented their work as part of 187 talks at national and international conferences.

Electronic measurement of an 20nm quantum dot in a nanowire
(Image: C. Jünger, Department of Physics, University of Basel)

News from the network

In 2019, scientists from the SNI network published 66 articles in renowned scientific journals. The examples set out here reflect the diverse range of subject areas supported by the SNI.



At low temperature, a DNA strand is removed from the gold surface using the tip of an atomic force microscope. In the process, it is possible to determine physical parameters such as elasticity and binding properties. (Image: Department of Physics, University of Basel)

Cryo-force spectroscopy reveals the mechanical properties of DNA components

Physicists from the University of Basel have developed a new method to examine the elasticity and binding properties of DNA molecules on a surface at extremely low temperatures. Using a combination of cryo-force spectroscopy and computer simulations, they were able to show that DNA molecules behave like a chain of small coil springs. The researchers reported their findings in Nature Communications.

Original paper:
doi: 10.1038/s41467-019-08531-4

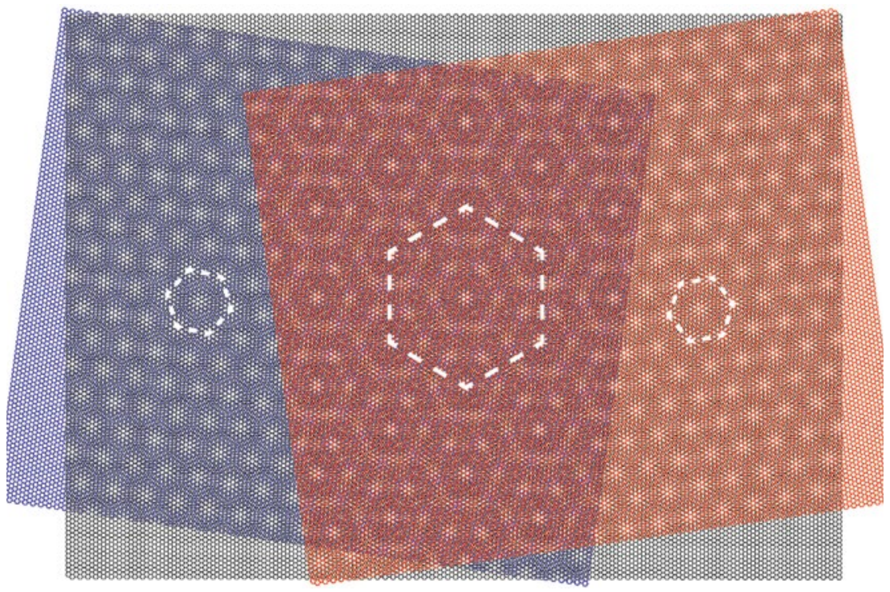
"Participating in the SNI network is a real plus for the University of Applied Sciences and Arts Northwestern Switzerland."

Prof. Dr. Crispino Bergamaschi, President of FHNW and member of the Argovia Board

Super superlattices: The moiré patterns of three layers change the electronic properties of graphene

Combining atomically thin layers of graphene and boron nitride at a slight angle to one another changes their electrical properties. Physicists at the University of Basel have now shown for the first time that combining this with a third layer can result in new material properties in a three-layer sandwich of carbon with boron nitride layers either side. Writing in the journal Nano Letters, the researchers report that this significantly increases the number of potential synthetic materials.

Original paper:
doi: 10.1021/acs.nanolett.8b05061



A graphene layer (black) of hexagonally arranged carbon atoms is placed between two layers of boron nitride atoms, which are also arranged hexagonally but with slightly different dimensions. The overlap creates various sizes of honeycomb pattern. (Image: A. Baumgartner, SNI, University of Basel)

Controlled and charge-neutral

A team of researchers from the SNI network has developed a chemical and optical strategy for transferring complex biomolecules such as insulin into the gas phase in the form of uncharged molecules. For this, the researchers from Basel, Karlsruhe, Vienna and Guangzhou use a technique known as photocleavage to separate certain charged groups of protein ions with a view to altering their charge state, or rather generating neutral molecules. The research has important implications for matter-wave interference experiments and was published in the journal Chemical Communications.

Original paper:
doi: 10.1039/c9cc05712a

Geometry of an electron determined for the first time

For the first time, physicists at the University of Basel have shown what a single electron looks like in an artificial atom. A newly developed method allows them to determine the probability that an electron will be present within a given space. This paves the way for improved control of electron spins, which could serve as the smallest information unit in a future quantum computer. The experiments were published in Physical Review Letters, and the related theory was published in Physical Review B.

Original paper: doi: 10.1103/PhysRevLett.122.207701 and doi: 10.1103/PhysRevB.99.085308

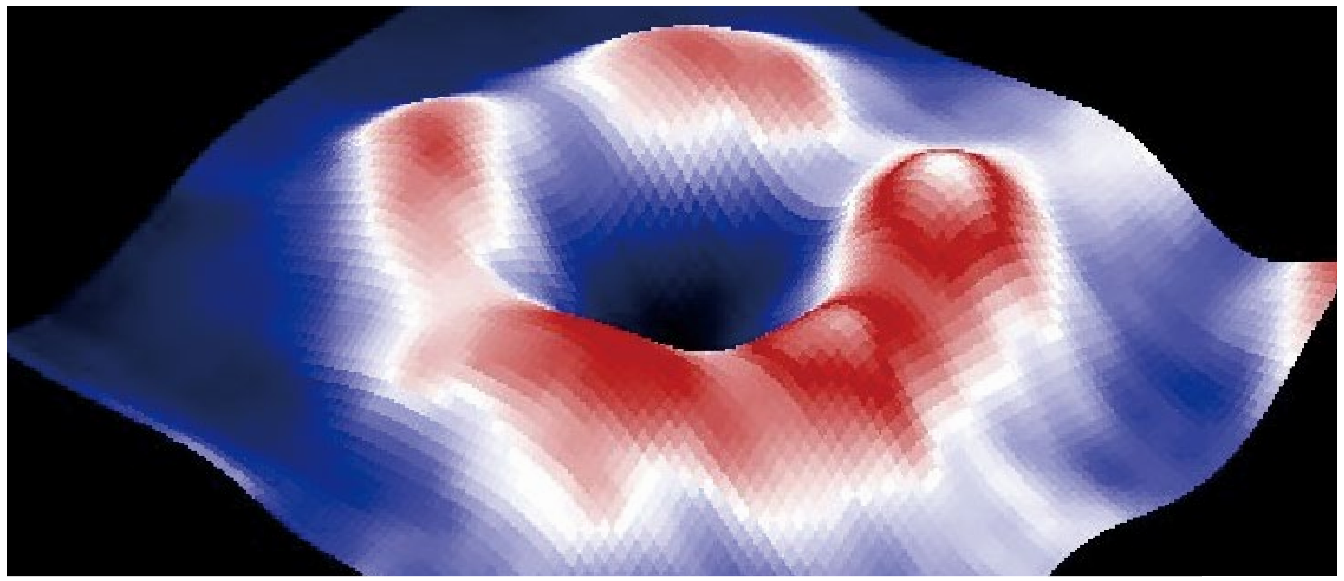
"I value being a member of the Argovia Committee of the SNI – not only does it give me an insight into the activities of the SNI, but I'm always learning something new."

Dr. Walter Riess, Head of the Science & Technology department at the IBM Research laboratory (Zurich), coordinator of the Binnig & Rohrer Nanotechnology Center and member of the Argovia Board

Two proteins form a pore

Two membrane proteins belonging to the nuclear pore complex self-assemble into a nanopore with a diameter of about 20 nanometers when integrated in a lipid bilayer *in vitro*. The two proteins arrange themselves into a ring-like membrane structure that encircles an aqueous, electrically conductive pore. Scientists from the University of Basel have described the formation of these *de novo* nanopores in the journal Biochemistry.

Original paper: doi: 10.1021/acs.biochem.8b01179



Two proteins that anchor the rest of the pore complex components to the nuclear envelope are enough to form a nanopore in a phospholipid membrane. (Image: T Kozai, Biozentrum, University of Basel)

Charge separation provides the key to harnessing solar energy

Researchers from the SNI network and the University of Basel's Department of Chemistry have examined various charge-separated states. Understanding how these intermediate products of photosynthesis are formed is crucial for the development of artificial photosynthesis systems that can transform solar energy into energy that can be stored chemically.

Writing in the journal Chemical Science, the researchers describe that the yield of charge-separated states can depend on the excitation wavelength. In the studied systems, they found that shorter intramolecular distances result in more efficient light-induced charge recombination, while thermal charge recombination is more efficient at longer intramolecular distances.

Original paper: doi: 10.1039/C9SC01381D

A new synthetic approach to the molecular motor

Writing in the European Journal of Organic Chemistry, chemists at the University of Basel describe a new synthetic route to stable pseudorotaxanes in water.

Pseudorotaxanes consist of two parts – a rod-like molecular axle threaded through a ring-shaped molecule – that are held together by intermolecular interactions. Unlike rotaxanes, they lack terminal groups that prevent the axle from exiting the ring-shaped molecule. Since the axle can move relative to the ring-shaped molecule, pseudorotaxanes serve as interesting model systems for the construction of molecular machines, pumps or switches. The synthetic route they describe leads to molecules that are highly thermodynamically stable and kinetically inert.

Original paper: doi: 10.1002/ejoc.201801864

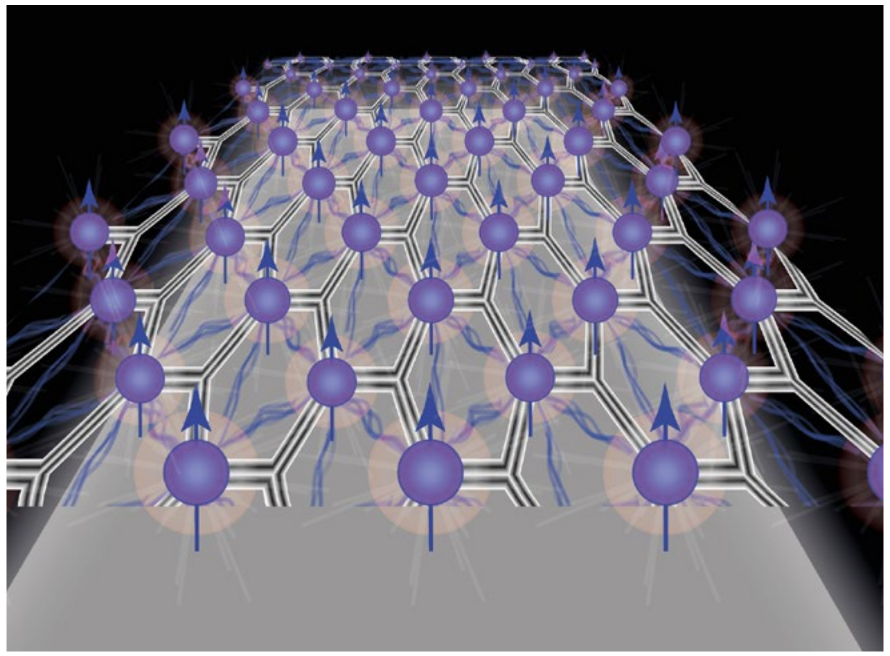
"For me, the SNI represents a unique combination of innovative basic research and applied projects."

Prof. Dr. Per Magnus Kristiansen, FHNW School of Engineering and member of the SNI Board

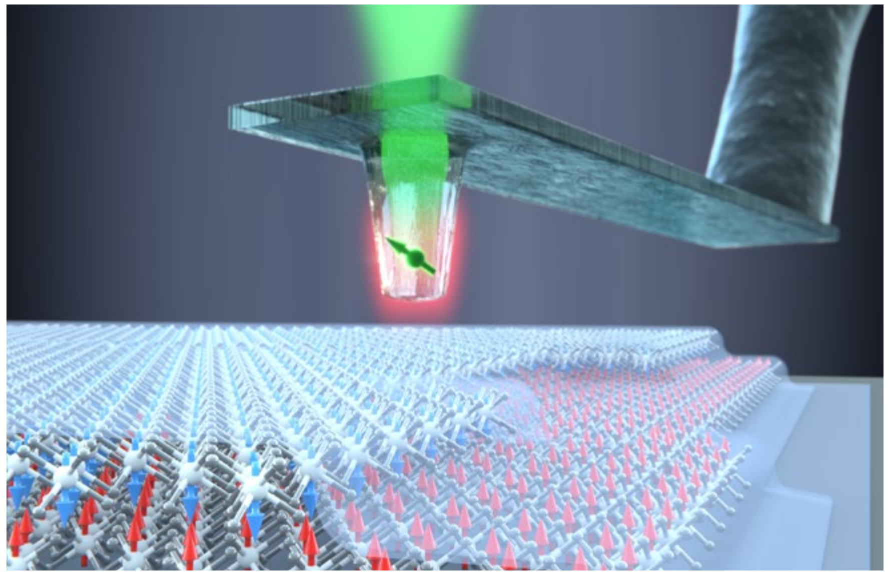
Spontaneous spin polarization demonstrated in a two-dimensional material

Physicists from the University of Basel have demonstrated spin alignment of free electrons within a two-dimensional material. Writing in Nature Nanotechnology, they described their observation of spontaneous spin polarization, which cannot occur in ideal two-dimensional materials according to a well-known theorem from the 1960s.

Original paper:
doi: 10.1038/s41565-019-0397-y



In a two-dimensional layer of molybdenum disulfide, the electron-electron interactions (blue threads) force the spins of the electrons (violet spheres) to align. (Image: Department of Physics, University of Basel)



A diamond quantum sensor is used to determine the magnetic properties of individual atomic layers of the material chromium triiodide in a quantitative manner. It was shown that the direction of the spins in successive layers alternate in the layers. (Image: Department of Physics, University of Basel)

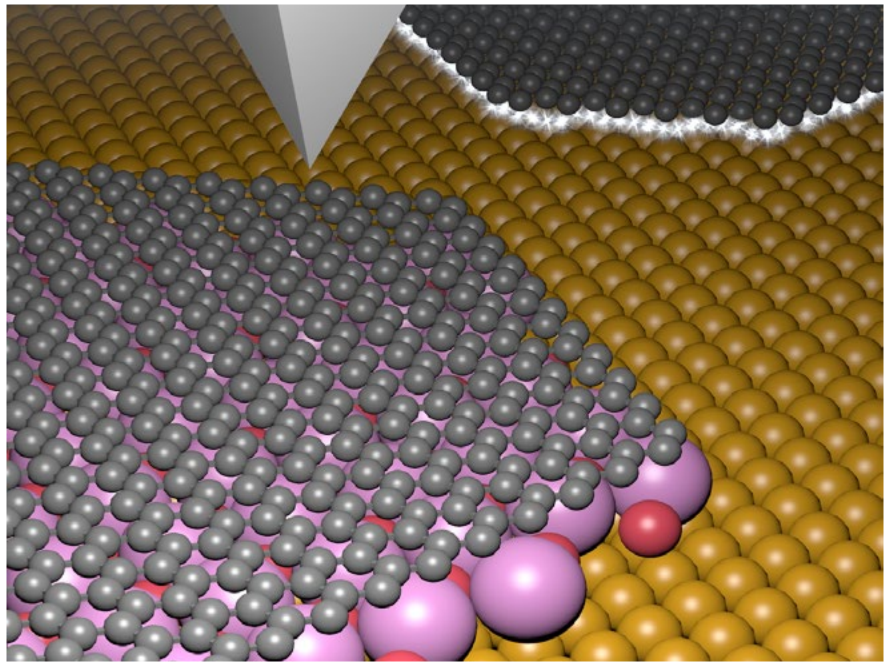
Unprecedented insight into two-dimensional magnets using diamond quantum sensors

For the first time, physicists at the University of Basel have succeeded in measuring the magnetic properties of atomically thin van der Waals materials on the nanoscale. They used diamond quantum sensors to determine the strength of the magnetization of individual atomic layers of the material chromium triiodide. In addition, they found a long sought-after explanation for the unusual magnetic properties of the material. The findings were published in the journal Science.

Original paper:
doi: 10.1126/science.aav6926

"For our focus on nanotechnology and materials, the SNI is one of the most important partners and has an excellent network for scientific research."

Dr. Martin Bopp, Managing Director of Hightech Zentrum Aargau



Potassium bromide molecules (pink) arrange themselves between the copper substrate (yellow) and the graphene layer (gray). This causes electronic decoupling, as demonstrated by scanning probe microscopy studies. (Image: Department of Physics, University of Basel)

Decoupled graphene thanks to potassium bromide

The use of potassium bromide in the production of graphene on a copper surface can lead to better results.

When potassium bromide molecules arrange themselves between graphene and copper, it results in electronic decoupling. This alters the electrical properties of the graphene produced, bringing them closer to pure graphene, as reported by physicists from the universities of Basel, Modena and Munich in the journal ACS Nano.

Original paper:
doi: 10.1021/acsnano.9b00278

The combination is key
Scientists from the SNI network have described how electron diffraction can be used to determine crystal structures efficiently. As part of the Nano Argovia project A3EDPI, the researchers combined an EIGER hybrid pixel detector with a classical electron microscope and calibrated the system to allow the quick and reliable calculation of diffraction data.

Writing in the journal Acta Crystallographica, they describe the results of this interdisciplinary collaboration by researchers from the Paul Scherrer Institute (PSI), the Universities of Basel and Dortmund, ETH Zurich, and Dectris (Baden-Dättwil).

Original paper: doi: 10.1107/S2059798319003942

In an article in Nature Communications, the scientists led by Dr. Tim Grüne present three-dimensional sample supports that allow the collection of complete datasets.

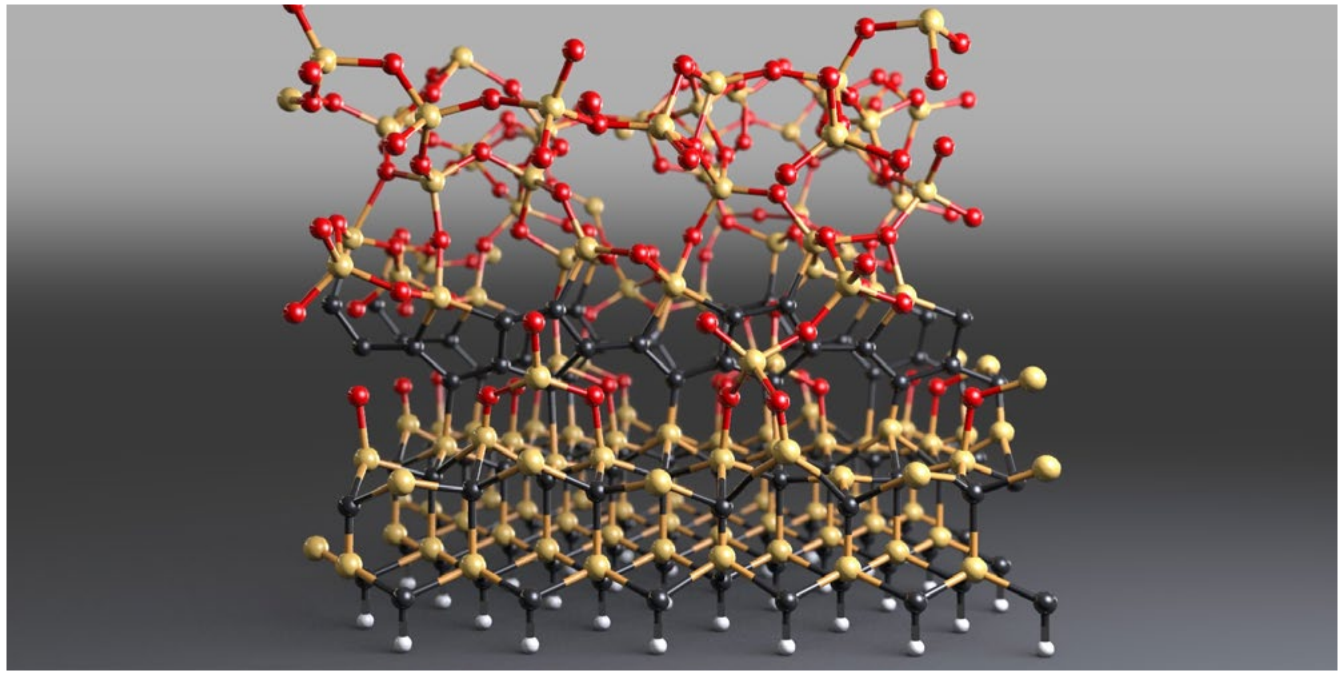
Original paper: doi: 10.1038/s41467-019-11326-2

"The diversity of topics addressed within the SNI network is fascinating."

Prof. Dr. Torsten Schwede, Vice President for Research of the University of Basel and member of the SNI Board

Silicon as a semiconductor: Silicon carbide would be much more efficient
In power electronics, semiconductors are based on the element silicon – but silicon carbide would offer much higher energy efficiency. Writing in the journal Applied Physics Letters, physicists from the University of Basel, the Paul Scherrer Institute and ABB explain what exactly is preventing the use of this combination of silicon and carbon.

Original paper: doi: 10.1063/1.5112779



The oxidation of silicon carbide causes the formation of defects: Irregular clusters of carbon rings (irregular black structures embedded in red and yellow atoms) occur at the interface between silicon carbide (periodic black-yellow atoms) and the insulating silicon dioxide (red-yellow atoms). These clusters are bound within the crystal lattice and disturb the flow of current. (Image: Department of Physics, University of Basel)

Ideal method for determining the length of graphene nanoribbons
In ACS Nano, researchers from the SNI network describe how Raman spectroscopy is a sensitive method for the investigation of graphene nanoribbons (GNRs), allowing analysis of their structural integrity, length and substrate interaction.

In contrast to low-temperature scanning tunneling microscopy, Raman spectroscopy can readily be used for practical device applications and characterization.

Original paper: doi: 10.1038/s41565-019-0533-8

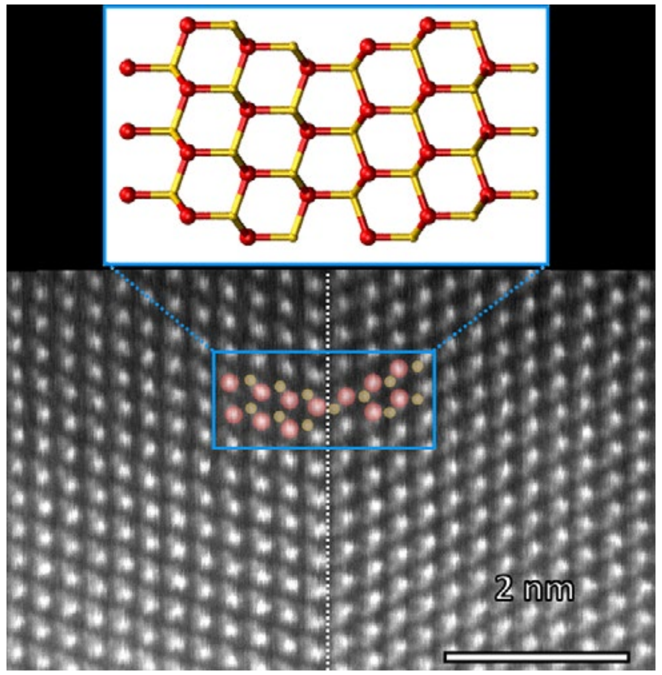
Molecular electronics: A molecular bridge further
Electronics built from molecules could open up new prospects for the miniaturization of circuits.

Empa researchers, together with partners from Switzerland, the Netherlands, Israel and the UK, have succeeded in solving a crucial detail in the realization of these circuit elements: a molecular bridge for electrons that remains mechanically and electronically stable at room temperature. The results have recently been published in the journal Nature Nanotechnology.

Original paper: doi.org/10.1021/acsnano.9b05817

Improved thermal conductivity thanks to a different atomic configuration
Fine-tuning the thermal conductivity of materials is one of the latest challenges in the world of nanosciences. Working with colleagues in the Netherlands and Spain, researchers at the University of Basel have shown that the atomic vibrations that influence thermal conductivity can be controlled simply by altering the arrangement of atoms in nanowires. For this work, the researchers prepared gallium phosphide nanowires in which successive crystal layers were periodically rotated by 60 degrees relative to one another. The scientists published their results in the journal Nano Letters.

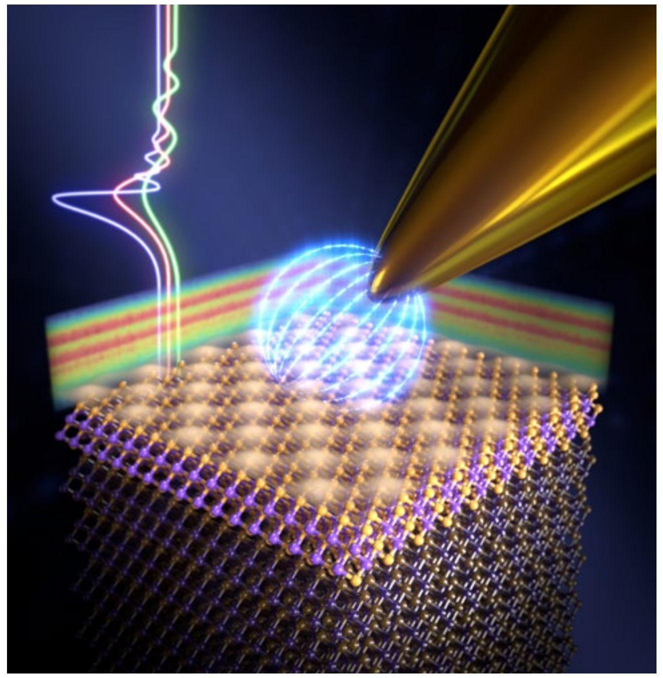
Original paper: doi: 10.1021/acs.nanolett.9b01775



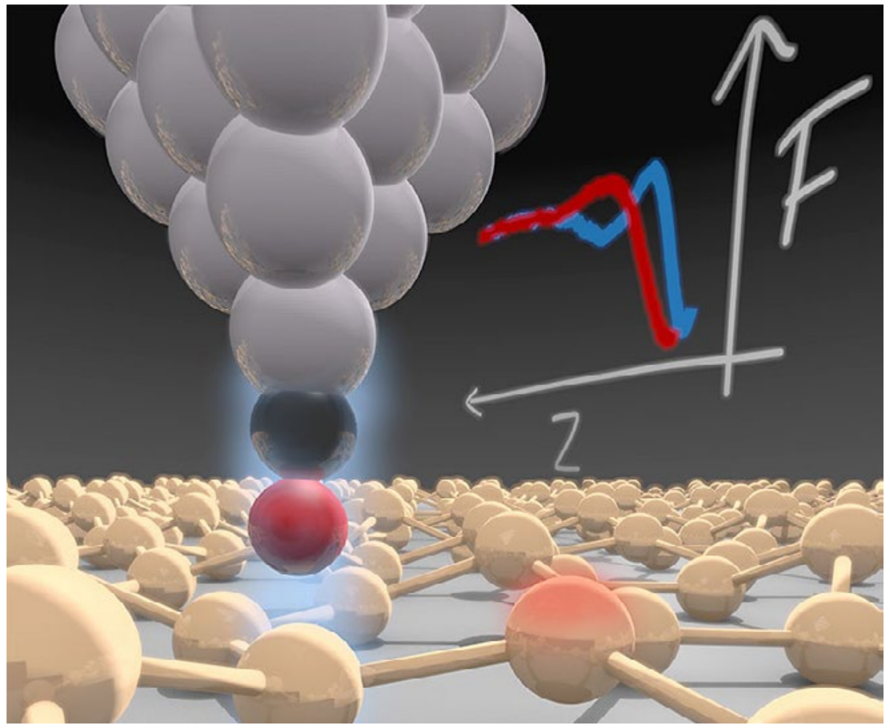
Two layers of gallium phosphide twisted 60 degrees against each other. (Image: Department of Physics, University of Basel)

How to control friction in topological insulators
Topological insulators are innovative materials that conduct electricity on the surface but act as insulators on the inside. Physicists at the University of Basel and Istanbul Technical University have begun investigating how they react to friction. Their experiment shows that the heat generated by friction is significantly lower than in conventional materials. This is due to a new quantum mechanism, as the researchers report in the journal Nature Materials.

Original paper: doi: 10.1038/s41563-019-0492-3



The gold tip is moved across the surface of the topological insulator and experiences energy loss only at discrete, quantized energies (indicated by the curves). (Image: Department of Physics, University of Basel)



A low-temperature atomic force microscope with a single carbon atom at the tip allows quantitative measurement of forces between the sample and the tip. With two-dimensional silicon (silicene), it is possible to determine surface buckling quantitatively. (Image: Department of Physics, University of Basel)

2D materials: Arrangement of atoms measured in silicene

Silicene consists of a single layer of silicon atoms. In contrast to the ultra-flat material graphene, which is made of carbon, silicene shows surface irregularities that influence its electronic properties. Now, physicists from the University of Basel have been able to precisely determine this corrugated structure. As they report in the journal PNAS, their method is also suitable for analyzing other two-dimensional materials.

Original paper:
doi: 10.1073/pnas.1913489117

Machine learning at the quantum lab

The electron spin of individual electrons in quantum dots could serve as the smallest information unit of a quantum computer. Scientists from the Universities of Oxford, Basel and Lancaster have developed an algorithm that can be used for the automatic measurement of quantum dots.

Writing in the Nature-family journal npj Quantum Information, they describe how they can speed up this hugely time-consuming process by a factor of four with the help of machine learning. Their approach to the automatic measurement and control of qubits therefore represents a key step toward their large-scale application.

Original paper: doi: 10.1038/s41534-019-0193-4

Miniaturized isolation and preparation

Scientists from the University of Basel have developed a microfluidic method whereby proteins can be isolated quickly and selectively, and then prepared for structural elucidation using cryo-electron microscopy. The researchers' approach requires less than a microliter of cell lysate.

As they explain in the journal Proceedings of the National Academy of Sciences, the method is suitable for high-throughput structural elucidation and provides new ways of isolating sensitive protein complexes and clarifying their structure.

Original paper: doi.org/10.1073/pnas.19072141167

"The granting of national and international third-party funding to members of the SNI network is an endorsement of previous scientific achievements and of the SNI's approach, in which basic research is combined with practical applications."

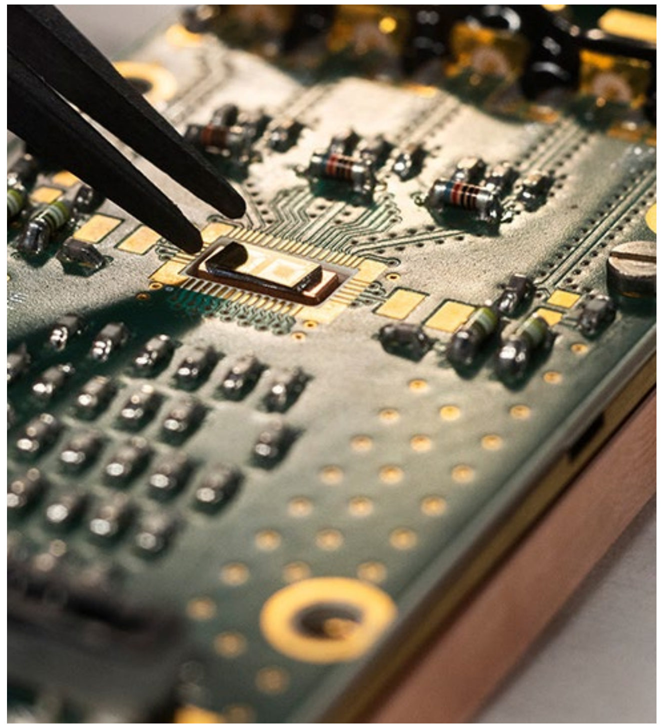
Prof. Dr. Andrea Schenker-Wicki, President of the University of Basel and member of the Argovia Board

Department of Physics heads up new National Center of Competence in Research

The University of Basel has been awarded a grant for a new National Center of Competence in Research (NCCR) in the field of quantum technology, which is to be headed up by the Department of Physics.

The aim of the new NCCR, known as "SPIN", is to develop technology with exceptional scalability as a key building block for a universally applicable quantum computer. For this work, the scientists from the University of Basel, the IBM Research laboratory, ETH Zurich and EPF Lausanne are using the semiconductor silicon, which has proven effective in industry over several decades. They are confident that silicon technology offers a very promising way of integrating billions of on-chip components, which would lead to extremely powerful quantum computers.

Further information:
https://nanoscience.ch/en/2019/12/16/the-university-of-basel-gains-two-new-national-centers-of-competence-in-research-nccr/
and
https://nanoscience.ch/en/2019/12/16/the-university-of-basel-gains-two-new-national-centers-of-competence-in-research-nccr/



In very close analogy to the functionality of a classical silicon transistor, spin qubits are also controlled or read out from the outside by applying both low and high frequency electrical signals. (Image: C. Flierl)

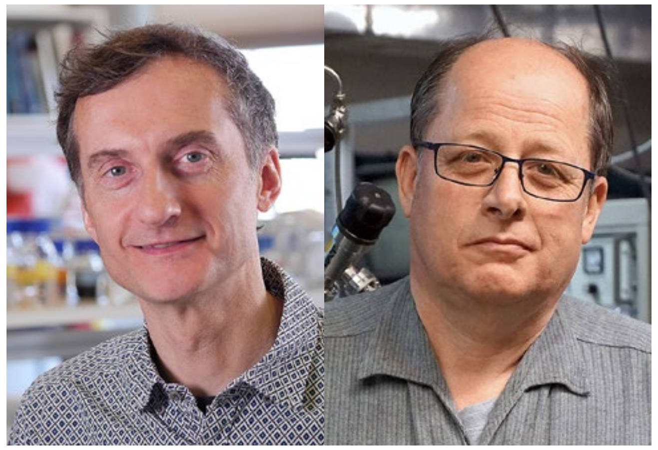
Patrick Maletinsky (Image: Department of Physics, University of Basel)

Patrick Maletinsky receives ERC Consolidator Grant

Three researchers from the University of Basel have been awarded one of the coveted ERC Consolidator Grants from the European Research Council (ERC). Professor Dr. Patrick Maletinsky from the Department of Physics, Professor Dr. Marek Basler from the Biozentrum, and Professor Dr. Dennis Gillingham from the Department of Chemistry are set to receive a total of EUR 6.7 million in funding over five years.

Patrick Maletinsky works with atomically thin magnetic systems known as van der Waals magnets, which he studies with the help of novel quantum sensors.

Further information:
https://nanoscience.ch/en/2019/12/10/patrick-maletinsky-receives-erc-consolidator-grant/



Alexander F. Schier (Bild: T. Hubbuch, Universität Basel) Ernst Meyer

EU research funding for SNI vice directors Alex Schier and Ernst Meyer

The European Research Council (ERC) has awarded generously endowed ERC Advanced Grants to two University of Basel scientists. Biologist Professor Dr. Alex Schier and physicist Professor Dr. Ernst Meyer will each receive funding in the six figures for their innovative research projects.

The ERC Advanced Grants, which are awarded by the European Research Council, are among the most prestigious and competitive grants in basic research.

Further information:
https://nanoscience.ch/en/2019/03/28/eu-research-funding-for-two-scientists-from-the-university-of-basel/

Innovation at the SNI
A good year for start-ups

Two new start-ups were founded in the SNI network in 2019: ELDICO Scientific and NUONEX, both with roots in Nano Argovia projects. The year ended on a high note for the two young companies Qnami and ARTIDIS – also founded by SNI members. SNI doctoral students also enjoyed an opportunity to get to grips with the topic of innovation and entrepreneurship.

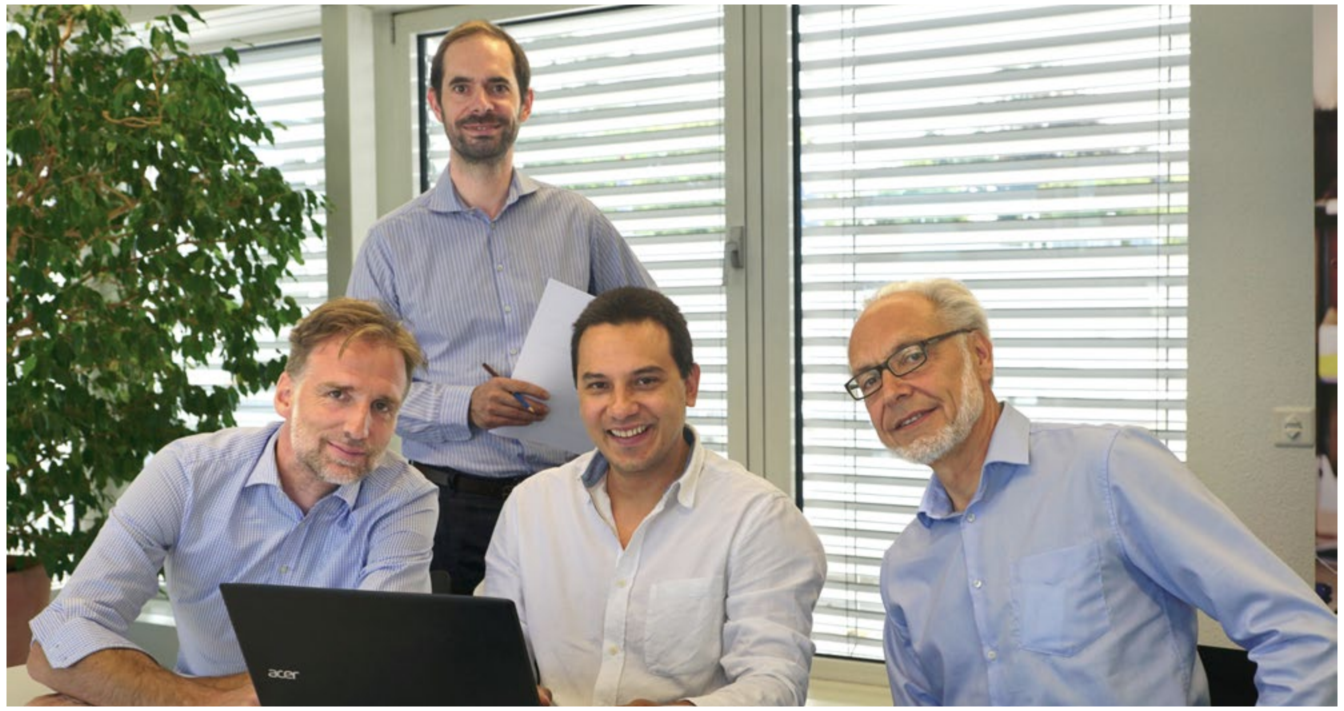
The primary channel for knowledge transfer from the SNI to industry is the Nano Argovia program, which provides a setting in which new research findings can be leveraged for the development of innovative processes and products. Under the program, an industry partner always teams up with at least two academic partners offering complementary fields of expertise. Many of the projects, which have a duration of up to two years, result in publications, patent applications or follow-up projects.

Structural analysis with electron beam diffraction
In the Nano Argovia project A3EDPI, researchers led by Dr. Tim Grüne (then at PSI, now at the University of Vienna) paved the way for the foundation of the start-up ELDICO Scientific. Their investigations demonstrated how electron diffraction can be employed to determine the structure of minute nanocrystals in powders that can only be analyzed with great difficulty – if at all – using conventional methods.

For this project, industry partner Dectris worked with Dr. Gunther Steinfeld and Dr. Gustavo Santiso-Quinones of Crystallise!. Recognizing the potential of the results, the two chemists and crystallographers founded ELDICO Scientific along with Nils Gebhardt and Dr. Eric Hovestreydt in June 2019.

The young company is now in the process of rolling out an electron diffractometer designed specifically for crystallographic measurements. This means that the development process can dispense with some of the costly components of an electron microscope; however, the sample holder must be optimized to allow the sample to rotate extremely accurate in the electron beam.

"The device elegantly combines two established techniques," remarked Eric Hovestreydt, CEO at ELDICO, on the results of the Nano Argovia project. "The result is a radical simplification with amazing potential, which ELDICO will exploit."



The four founders of ELDICO Scientific, Gunther Steinfeld, Nils Gebhardt, Gustavo Santiso-Quinones and Eric Hovestreydt (left to right), will commercialize an electron diffractometer for the analysis of nanoscale materials.

2019 was a successful year for the founders of Qnami Alexander Stark, Felipe Favaro, Mathieu Munsch and Patrick Maletinsky.

Fully automated sample preparation
The foundations for the company NUONEX, formed in March 2019 by Thomas Stohler and Silvan Häfeli, were also laid by Nano Argovia projects, carried out primarily by the group led by Dr. Thomas Braun at the Biozentrum's C-CINA.

Within the SceNA and MiPIS projects, the team developed the cryoWriter – a device for preparing samples to be examined with a cryo-electron microscope. In a fully automated process under controlled and adjustable conditions, the cryoWriter applies minute sample quantities to a grating which is then immersed in liquid ethane to shock-freeze the sample. The method is ideally suited to the requirements of cryo-electron microscopy. Former nanoscience student Thomas Stohler along with engineer and business expert Silvan Häfeli now plan to market the platform to clients in the field of research.

Quantum platform for materials analysis
For Qnami, a company founded in 2017 by Professor Dr. Patrick Maletinsky, Dr. Mathieu Munsch, Dr. Felipe Favaro and Dr. Alexander Stark, 2019 was a successful year. After two years of development work, the team recently unveiled its ProteusQ quantum microscope for materials analysis at the nanoscale. "We created ProteusQ to support researchers and R&D engineers in the development of novel materials for future applications in electronics or healthcare," said Mathieu Munsch, CEO of Qnami, commenting on this significant milestone in the young company's history.

Qnami has secured over 2.6 million Swiss francs in funding for the market launch and further refinement of its product. This round of financing was led by Quantonation, a venture capital fund specializing in quantum technology. Other sources of support include the Swiss venture capital com-

In 2019, Thomas Stohler and Silvan Häfeli founded NUONEX. They plan to launch a device known as the cryoWriter, which allows optimum sample preparation for cryo-electron microscopy. (Image: NUONEX) pany investiere, the German High-Tech Gründerfonds, start-up funding from Zurich Cantonal Bank and private business angels.

The team, which has grown to ten employees, achieved a great deal in 2019. It is now poised to make the quantum microscope available to beta testers and to process its first orders.

A unique support program

ARTIDIS AG, a start-up with roots in the research team led by Argovia Professor Dr. Roderick Lim, also concluded 2019 with very positive news: It was one of sixteen start-ups chosen from around the world to join the accelerator program of the Texas Medical Center's Innovation Institute.

"This is a great opportunity for ARTIDIS as it provides access to a unique environment at the forefront of science and innovation," explained Dr. Marija Plodinec, the start-up's CEO. At the end of the year, ARTIDIS also announced the successful closure of a CHF 8.8 million seed financing in two rounds securing early clinical validation and the next development phase towards market entry in 2021.

ARTIDIS developed the first nanomechanical biomarker for cancer diagnosis and treatment optimization. As demonstrated by a clinical trial employing the nanotechnology platform, the quantitative data on the mechanical behavior of the cells under examination can yield a diagnosis within three hours. What is more, the data can be used to predict whether the tumor will metastasize. Consequently, ARTIDIS enables the development of customized treatment plans tailored to the individual needs of patients.

Joining the Texas Medical Center (TMC) will open up new funding and collaboration opportunities for ARTIDIS. Comprising over sixty medical institutions, the TMC is the world's largest medical complex and a pioneer in the advancement of the life sciences. The TMC Innovation Accelerator program aims to drive progress in the healthcare industry by bringing cutting-edge technologies into hospitals.

Entrepreneurs of tomorrow

These four examples illustrate how basic science research at the SNI can lead to products that bring genuine added value to customers. To give doctoral students at the SNI's PhD School an opportunity to explore the entrepreneurial mindset and find out about activities at the University of Basel, the 2019 Annual Event was preceded by a workshop on innovation for doctoral students.

Dr. Alessandro Mazzetti of the University of Basel's Innovation Office explained how academic work can gradually make the transition from an invention to an innovative product, and gave an overview of the range of activities involved. He was greatly impressed by the interest and openness shown by the doctoral students: "The students were eager to get involved in Basel's innovation ecosystem. They contributed positively to the workshop, asking lots of questions and trying to understand what it really means to be an innovator and an entrepreneur."

Inspired by the thought-provoking workshop to find out more about the topic of innovation, some of the doctoral students subsequently attended the monthly "Entrepreneurs Club" to get first-hand insights into the University of Basel start-up scene.

The team of ARTIDIS AG concluded 2019 with very positive news. (Image: ARTIDIS)

State-of-the-art materials analysis for industrial companies

ANAXAM supports the development of innovative manufacturing techniques

In 2019, under the lead of the Paul Scherrer Institute (PSI), the Swiss Nanoscience Institute (SNI) teamed up with the PSI, the University of Applied Sciences Northwestern Switzerland (FHNW), the Canton of Aargau and a number of industrial partners to plan a technology transfer center for applied materials analysis backed by the Swiss Federal Government. The center, known as ANAXAM (Analytics with Neutrons and X-Ray for Advanced Manufacturing) provides cutting-edge materials analysis services to industrial companies working with modern manufacturing technologies. In late September, the umbrella organization Advanced Manufacturing Technology Transfer Center (AM-TTC) Alliance approved the concept and the financial support required for the start-up phase, allowing ANAXAM to open its doors in December.

Innovative manufacturing "Made in Switzerland"

"Made in Switzerland" is synonymous with quality, and should remain so in future. Accordingly, a great deal of research and development on modern manufacturing technologies takes place in Switzerland. However, before an improved technology, an innovative process or a new material can make the transition from the laboratory to industrial production, there are a number of hurdles to be overcome.

The Federal Government's "Action Plan for Digitalization" was launched to support efforts to further cement Switzerland's status as an outstanding manufacturing location. Among the plan's objectives is the creation of technology transfer centers devoted to innovative manufacturing technologies, with a view to promoting technology transfer from research to industry. The AM-TTC Alliance is the umbrella organization for all of the new centers, responsible for defining their strategic orientation and coordinating among the

In cooperation with ANAXAM, a new coating for titanium implants is being developed as part of a Nano Argovia project.

"ANAXAM is another forward-looking platform for interdisciplinary collaboration that forms a bridge between research and industry, and we are delighted to be contributing to this public-private partnership with our expertise and infrastructure."

Prof. Dr. Christian Schönenberger, Director of the SNI

individual facilities. The alliance gives industrial companies access to the infrastructure they need to develop new and improved processes and bring innovative products to market.

Materials analysis supports optimization
"Outstanding materials analysis can provide crucial information in the context of technology transfer. In the Canton of Aargau, this gave rise to the idea of establishing a technology transfer center to allow Swiss industrial companies to benefit from the neutron and X-ray analysis carried out at the Paul Scherrer Institute (PSI)," reports Dr. Christian Grünzweig, director of ANAXAM. "In addition to its activities as a service provider, ANAXAM is also a guarantor of innovation in the field of analytics," he adds.

The array of methods, devices and expertise offered by ANAXAM is broadened by the participation of the FHNW and the SNI, resulting in a diverse spectrum of applications in a variety of industrial fields. The most varied materials can be analyzed and measured in detail, minute modifications – including those affecting a product's interior – can be represented, and production processes can be examined and optimized using the methods at the center's disposal.

Key milestone reached
After intensive preparations by representatives of the PSI, the Canton of Aargau, the FHNW and the SNI, the ANAXAM association was formed in May to set up the ANAXAM Technology Transfer Center for applied materials analysis in the field of innovative manufacturing technologies. In late September, ANAXAM was given the green light by the umbrella organization AM-TTC. As a result, for the start-up phase from 2019 to 2020, ANAXAM was granted funding to the tune of 2.3 million Swiss francs, enabling the association to open the center in Villigen on 1 December. An application for further funding in the development phase (2021 to 2024) has been submitted to the State Secretariat for Education, Research and Innovation (SBFI).

"For Aargau, with its thriving industrial sector, the establishment of this center is a key milestone," remarked Vincenza Trivigno, chancellor of the Canton of Aargau and an active participant in the preparations, adding that "ANAXAM will promote and accelerate the development of novel, highly innovative and competitive products and processes."

The materials analysis services on offer at ANAXAM go beyond laboratory work: ANAXAM employs highly trained personnel with the necessary skills to efficiently use the large-scale research facilities and infrastructure, who can offer professional advice to the center's customers from industrial companies at all times.

SNI involvement
The SNI is represented on the association's board by Argovia Professor Martino Poggio. The practical execution of jobs assigned to ANAXAM will primarily involve the Nano Imaging Lab (NI Lab), which specializes in detailed imaging and analysis of surfaces.

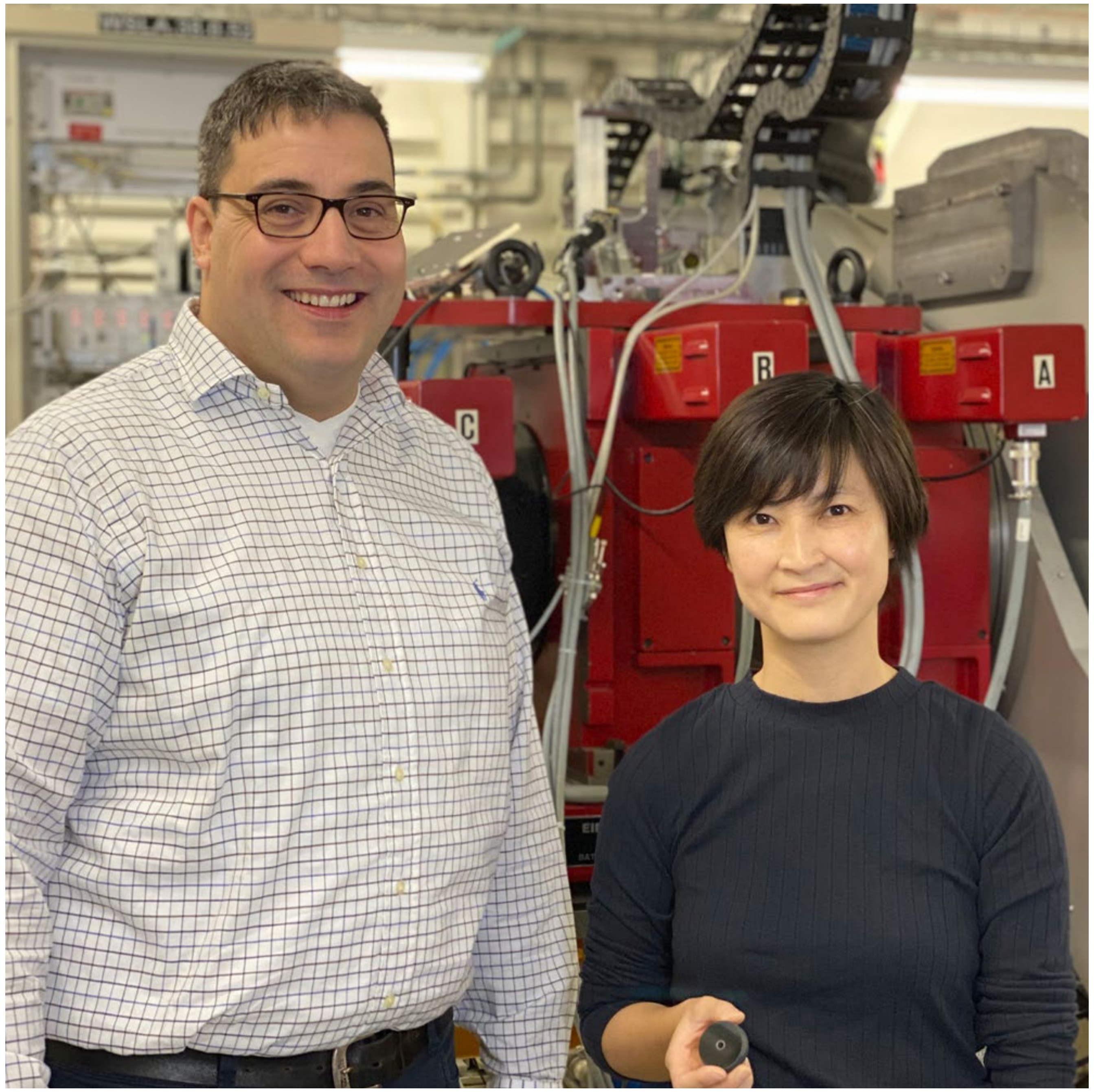
Moreover, funding for projects based on modern manufacturing technologies can be obtained under the Nano Argovia program. Two Nano Argovia projects have already been approved for 2020, to be executed in collaboration with ANAXAM.

In one, researchers at the FHNW School of Life Sciences will work with the company Acthera Therapeutics AG (Basel-Stadt) to develop a stable formulation for liposomes that are loaded with active agents and react to changes in blood pressure. The team plans to extrapolate the entire production and storage process to the pilot scale in order to produce material for pre-clinical trials.

In the second project in collaboration with ANAXAM, the FHNW School of Life Sciences will team up with the company Orchid Orthopedics Switzerland GmbH (Baden-Dättwil) to explore surface treatments for joint implants. The researchers will examine a process for improving titanium implants with a plasma-sprayed ceramic coating, as well as optimized post-treatment methods. Their goal is to develop joint implants that can sustain heavy loads with minimal abrasion due to movement and strain, and do not trigger immunological reactions.

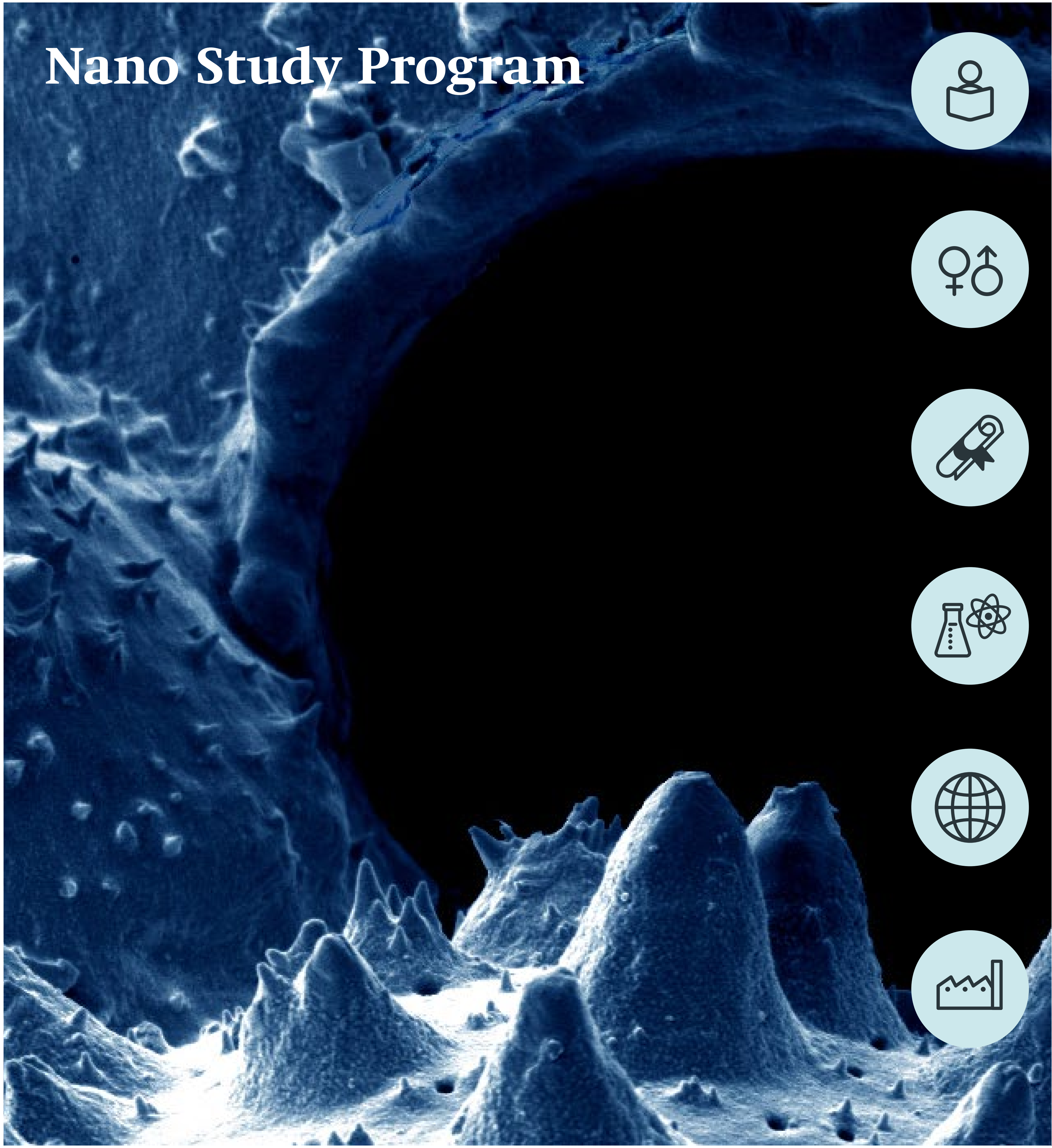
"In addition to its activities as a service provider, ANAXAM is also a guarantor of innovation in the field of analytics."

Dr. Christian Grünzweig, Director of ANAXAM



Christian Grünzweig and Sin Ting Cynthia Chang work together for ANAXAM on Nano Argovia projects and use the unique infrastructure of PSI.

Nano Study Program



100

In 2019, 53 students were enrolled on the bachelor's program and 47 on the master's program.

25%

25% of the students are women.

19+13

19 students successfully completed the bachelor's program and 13 completed the master's program.

34

In 2019, students were able to choose from 34 different block courses.

4

Four students received Argovia Travel Grants, which support students completing projects and master's theses abroad. The students worked at University of Cambridge (UK), Ben Gurion University (Israel), Freie Universität Berlin (Germany), and Institute of Catalysis in Madrid (Spain).

8

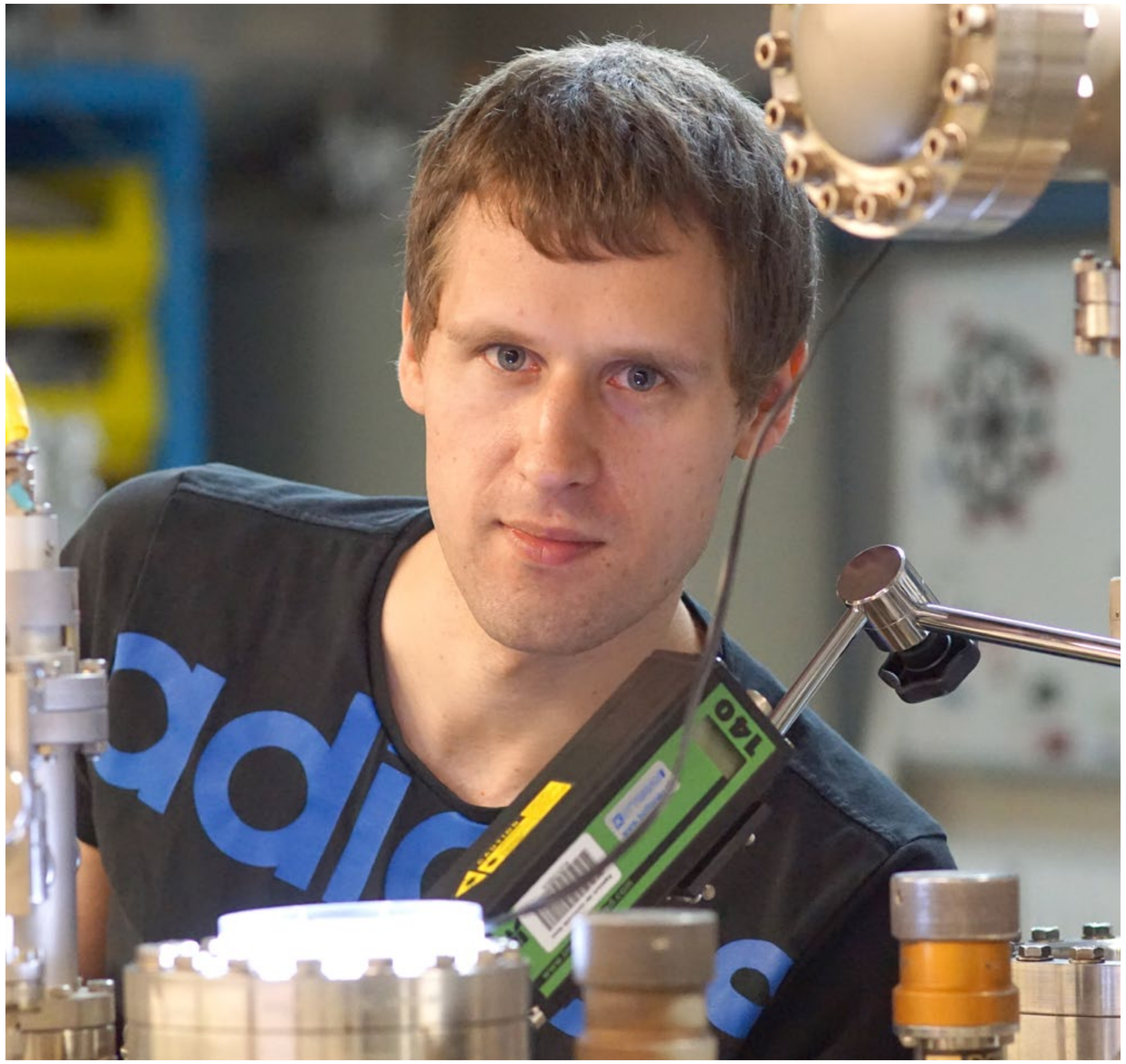
As part of the study program, students visited the companies Sensirion, CSEM, ABB, Sensirion, Mibelle, Nanosurf, Glas Trösch, Huntsmann, and Roche.

Scanning electron microscope image of a section of the endoskeleton of a radiolarian.
(Image: Taken by N. Brunner, student on the nanoscience study program, during a block course at the NI Lab)

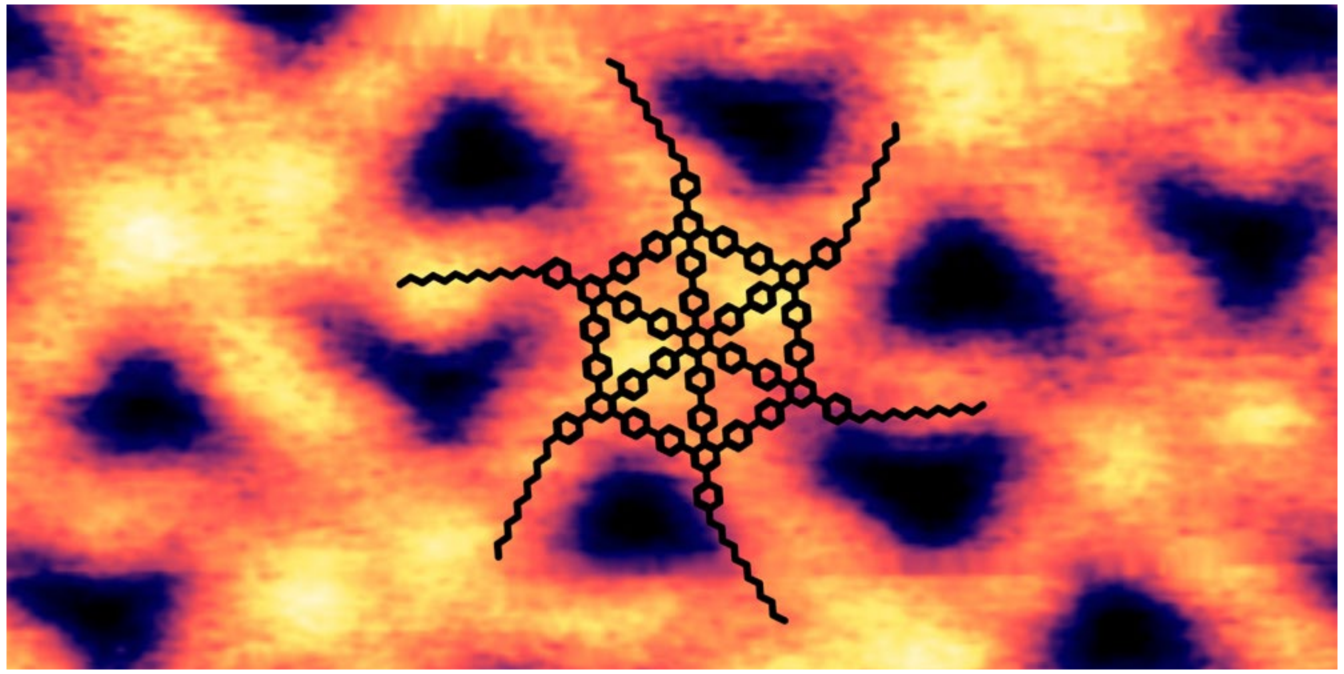
Complex molecules on surfaces

Sebastian Scherb receives the prize for the best master's thesis

At the first master's degree ceremony for nanosciences in November 2019, Sebastian Scherb was awarded the prize for the best master's thesis in nanosciences of 2018. Working at the Department of Physics at the University of Basel, he investigated a new method for the surface deposition of individual complex molecules.



Sebastian Scherb investigated a new method for the surface deposition of individual complex molecules and was awarded the prize for the best master's thesis in nanosciences of 2018.



Sebastian Scherb imaged graphylene-1 molecules on a gold surface. (Image: S. Scherb, Department of Physics, University of Basel)

"It was hugely exciting for me to investigate how these complex molecules behave on different surfaces."

Sebastian Scherb, former student nanoscience, currently PhD student at Department of Physics, University of Basel

Seeking a method for large molecules

In his prizewinning master's thesis, Sebastian Scherb was able to show that electrospray deposition can be used to deposit large molecules on surfaces. In this method, molecules are sprayed from a solution by applying a high voltage. Then, in an ultrahigh vacuum, a differential pumping system transports the molecules onto the surface, where they self-assemble into molecular layers.

Sebastian conducted his analyses with two graphene-like compounds that promise a wide range of applications thanks to their special electronic properties. The first, graphylene-1, is a complex molecule that resembles a wagon wheel. Into this wheel, it is then possible to incorporate functional groups that give the molecule a specific set of properties. In addition, he also tested the method for graphene ribbons with lengths of up to 600 nanometers (graphene nanoribbons).

Astonishing observations

Using high-resolution atomic force and scanning tunneling microscopy, Sebastian was able to create a detailed image of the molecules deposited on the gold and potassium bromide surfaces. His images showed that the molecules survive the process well, remain intact, and can form molecular layers on the surfaces.

Since he performed the graphylene analyses both at room temperature and at very low temperatures (-268°C), Sebastian also observed an unexpected effect: at low temperatures, the individual graphylene molecules were much closer together than at room temperature. Simulations performed after the master's thesis suggest that, at higher temperatures, the molecules are forced apart due to increased mobility of their side chains. The extremely weak van der Waals forces responsible for holding the molecular layer together permit these different variations depending on the temperature.

Fascinating atomic force microscopy

Sebastian greatly enjoyed the work and was particularly fascinated by the microscopic analyses. During the block courses as part of the bachelor's program, he was especially interested in applications of atomic force microscopy. This is a topic that will continue to keep him occupied in the future, for Sebastian stayed on to work in Professor Ernst Meyer's team after completing his master's thesis and is now also writing his doctoral dissertation there.

Valuable impressions and experiences
Projects and master's theses abroad

The education received by our nanoscience students is filled with variety. The block courses on offer during their bachelor's degree are an opportunity to learn more about the different research groups at the University of Basel, the University of Applied Sciences Northwestern Switzerland (FHNW), the Paul Scherrer Institute, the Department Biosystems Science and Engineering at ETH Zurich in Basel, CSEM Muttenz, EMPA, or the Adolphe Merckle Institute in Fribourg. However, the prospect of immersing themselves in a different culture altogether entices many of our students abroad. In 2019, nine students returned from placements at international universities. Most of them benefited from an SNI travel grant, designed to financially support students while they complete a project or master's thesis abroad.

Project in Cambridge
Unconcerned by the Brexit debate, Yanik Weber chose to pursue a three-month project at the University of Cambridge (UK). In the group led by Professor Florian Hollfelder, he worked on the development of a microfluidic high-throughput platform to detect variants of the enzyme tryptophan synthetase with higher catalytic activity. Yanik Weber particularly enjoyed the openness and willingness of his colleagues to support his research with constructive suggestions. "Even as a guest, I was given full access to all the devices and chemicals. This was instrumental in helping me achieve such positive results in the short time I was there," he reports.

Master's thesis in Copenhagen
Sebastian Buchmann also opted to spend time in another European country. He researched and wrote his master's thesis at the Technical University of Denmark's Department of Micro and Nanotechnology in Copenhagen. In the group led by Professor Jenny Emnéus, he worked on a two-dimensional model brain on a chip. The model uses a microfluidic system to grow nerve cells involved in a key signal pathway in the brain that is impaired in patients suffering from Parkinson's disease. Buchmann also appreciated his group's helpful attitude, not to mention Copenhagen's unique atmosphere. "I'm very happy to have completed my master's thesis abroad, and I would like to thank the SNI for the financial support."

Valuable experience in Japan
Charlotte Kress ventured significantly further afield for one of her projects, spending three months at Osaka Prefecture University in Professor Nobutaka's research group. The main part of her work revolved around the production and processing of a protein able to modify the functionalization of a carbon-carbon double bond.

Charlotte felt well-equipped for her demanding work in Japan thanks to the block courses she had attended. She also coped well with being immersed in a completely new culture. Her research group was made up entirely of Japanese bachelor's and master's students, and while communication was not always easy, she soon felt at home. She became a part of the team, and despite the cultural differences she was able to form a small social network during her brief stay, which made her goodbyes all the more difficult when the time came for her to leave.

Aside from the value of the experience itself, Charlotte's time in Japan also helped her to appreciate her bachelor's degree in Basel: "In the English-language seminars, I soon realized that I was always able to keep up and had something to contribute, whatever the topic. All that studying during my degree was worth it!"

"I'm very happy to have completed my master's thesis abroad, and I would like to thank the SNI for the financial support."

Sebastian Buchmann, former nanoscience student at the University of Basel, wrote his master's thesis at the Technical University of Denmark.

Students on the nanoscience study program can apply for funding for a stay abroad to complete a project or master's thesis. The coordinator of the nanosciences program, Anja Car, supports students like Charlotte Kress in all aspects of planning and follow-up.

"In the English-language seminars, I soon realized that I was always able to keep up and had something to contribute, whatever the topic. All that studying during my degree was worth it!"

Charlotte Kress, nanosciences student at the University of Basel, completed a project thesis at Osaka Prefecture University.

"Project and master's theses are an ideal opportunity for students to gain experience abroad and expand their network."

Dr. Anja Car, coordinator of the nanosciences program at the University of Basel

Exciting months in the USA
Patrick Weber spent nine months on the USA's East Coast, at Duke University's Institute of Biomedical Engineering (Durham, North Carolina) for his master's thesis. In the group led by Professor Ashutosh Chilkoti, he worked on elastin-like polypeptides, which are used as carriers for pharmaceutical agents. In a manner similar to liposomes or polymersomes, these peptides form tiny micelles that can be functionalized with tumor-specific or cytotoxic ligands and loaded with drugs. The key issue addressed in Patrick Weber's work was the critical concentration of micelles for the technique to be effective.

Patrick found his time in the USA both fascinating and instructive. "I grew as a scientist," he writes in his report. He also thoroughly enjoyed his experiences outside the lab, savoring the impressive natural landscapes of North Carolina and beyond, and making plenty of new friends.

Daniel Stähli was also drawn to the USA for his master's thesis. Working in the laboratory of Professor Tony Wyss-Coray at Stanford University (Palo Alto, California), he explored how the blood-brain barrier changes with age. In his thesis, he showed that plasma can reach various brain cells more effectively than previously assumed. Moreover, he and the team he was a part of – which is renowned in the field of aging research – developed a method to identify proteins that cross the blood-brain barrier.

"I learned a great deal about science at Stanford, and had a wonderful time. I can highly recommend both the university and the group," reports Daniel Stähli.

Fellow master's student Laurent Dubois enjoyed his time at Harvard University (Cambridge, Massachusetts) so much that he just couldn't stay away: After finishing work on the final stage of cell division in bacteria for his master's thesis, he spent a brief period back in Basel completing his master's degree before returning to Harvard to write his doctoral thesis.

The value of a semester abroad
Projects or master's theses are not the only reasons students spend time abroad. They can also take part in an exchange semester, during which they earn ECTS credits. Julian Koechlin chose this option for the first semester of his master's degree, which he spent at the University of Valencia (Spain). Julian Koechlin's assessment of his stay at this large university of over 50,000 students was very positive. "The teaching was on the mediocre side, delivered with rather less enthusiasm than I was used to in Basel, but I thoroughly enjoyed all the personal experiences, coming into contact with new people, and life in Spain," he remarked.

This year other nanoscience students also returned from international stays at Ben-Gurion University (Israel) and the Institute of Catalysis (Madrid, Spain).

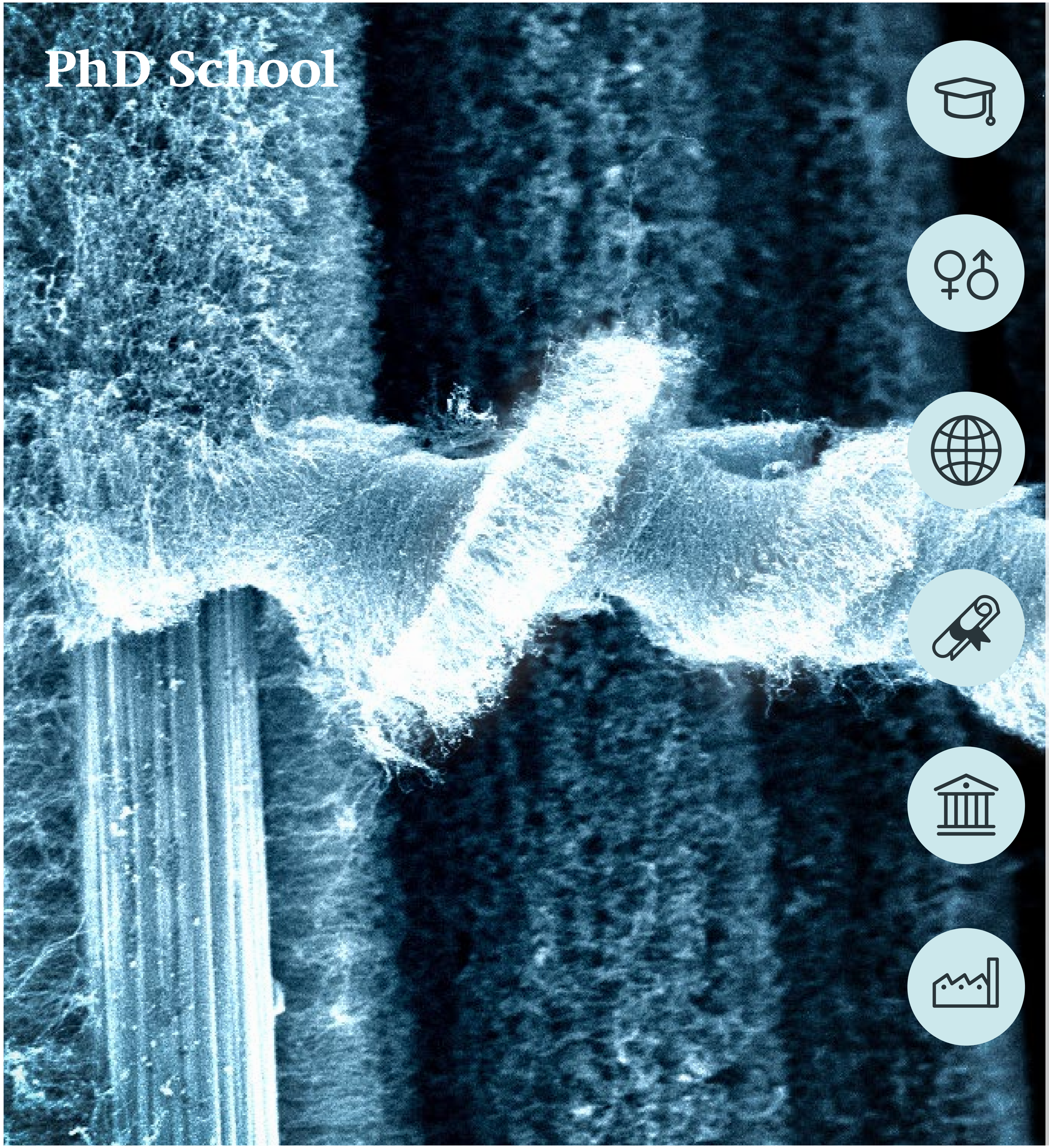
The SNI's Argovia travel grant funds students completing a project or master's thesis abroad. The grant covers travel and living costs up to 5,000 Swiss francs. Beneficiaries welcome this financial support, and the vast majority turn in glowing reports on their time at an international university (https://nanoscience.ch/de/studium/masterstudium/mobilitaet/, in German).

"I learned a great deal about science at Stanford, and had a wonderful time. I can highly recommend both the university and the group."

Daniel Stähli, former nanosciences student at the University of Basel, wrote his master's thesis at Stanford University.

Daniel Stähli and Yanik Weber learned a great deal during their stay abroad and enjoyed their time. They would recommend that all nanoscience students gain international experience.

PhD School



38

In 2019, 38 PhD students were enrolled in the SNI PhD School.

24%

24% of the PhD students are women.

14

PhD students from 14 different countries are enrolled in the SNI PhD School.

7

In 2019, seven doctoral students successfully completed their PhDs.

46%

46% of the 27 PhD students who had completed their PhDs by the end of 2019 work at a federal or research institution.

43%

43% of the 27 former PhD students work in industry.

Carbon nanotubes grown on and stripped off the carbon fibre fabric.
(Image: W. Szmyt, PhD student of the SNI PhD School, School of Engineering, FHNW)

SNI PhD School
Diverse, interdisciplinary topics

In 2019, seven young scientists successfully completed their dissertation at the SNI PhD School. They conducted their practical and theoretical work at the University of Basel's Biozentrum and Departments of Chemistry and Physics as well as at the FHNW's School of Life Sciences. In recent years, they have not only received excellent scientific training in their respective research groups, but have also been able to take advantage of numerous opportunities for interdisciplinary scientific exchange at SNI events. In addition, they attended courses on intellectual property, innovation, rhetoric and communication, specially developed for the PhD School, as well as courses on identifying their own strengths and talents.

Major steps toward artificial photosynthesis
Global demand for energy is steadily rising. For the most part, this demand is met by fossil fuels, which are in limited supply – besides contributing to climate change. Harnessing the sun's energy is a potential alternative to fossil fuels. We can learn how to tap this energy source from nature: in photosynthesis, solar energy is converted into storable, chemically bound energy with the help of light-absorbing compounds.

For her doctoral thesis at the University of Basel's Department of Chemistry, Dr. Svenja Neumann explored various processes that are relevant both to our understanding of natural photosynthesis, and to the development of artificial photosynthesis systems. The focus of her research was on the interplay between photoexcitable molecules, electron donors and electron acceptors. In particular, Svenja Neumann examined the distance-dependent rate of electron transfer, efficient formation of charge-separated states, and the phenomenon known as the z-scheme of photosynthesis. She also looked at undesired reaction pathways to support the development of future artificial photosynthesis systems.

Immediately after completing her doctoral thesis, Svenja Neumann took a job as group leader in the production division of Bachem AG (Bubendorf).

"My time at the PhD School gave me insights into a wide range of doctoral topics besides photochemistry – not to mention an enjoyable setting in which to develop my presentation skills by taking part in seminars and conferences."

Dr. Svenja Neumann, former SNI PhD student

Marietta Batzer worked with color centers of diamonds.

Improved sensor technology
The spin of individual electrons in color centers of diamonds can be used as quantum memory or in quantum sensor technology.

Dr. Marietta Batzer studied quantum sensors of this kind as part of her doctoral research at the Department of Physics of the University of Basel. By integrating these sensors into an atomic force microscope, it is possible to visualize extremely small magnetic and electric fields in nanometer resolution.

As part of her work, Marietta Batzer studied the influence of the diamond surface on the spin and optical properties of the color centers with a view to improving them. She was also involved in developing a new technique that combines top-down fabrication with bottom-up growth in order to obtain sharp tips with a good crystal structure. This combination of different approaches paves the way for a significant improvement in the quality of the sensors – and therefore in image quality.

"The interdisciplinary nature of the SNI PhD School inspired me to think beyond the boundaries of my own field of research."

Dr. Marietta Batzer, former SNI PhD student

Focus on tiny electrical contacts
Electronic components are becoming smaller and smaller, and even single molecules can fulfill key functions in circuits. For his doctoral thesis at the University of Basel's Department of Physics, Dr. Jan Overbeck explored the properties of nanomaterials used in these minute contacts.

Jan Overbeck employed the mechanically controlled break junction technique to study the electrical properties of both individual molecules and molecular chains. Using electrical transport measurements and Raman spectroscopy, he examined the properties of two-dimensional graphene and one-dimensional graphene nanoribbons.

Thanks to novel substrates and optimized measurement techniques, his optical examination of the graphene ribbons resulted in the identification of a new, length-dependent vibrational mode that is sensitive to damage in the ribbons and substrate interactions. Finally, he succeeded in integrating these tiny graphene ribbons in circuits to allow characterization of their electrical properties.

Jan Overbeck works at the Transport at Nanoscale Interfaces Laboratory, Empa (Dübendorf).

Mirko Rehmann used hydrogen etching to produce tailor-made graphene ribbons.

Creating atomic structures with plasma

In his doctoral dissertation, Dr. Mirko Rehmann studied various aspects of the hydrogen plasma etching of graphite and graphene. Plasma etching is a promising method for the production of graphene nanostructures in atomic precision for novel electronic and quantum mechanical applications.

Mirko Rehmann discovered that, in graphite, it is possible to create not only perforated surfaces but also surfaces with well-defined hexagonal pits. While studying individual graphene layers, Rehmann noticed that the substrate for the single-atom carbon layer had a significant influence on results. Using the hydrogen etching process, he was able to attack targeted areas of the graphene in order to produce tailor-made graphene ribbons.

With the aid of microscopic analyses, he determined the quality of the edges produced by plasma etching and found that they continue to show irregularities in the crystal lattice. He also succeeded in confirming this through analyses of electrical transport in combination with quantum transport simulations. It is therefore essential to optimize the etching process further in order to obtain graphene edges with a perfect crystal structure.

Matter wave experiments with large biomolecules

Light is not alone in behaving like a wave. Matter beams also produce interference patterns in double-slit experiments – a hallmark of wave-like behavior.

For his doctoral thesis at the University of Basel's Department of Chemistry, Dr. Jonas Schätti chemically altered biomolecules such as peptides and proteins to make them suitable for use in matter wave interference experiments.

Experiments of this sort rely on charge-neutral biomolecular beams, which to date have only been successfully formed for small peptides. In close collaboration with a team from the University of Vienna, the biomolecules synthesized by Jonas Schätti were examined in terms of their usability in matter wave experiments. The researchers developed methods to transfer complex biomolecules like insulin into the gas phase uncharged. A central aspect of Schätti's work was the ionization of neutral protein beams under high vacuum.

For his doctoral thesis, Jonas Schätti worked at the exciting intersection between chemistry and quantum physics.

"The SNI PhD School is an opportunity to see your field of research from entirely new perspectives thanks to the close contact with colleagues working in other areas of the natural sciences."

Dr. Jonas Schätti, former SNI PhD student

Microfluidic system for efficient sample preparation

In his doctoral dissertation at C-CINA (Biozentrum, University of Basel), Dr. Claudio Schmidli developed a microfluidic method for isolating proteins. He combined this with the cryoWriter platform, which enables the quick, gentle, and cost-effective preparation of samples for cryo-electron microscopy (cryo-EM). Researchers using the new method need less than 1 microliter of cell lysate to determine the atomic structure of a protein.

The method lays the foundation for the high-throughput analysis of proteins using cryo-EM, which was not possible until now because of the elaborate isolation steps that this entailed. Given that only very small quantities of protein are needed, the new method can also be used to prepare proteins for cryo-EM structural analysis when they are only available in very small amounts – from biopsies, for example.

Immediately after completing his doctoral dissertation, Claudio Schmidli took up a position as research associate at Solvias AG in Kaiseraugst.

Christina Zelmer studied how cargo can be introduced into the nucleus with a high degree of selectivity.

Selective transport into the cell nucleus

Vesicles that selectively introduce active pharmaceutical ingredients into specific cell organelles could play a key role in targeted drug delivery, which is one of the key approaches in nanomedicine.

In her doctoral research at the Biozentrum and the Department of Chemistry of the University of Basel, Dr. Christina Zelmer studied how even quite large biocompatible vesicles pass through the nuclear membrane. To do this, she developed specific polymer-based vesicles, known as polymersomes, whose outer shells mimic natural membranes. Bound to these vesicles are nuclear localization signals that act as an entry ticket into the nucleus. Through detailed chemical, biophysical and cellular analyses, it was shown that only the vesicles marked with nuclear localization features can pass through the nuclear pore complexes.

The results demonstrate that the polymersomes are well placed to exploit transport routes through the nuclear membrane and therefore to introduce cargo such as active pharmaceutical ingredients into the nucleus in a highly selective manner.

"My doctoral dissertation was based between the Department of Chemistry and the Biozentrum of the University of Basel, allowing me to study interconnections that provide important insights into both subject areas."

Dr. Christina Zelmer, former SNI PhD student

Success stories
Still in contact

Many former SNI PhD students remain in contact with the SNI after completing their doctoral theses. This allows us to follow their career paths, to learn how they continue to pursue their goals and realize their dreams. Dr. Dilek Yildiz, for example, is currently a postdoc at Harvard University and Dr. Sascha Keller has fulfilled his dream of living and working in Japan for a few years.

A dream come true
Dr. Sascha Keller completed his dissertation at the Department of Chemistry in 2017. Working in the group of Professor Thomas Ward, he studied artificial metalloenzymes that can be used for the production of renewable fuels such as hydrogen, for example. With the help of biotin-streptavidin technology, he succeeded in producing effective artificial hydrogenases.

During his time in Basel, Sascha already dreamed of going to Japan and continuing his academic career there. Thanks to an Early Postdoc.Mobility fellowship from the Swiss National Science Foundation, he was able to make this dream a reality in 2018, when he began work as a postdoc at the University of Tokyo.

In fall 2019, he was then awarded a Standard JSPS (Japan Society for the Promotion of Science) International Fellowship for Research in Japan, which will enable him to extend his placement and spend a further two years conducting research in the country.

At the laboratory of Professor Yasuteru Urano, Sascha Keller is working on fluorescence probes for the detection of cancer. Using a new synthetic approach that he has developed, he hopes to produce novel probes that can visualize malignant tumors *in vivo*. This could be particularly helpful during the surgical removal of tumors. By using fluorescence to visualize the cancer, physicians could, for example, preserve the surrounding tissue during operations, which could bring decisive benefits in the case of brain tumors.


Sascha Keller enjoys his time at the University of Tokyo, but would like to return to Switzerland in the future.

Immersed in a different culture
The move to Japan presented Sascha Keller not only with a new scientific challenge but also with an opportunity to immerse himself in a completely different language and culture. This transition has ultimately been a success: he can now read Japanese and make himself understood. This means he can really enjoy the country, its culture and, especially, its varied cuisine.

Looking back on his time at the SNI PhD School, which was two years ago now, he has particularly fond memories of the friendships he forged there. However, his academic development was also shaped by the unique opportunities to engage in regular discussions with other PhD students and to participate in the SNI's internal seminar program.

In the future, he would like to return to Switzerland and work in research at one of the large pharmaceutical companies established here.

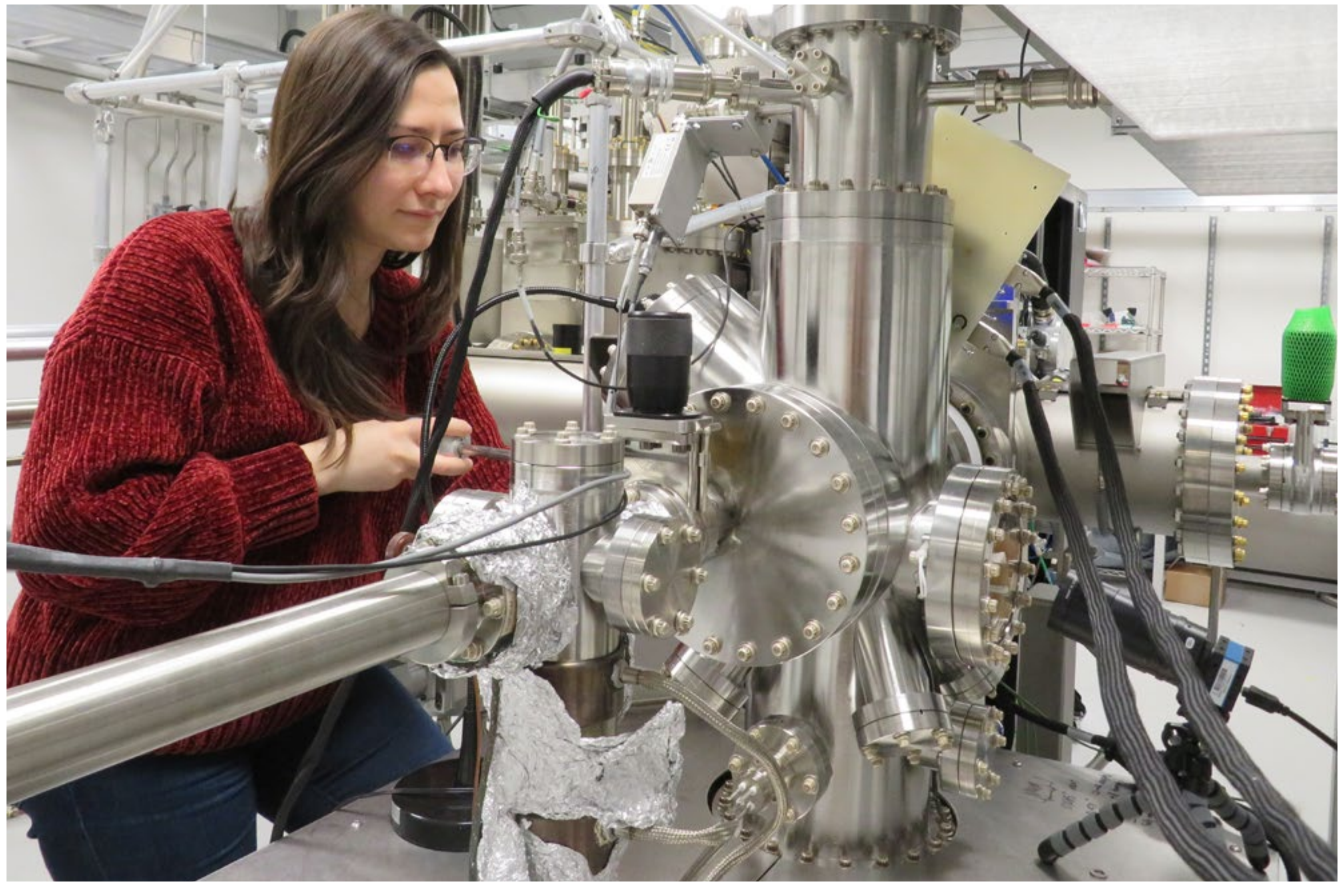
From Basel to Harvard via ETH
Dr. Dilek Yildiz completed her doctorate in Professor Ernst Meyer's group at the Department of Physics in 2018. Writing in Nature Materials in 2019, she and her former team published findings from this work and provided a description of friction in topological materials. For the first time, they presented experimental evidence that, due to a new quantum mechanism, the heat generated by friction is significantly less than in conventional materials.

A focus on exotic materials
Dilek Yildiz no longer conducts research in Switzerland but rather at Harvard University in Cambridge (USA). After completing her doctoral dissertation, she spent six months as a postdoc at ETH Zurich, where she helped to set up an ultra-high-vacuum photon scanning tunneling microscope. But Dilek was also keen to discover the world of research outside Switzerland, and so she seized upon the offer of a postdoctoral position at Harvard University.

Together with her research group there, she studies the behavior of electrons in exotic materials such as high-temperature superconductors and topological insulators. This includes analyzing the electronic structure of these materials using scanning tunneling microscopy (STM) and inducing phase transition by means of atomic force microscopy (AFM).

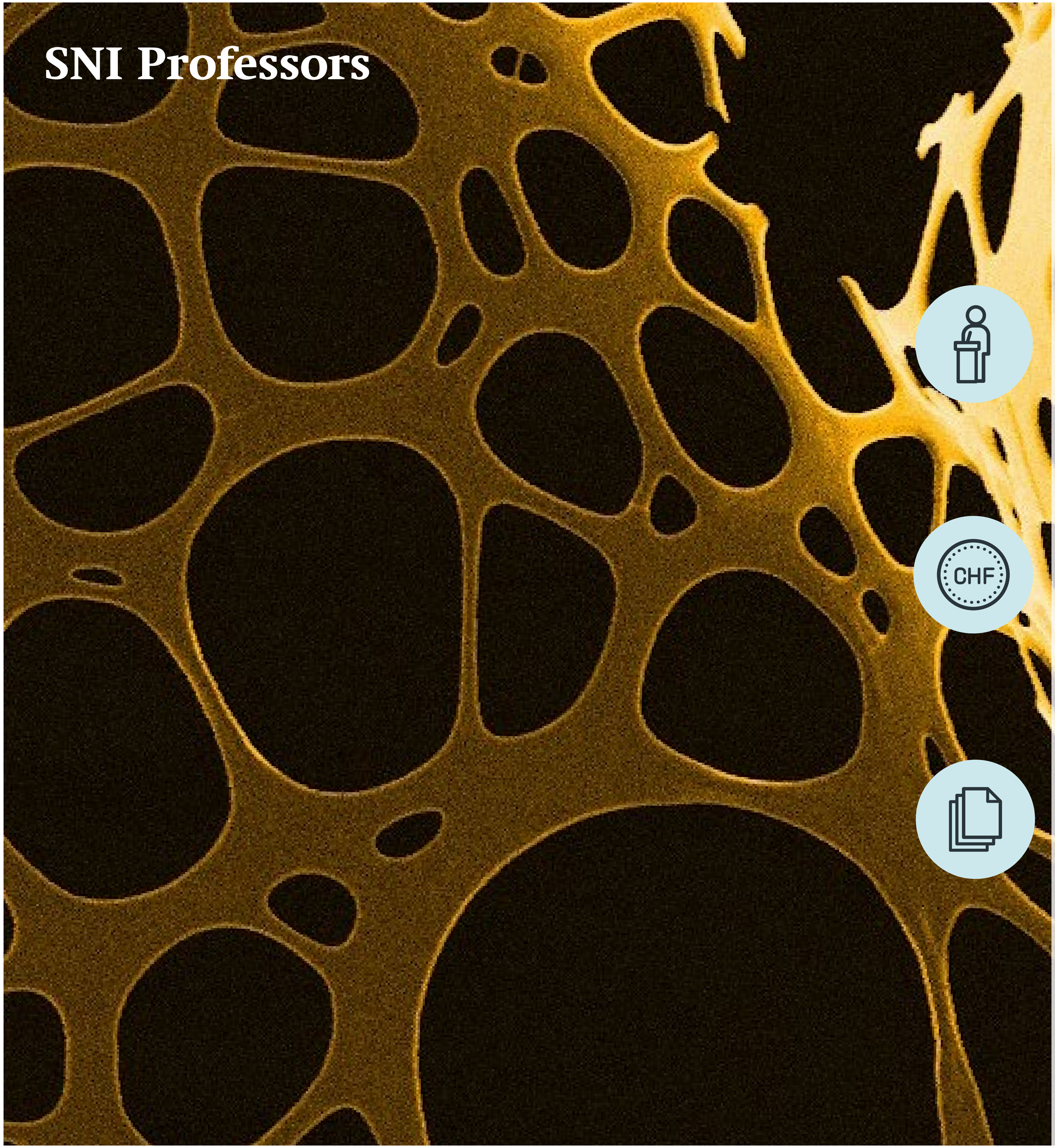
Dilek is primarily tasked with designing a scanning probe microscope with an STM and AFM setup that works at temperatures below 30 millikelvin (-273.12°C) in order to study and manipulate quantum states in these exotic materials. Her expertise means she is ideally suited to this task.

The benefits of an interdisciplinary environment
Dilek Yildiz enjoys the cosmopolitan atmosphere in Cambridge and the sense of dynamism at the university. Looking back on her time at the SNI PhD School, she particularly values the insights she gained into other areas of research thanks to the varied program of events and contact with SNI PhD students from different departments. "During my time in Basel, I realized that interfacing with other areas of science helps you explain your own work better and see things from a different perspective," she explains.


Dilek Yildiz works in the lab of Professor Jennifer Hoffman at Harvard University and is still in contact with her former colleagues in Basel. (Image: D. Yildiz)

Besides this, the city of Basel – located in the heart of Europe – came to feel like home over the years she spent working on her dissertation there. Although she is now several hours away by plane, she remains in contact with her former colleagues and friends. "I hope that we will find an opportunity to collaborate with each other in the future," says Dilek Yildiz.

SNI Professors



5

The SNI financially supports five professors. Argovia professor Martino Poggio works at the Department of Physics, Argovia professor Roderick Lim at the Biozentrum at the University of Basel. Thomas Jung, Michel Kenzelmann, and Frithjof Nolting are titular professors, who teach at the University of Basel and lead research teams at the Paul Scherrer Institute.

1.2 Mio.

In 2019, the Argovia professors Martino Poggio and Roderick Lim managed to attract about 1.2 million Swiss Francs in external funding for their research.

10

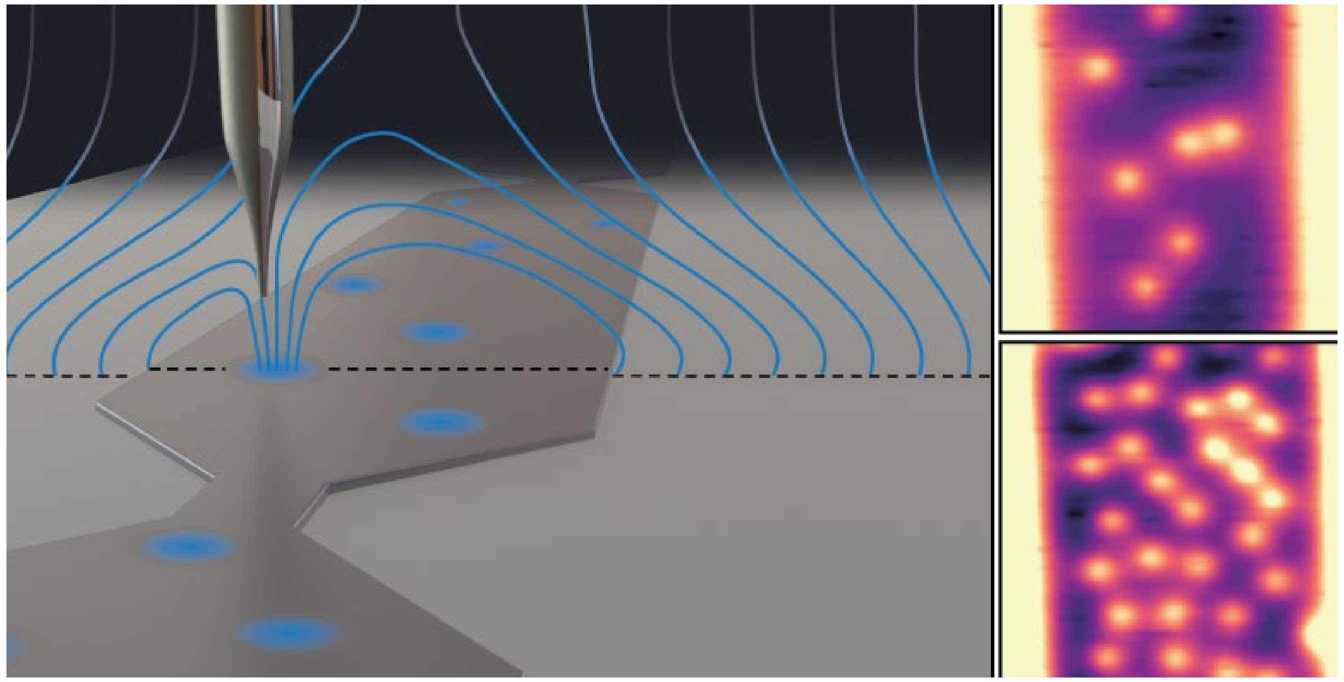
The Argovia professors and their teams published 10 scientific papers and gave 20 talks at various national and international conferences.

Scanning electron microscope image of a broken TEM grid. (Image: A. Campo, Department of Physics, University of Basel)

Detailed information about vortices
Imaging of ultra-thin superconductors delivers key information

In 2019, Argovia Professor Martino Poggio from the Department of Physics at the University of Basel continued his research into nanowires, including a more intensive study of thin molybdenum silicide (MoSi) films. At very low temperatures, these amorphous films have superconducting properties, but it is possible to manipulate these properties locally with the help of individual photons. The MoSi films are of considerable interest to scientists because the absorption of individual photons produces a clear signal – and the films can therefore be used as sensitive photon detectors. Superconducting vortices are responsible for this phenomenon. The Poggio Lab has imaged and examined vortices of this kind in MoSi for the first time and described the results in Physical Review B. The method allows the optimization of materials for a wide range of applications.

Lorenzo Ceccarelli and Martino Poggio study superconducting vortices.



The Poggio team succeeded in imaging vortices in MoSi for the first time using a newly developed, highly sensitive superconducting quantum interference device at the end of a tiny scanning probe. (Image: L. Ceccarelli, Department of Physics, University of Basel)

Sensitive photosensors

Molybdenum silicide (MoSi) is an amorphous material used as a thin film for the production of nanowire photon detectors. Normally, MoSi has superconducting properties at very low temperatures – that is, it conducts electricity without resistance. But when individual photons collide with the material, they cause localized changes in resistance and the MoSi film behaves like a normal electrical conductor. Accordingly, the material can be used to produce nanowires for the detection of individual photons. These superconducting nanowire single-photon detectors (SNSPDs) are fast, sensitive and efficient and lend themselves to numerous applications.

Within the NCCR QSIT, such MoSi films were produced in a collaboration with the group of Professor Richard Warburton and the company ID Quantique in the laboratory of Professor Christian Schönenberger and are now already in commercial use.

Vortices influence properties

Some experts in this field attribute the change in conducting properties to superconducting vortices. However, since the vortices in thin, amorphous MoSi are very weak, it has not yet been possible to image them or to gain a better understanding of the causes of this phenomenon.

In 2019, PhD student Lorenzo Ceccarelli from the Poggio team succeeded in imaging vortices in MoSi for the first time using a newly developed, highly sensitive superconducting quantum interference device at the end of a tiny scanning probe.

To do this, he began by applying magnetic fields, from below, which also lead to the formation of vortices in the amorphous MoSi films. The microscopic images allowed precise determination of the superconducting properties of the material and provided information about the conditions in which the vortices are formed. They also provide a direct visualization of the vortices, which have a central non-superconducting core.

Moreover, it was possible to map exactly how the vortices move and how they get caught on defects known as "pinning centers" in the material. This work suggests that the density and thickness of these pinning centers has a decisive influence on the quality of superconducting single photon detectors made of amorphous thin films.

Further applications of the method will follow

In further experiments in cooperation with scientists from the KTH Royal Institute of Technology in Stockholm, the scientists in Basel will investigate other commercially available superconducting nanowire photodetectors. Once the method has been refined, they also plan to study vortices generated by single photons.

Based on this research, the Poggio team has also embarked upon a collaboration with Professor Andreas Wallraff of ETH Zurich in order to study vortex motion in superconducting circuits used as qubits in quantum computers. As the errors seen there are often caused by vortices, the analyses carried out at the Poggio Lab can be used to record the specific effects of changes in materials.

Successful interdisciplinary collaboration
Combined knowledge of cell biology and biofunctional polymers

For many years, Argovia Professor Roderick Lim from the Biozentrum at the University of Basel has studied the molecular mechanisms that control transport into and out of the cell nucleus. In 2019, Lim's team concluded a successful interdisciplinary collaboration with the group led by Professor Cornelia Palivan from the Department of Chemistry. The two professors brought together their expertise in the fields of nuclear pore complexes and biofunctional polymers. This excellent collaboration has led to the development of a highly selective system for delivering artificial cargoes directly into the nuclei of cells.

Targeting the nucleus

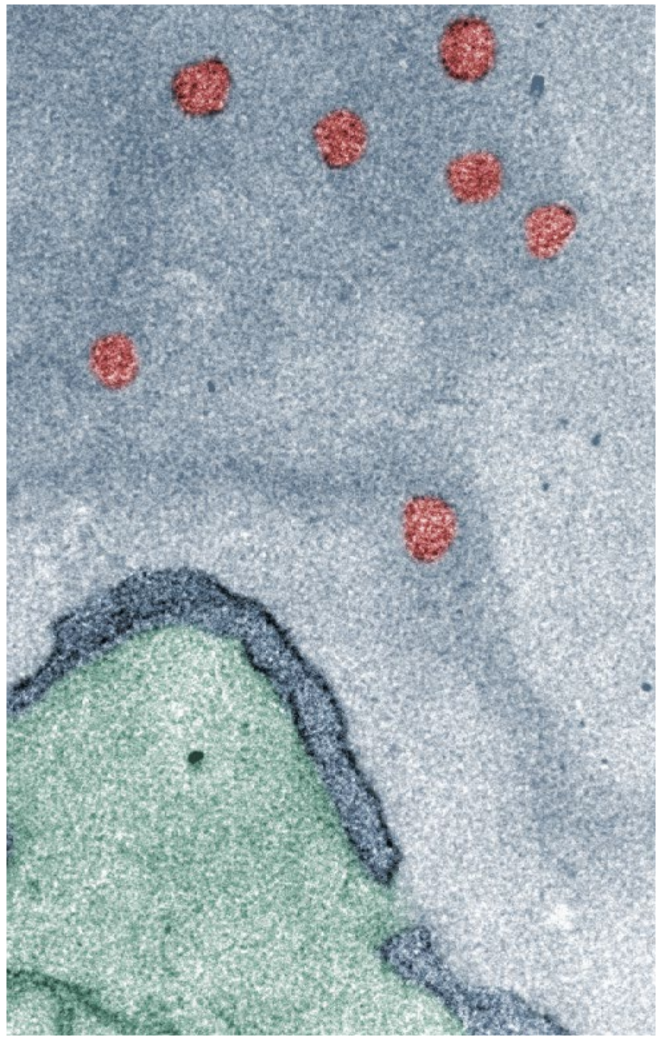
A key objective in nanoscience is to understand and emulate Nature's design principles for bio-inspired applications in healthcare and beyond. In nanomedicine for instance, it remains formidable to encapsulate and deliver drugs directly to specific organelles such as the cell nucleus. This is beneficial as it prevents exposing the drugs to other parts of the cell and would be advantageous in chemotherapy or gene therapy. Drugs introduced into the nuclei of tumor cells could stop the further proliferation of cancer cells. Desired genes introduced into the nucleus could replace non-functional genes. Before this type of nanotechnology can be applied in medicine, there are a number of hurdles to overcome. A method for tackling the first step in this process was recently published in the journal Proceedings of the National Academy of Sciences of the United States of America by the team led by Argovia Professor Dr. Roderick Lim in collaboration with the group led by Professor Dr. Cornelia Palivan.

For many years, Argovia Professor Roderick Lim has studied the molecular mechanisms that control transport into and out of the cell nucleus.

Biocompatible, polymer vesicles

In order to address the problem, Lim and Palivan jointly submitted a project proposal to the SNI PhD School in 2014. The proposal was approved the same year, and Christina Zelmer, whom Lim and Palivan selected for the project, began her doctoral research work in 2015.

Step by step, she developed biocompatible, flexible polymer vesicles (also known as polymersomes) that can trick cells into allowing their transport through the protective nuclear pore complexes in a highly selective manner so that they can introduce cargo into the nuclei.



To enter into the cell nucleus (grey), the polymersomes (red) selectively translocated across the nuclear membrane (dark blue) via the nuclear pore complexes (gaps in the membrane). (Image: C. Zelmer, University of Basel, and E. Bieler, Swiss Nanoscience Institute)

For this, Christina initially worked in Cornelia Palivan's laboratory to produce flexible vesicles from polymers whose structure mimic natural membranes. As larger molecules can only enter the nucleus through pores in the nuclear membrane (nuclear pore complexes), the vesicles are subject to some highly specific requirements. They must not only be below a certain size but also have recognition molecules on their surface that allow them to pass through the nuclear pore complexes.

The first task was therefore to produce polymer vesicles with a uniform diameter of about 60 nanometers. In addition, the vesicles, which self-assemble from triblock copolymers, needed to exhibit short-chain peptides – known as nuclear localization signals – on their surfaces.

Entry ticket into the nucleus

Once the polymersomes were constructed, Christina then moved to Roderick Lim's laboratory to study how the polymersomes interacted with the key transport proteins. "We postulated that the nuclear localization signals would allow the polymersomes to trick the cellular transport mechanism, which imports the cargo into the nucleus through the nuclear pore complexes. This mechanism involves karyopherins, which regulate passage through the pore barrier, as well as Ran guanosine triphosphate, which releases the polymersomes inside the nucleus. The same strategy is used by a number of viruses," explains Roderick Lim.

The researchers were able to track the path of the polymersomes by marking them with two different dyes and observing them using various microscopic techniques. Ruthenium red served both as a dye and as cargo for the vesicles. The positive results were successfully confirmed not only *in vitro* using a biosensor and isolated cell nuclei but also *in vivo* using live cell cultures.

Towards precision nanomedicine

Together the team has succeeded in developing biocompatible polymersomes that have a nuclear localization signal and are therefore able to deliver artifical cargo into the nucleus in a highly selective manner. Conversely, vesicles without this marker cannot be detected in the nucleus. "It was only thanks to our combined knowledge of biofunctional polymers, cell biology, and how nuclear pore complexes operate that we were able to complete this work successfully," comments Roderick Lim.

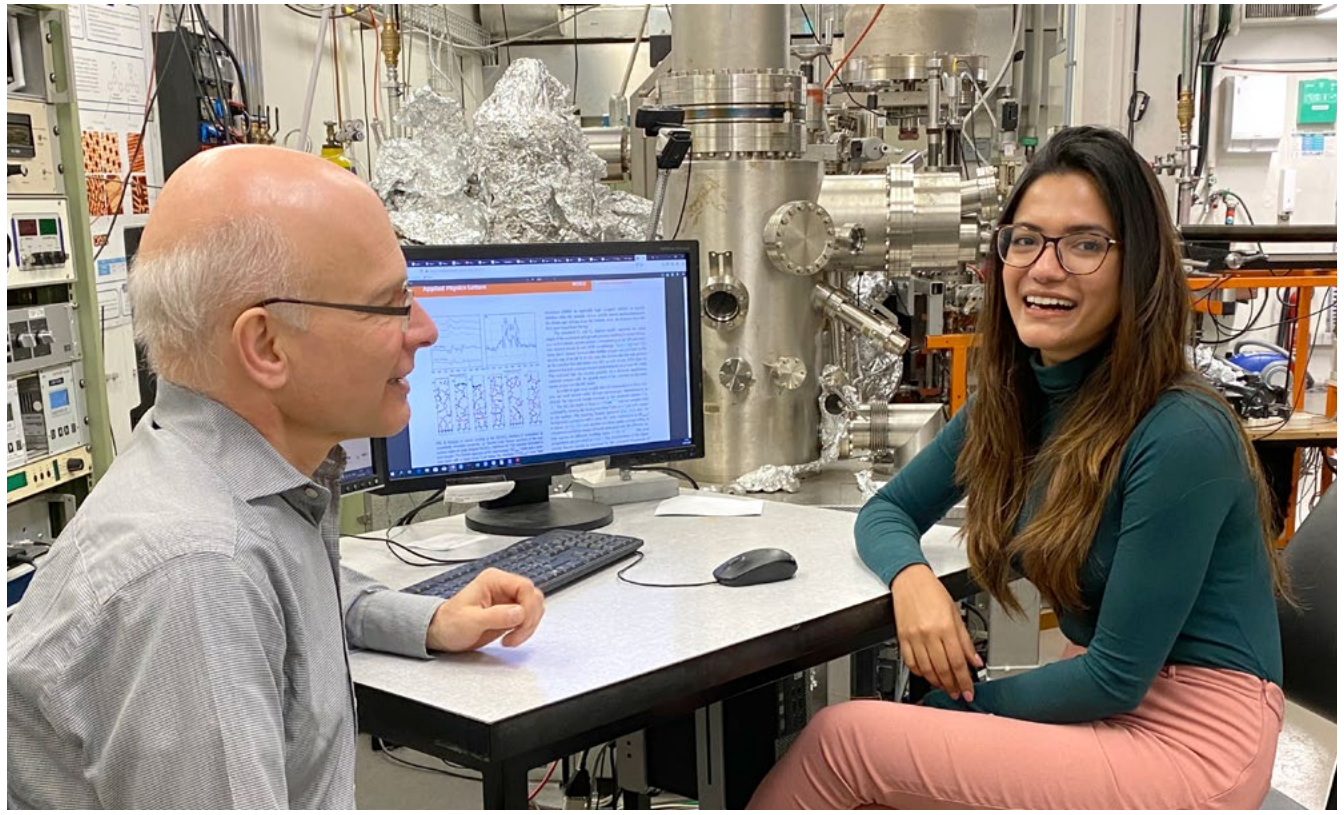
In subsequent trials, the dyes that were initially used will be replaced with therapeutic agents. Another option is to alter the size of the vesicles in order to increase the vesicle concentration in the nucleus. This work will also be conducted as an ongoing collaboration between the two groups, providing a beautiful demonstration that the SNI's interdisciplinary network offers an ideal platform for this kind of cooperation.

The SNI supports PSI titular professors
Thomas Jung investigates silicon carbide

Titular Professor Thomas Jung supervises a research group at the Department of Physics at the University of Basel and a team at the Paul Scherrer Institute. Both groups work with nanostructures – including molecules on surfaces and at interfaces – whose mechanical, magnetic and electronic properties are of interest to Thomas Jung. In 2019, for example, his team published a study in Applied Physics Letters that examines what exactly is preventing the use of silicon carbide in power electronics today.

Necessary infrastructure
Global energy consumption is rising steadily, as is the importance of electric power and sustainable sources of energy such as wind and solar power. However, electrical power is often generated a long distance away from the consumer. Efficient distribution, transport and control systems are therefore just as essential as transformer stations and power converters that turn the generated direct current into alternating current.

Enormous savings are possible
The power electronics used today must therefore be able to handle large currents and high voltages. Transistors made of semiconductor materials for field-effect transistors are now mainly based on silicon technology. But silicon carbide – a compound made up of silicon and carbon – would provide a number of decisive physical and chemical advantages over silicon alone. It has much higher heat resistance and delivers significantly better energy efficiency, which could lead to enormous savings.



Thomas Jung and Dipanwita Dutta can influence the occurrence of defects in the oxidation process of silicon carbide.

These advantages are known to be significantly compromised by defects at the interface between silicon carbide and the insulation material silicon dioxide. The defects are based on tiny, irregular clusters of carbon rings bound within the crystal lattice, as researchers led by Professor Thomas Jung were able to show experimentally. Using atomic force microscopy and Raman spectroscopy, they proved that the defects not only occur at the interface but are also found in some atomic layers of silicon carbide.

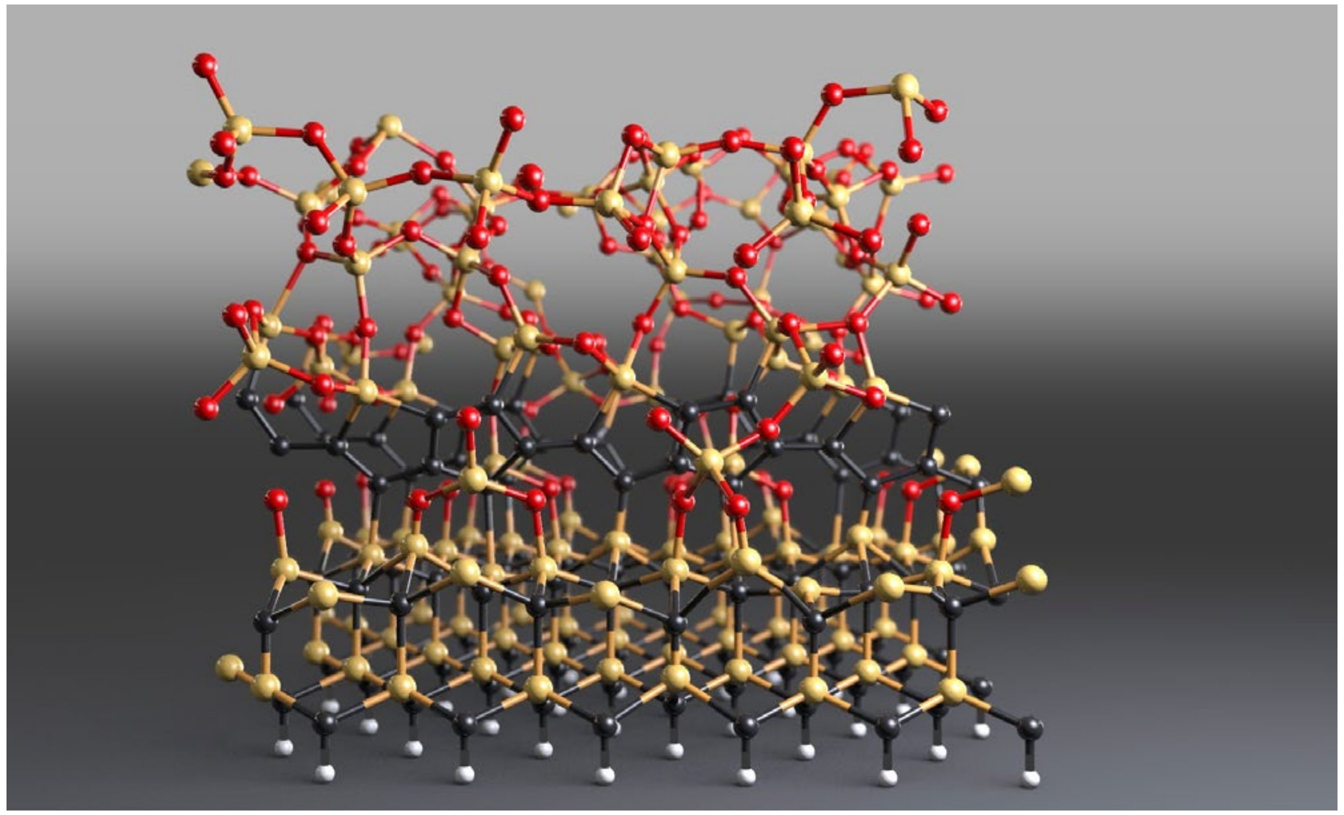
Experiments confirmed
The interfering carbon clusters, which are only a few nanometers in size, are formed during the oxidation of silicon carbide to silicon dioxide at high temperatures. "If we change certain parameters during oxidation, we can influence the occurrence of the defects," explains Dr. Dipanwita Dutta, who did her PhD in the Jung lab. For example, a nitrous oxide atmosphere during the heating process leads to significantly fewer carbon clusters. Post-treatment with nitrogen also has positive effects.

The experimental results were confirmed by the team led by Professor Stefan Gödecker from the Department of Physics at the University of Basel. Computer simulations showed exactly the same structural and chemical changes induced by graphitic carbon atoms as were observed experimentally. The positive effects of treating silicon carbide with nitrogen were also confirmed.

Better use of electricity
"Our work could advance the development of field-effect transistors based on silicon carbide and contribute to more effective use of electrical energy," says Thomas Jung, who initiated this project together with representatives of ABB as part of the Nano Argovia program.

"Our work could advance the development of field-effect transistors based on silicon carbide and contribute to more effective use of electrical energy."

Prof. Dr. Thomas Jung, Department of Physics, University of Basel and Paul Scherrer Institute



The oxidation process of silicon carbide forms defects: At the interface between silicon carbide (periodic black-yellow atoms) and the insulating silicon dioxide (red-yellow atoms), irregular clusters of carbon rings (irregular black structures embedded in red and yellow atoms) occur. These are bound within the crystal lattice and disturb the current flow. (Image: Departement of Physics, University of Basel)

Shaping the strategic direction

Titular professors Frithjof Nolting and Michel Kenzelmann dedicate their efforts to the ANAXAM technology transfer center

The two SNI-funded titular professors Frithjof Nolting and Michel Kenzelmann teach at the University of Basel and lead research groups at the Paul Scherrer Institute (PSI). In 2019, they dedicated their time to founding the ANAXAM* technology transfer center alongside their teaching and research activities. Frithjof Nolting is chairman and Michel Kenzelmann is a board member of the newly founded association ANAXAM, which launched the technology transfer center at the Paul Scherrer Institute in early December 2019.

Committed to the technology transfer center
Professor Frithjof Nolting is head of the Laboratory for Condensed Matter in the area of photon research at the PSI. Professor Michel Kenzelmann leads the PSI Laboratory for Neutron Scattering and Imaging. In the future, both areas will play a role in providing industrial companies with access to modern materials analysis using neutron radiation and X-rays. It made sense, therefore, that the two physicists would undertake intensive efforts in 2019 to founding the ANAXAM technology transfer center with initial funding from the federal government and the Canton of Aargau.

ANAXAM is intended to serve as a bridge between academia and industry, operating as a provider of the latest materials analysis services for industrial companies working with new production technologies. Through ANAXAM, participating companies receive access to the infrastructure of the PSI and the SNI, as well as to findings of current research and the expertise of the parent institutions – the PSI, the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) and the SNI.

Launched in December
Established as an association, the technology transfer center at the PSI commenced operations on December 1, 2019 – and therefore began fulfilling its first industrial orders. Before even reaching this stage, a great deal of work was required from everyone involved.

"In 2019, our focus was on developing the concept of ANAXAM in order to take advantage of support available from the umbrella association of all newly founded technology transfer centers in Switzerland (AM-TTC). We also set up the association ANAXAM to provide funding for the technology transfer center," says Frithjof Nolting, who serves as the association's chairman.

Ultimately, this work paid dividends. In September, the funding application was approved by the umbrella association, providing the center with access to total funding of CHF 2.3 million during its start-up phase, which runs until the end of 2020. In order to secure further funding in the developmental phase from 2021 to 2024, the members of the association's board – Frithjof Nolting, Michel Kenzelmann (both of the PSI), Vincenza Trivignio (Canton of Aargau), Professor Jürg Christener (FHNW) and Professor Martino Poggio (SNI) – submitted a further application to the State Secretariat for Education, Research and Innovation.

Exciting prospects
"We're looking forward to working closely with Dr. Christian Grünzweig (PSI), who leads ANAXAM as its managing director – and to the orders we expect to receive from industrial companies across Switzerland," say Frithjof Nolting and Michel Kenzelmann. "The first projects are already getting underway, and we're confident that ANAXAM's accumulated expertise makes it an excellent point of contact for a wide range of tasks and problems in the area of materials analysis."

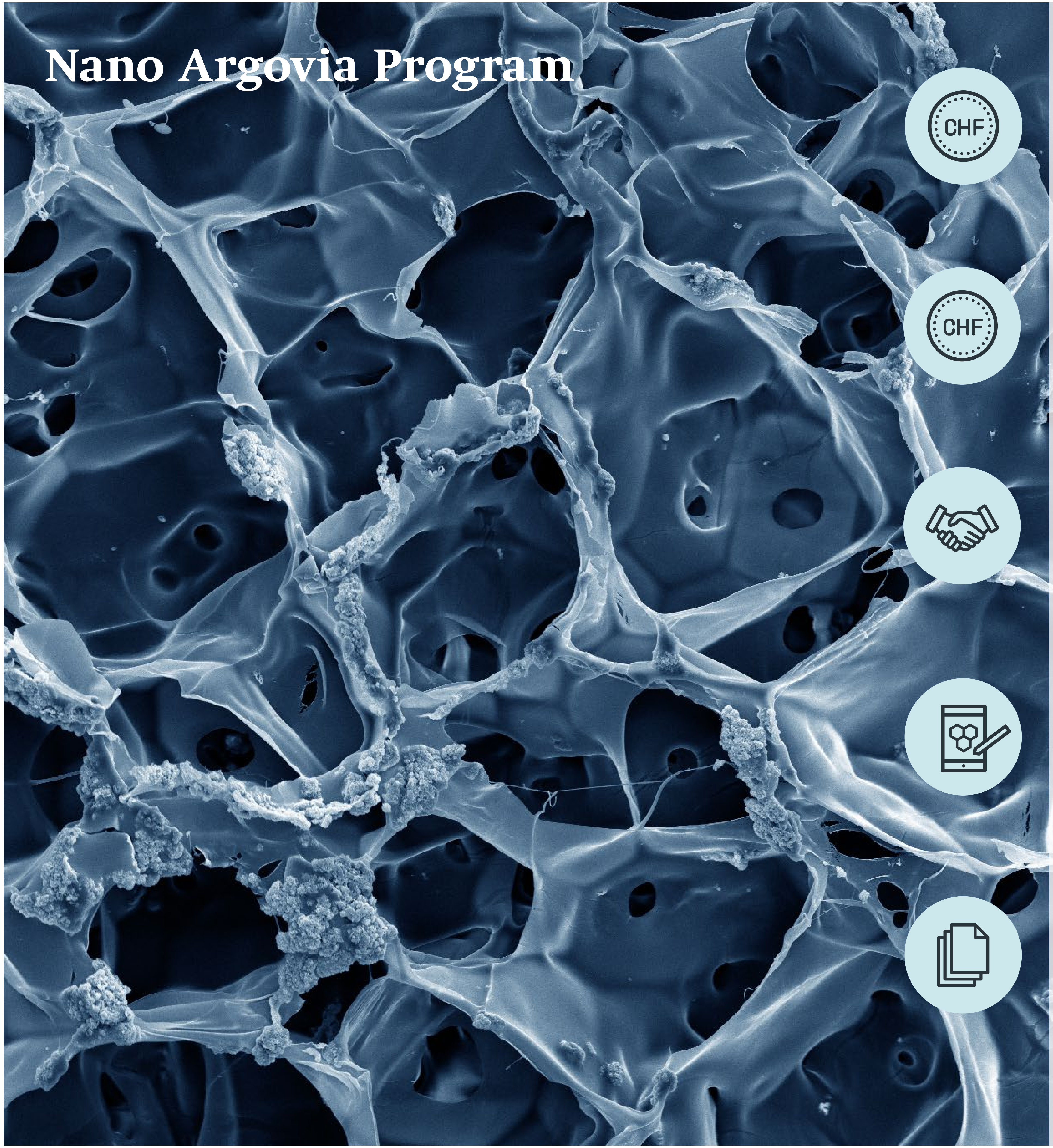
*ANAXAM stands for "Analytics with Neutrons and X-Ray for Advanced Manufacturing"

"The first projects are already getting underway, and we're confident that ANAXAM's accumulated expertise makes it an excellent point of contact for a wide range of tasks and problems in the area of materials analysis."

Prof. Dr. Frithjof Nolting (chairman of the association ANAXAM) and Professor Dr. Michel Kenzelmann (member of the board of ANAXAM)

Frithjof Nolting, Christian Grünzweig and Michel Kenzelmann from PSI are looking forward to collaborations with industry in the context of ANAXAM. (Image: Paul Scherrer Institute)

Nano Argovia Program



1.5 Mio. In 2019, the Nano Argovia program received CHF 1.5 million in funding from the SNI.

3.1 Mio. Project partners contributed about 1.6 million francs, the industrial partners about 1.5 million francs through in-kind services.

3 Each Nano Argovia project brings together at least three partners – two from research institutions in the SNI network and one from an industrial company in Northwestern Switzerland.

13 In 2019, six new projects were launched and seven projects were extended, two of them on a cost-neutral basis. Eight industry partner came from the Canton of Aargau.

6+40 The Nano Argovia program led to the publication of 6 scientific papers as well as 40 talks.

Scanning electron microscope image of a hydrogel developed in the Nano-Argovia project 3D Cellophil®.
(Image: F. Costanzo, Department of Biomedical Engineering, University of Basel in collaboration with the School of Life Sciences, FHNW)

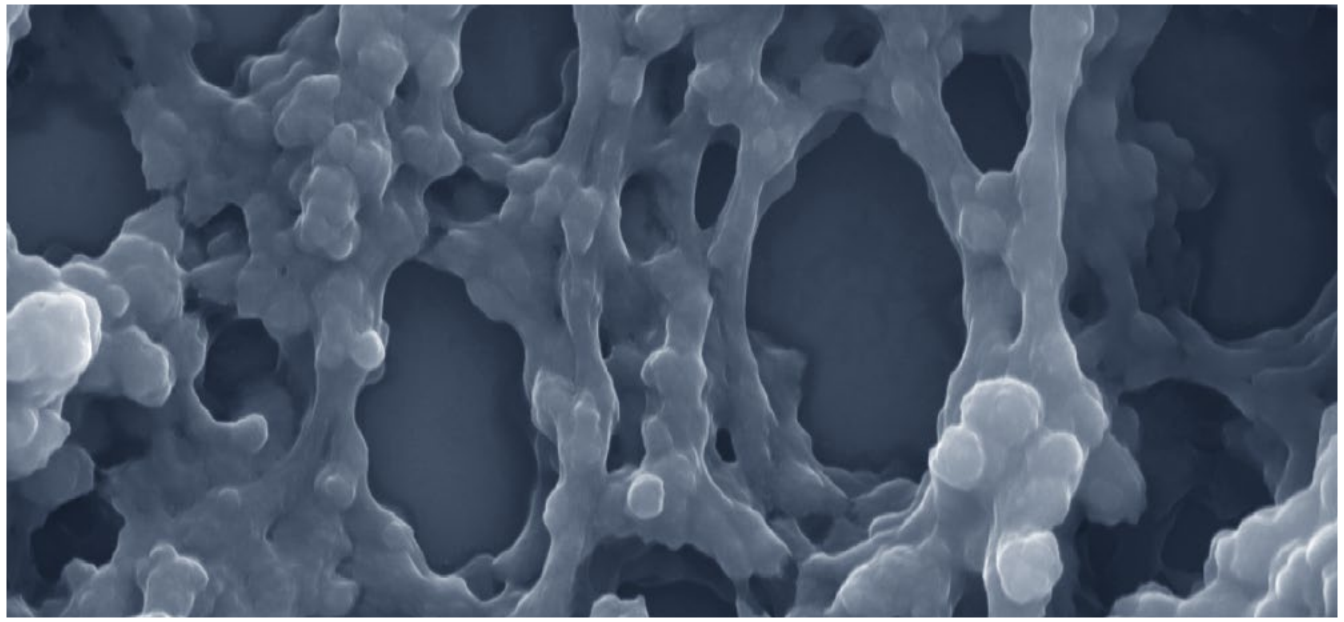
New projects in applied research

In 2019, six new projects were launched as part of the Nano Argovia program, with four partner companies from the Canton of Aargau and two from Basel. Based on the wide range of topics covered – from portable sensors for drinking water analysis and drug delivery systems to heart models and new safety elements – it is clear that nanotechnology is now key to many different areas. The Nano Argovia program supports this transfer of the latest nanoscientific achievements to industrial companies in Northwestern Switzerland.

First concentrated, then analyzed: Nano Argovia project DeePest researchers are developing a portable system for drinking water analysis

In the Nano Argovia project DeePest, scientists from the Schools of Life Sciences and Engineering at the University of Applied Sciences Northwestern Switzerland (FHNW) are working alongside industry partner Mems AG (Birmenstorf) to develop a fully automatic sensor for detecting pesticides in drinking water.

The system is intended to offer a cost-effective extension to existing analysis methods and enable continuous detection of a wide range of pesticides in drinking water systems. The pesticides are first concentrated using nanostructured polymers and then analyzed using a bimodal (NMR and fluorescence) detector.



In the DeePest project, different hydrogels used to concentrate pesticides are investigated. (Image: J. Pascal, FHNW)

"We are optimistic that the DeePest Nano Argovia project will enable us to expand our product range and offer an inexpensive, fully automated pollutant sensor to monitor the drinking water cycle."

Dr. Daniel Matter, Managing Director and Chairman of the Board of Directors of Mems AG

Creating a heart model inspired by origami: In the Nano Argovia project KOKORO, scientists are using nanostructured cellulose as a scaffold for cell cultures

In the Nano Argovia project KOKORO (Japanese: heart), a team of researchers from the School of Life Sciences at the University of Applied Sciences Northwestern Switzerland (FHNW), the Department of Biomedicine at the University of Basel (DBM), and Omya International AG (Oftringen) is developing a novel three-dimensional heart model.

Suitable cellulose paper serves as scaffolding. Using a 3D bioprinting process, thin layers of heart muscle cells are applied and a network of vascular cells ensures optimal blood supply to the heart tissue. The resulting tissue layers are then folded in a similar way to the Japanese art of folding, origami. Such heart models can be used to investigate the efficacy of medical treatments prior to animal experiments, and thereby help reduce their number.

Due to its nanostructure, a newly developed cellulose paper can serve as an ideal scaffold for heart muscle cells and forms the basis for the origami heart model. (Image: M. Gullo, FHNW)

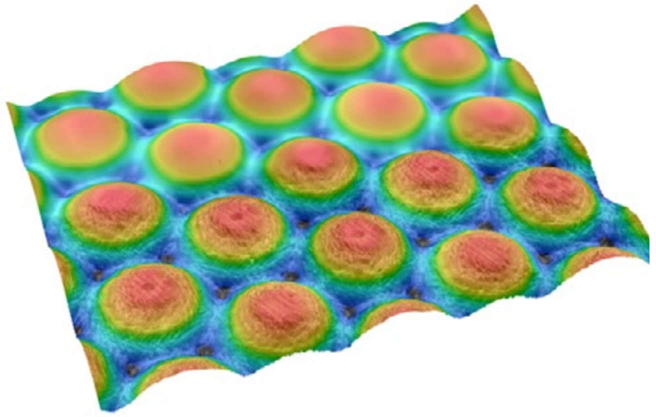
"The dimensions of the fibers and their spatial arrangement are decisive in the construction of artificial tissue."

Dr. Joachim Schoelkopf, Head of Basic Research at Omya International AG

Tiny structures for security: In the Nano Argovia project LASTRUPOL, a new fabrication process for security features has been developed

In the Nano Argovia project LASTRUPOL, researchers from the FHNW School of Engineering, the Paul Scherrer Institute (PSI) and the industrial partner Gemalto AG (Aarau) worked together to develop a new manufacturing process for security elements on identity documents.

The three-dimensional optical structures were manufactured with high precision and surface quality in a process that was as economical as possible. To this end, ultra-short laser pulses were first used to remove material from a plastic surface in a very targeted manner. Subsequently, the surface covered with structures in the micrometer range was smoothed to achieve a surface roughness in the two-digit nanometer range without affecting the fine structures.



The surface of the lasered structures is smooth; only the high roughness is reduced while the structure is retained. (Image: P.M. Kristiansen, School of Engineering, FHNW)

"The Nano Argovia project LASTRUPOL offered an excellent opportunity to benefit from the know-how of experts at the University of Applied Sciences and the PSI."

Dr. Christian Sailer, Head of Physical Document Security R&D Switzerland at Gemalto AG

Using nanoparticles to defeat cancer: The Nano Argovia project NCT Nano is investigating a new approach to cancer immunotherapy

Scientists from TargImmune Therapeutics (Basel), the Department of Chemistry at the University of Basel, and the Department of Biosystems Science and Engineering at ETH Zurich in Basel have characterized a new targeted approach to cancer immunotherapy in the Nano Argovia project NCT Nano.

They have investigated certain nanoparticles that smuggle specific cargo into cancer cells. This freight concurrently triggers both the destruction of targeted cancer cells and an anti-tumor immune response, destroying the tumors.

By providing detailed information on structure, morphology and mechanism of action, the Nano Argovia NCT Nano project contributes significantly to the preclinical development of these nanoparticles.

"The Nano Argovia project has significantly contributed to the preclinical research of our nanoparticles, which are under development as a novel cancer therapy. An important milestone on the way to clinical application has thus been reached."

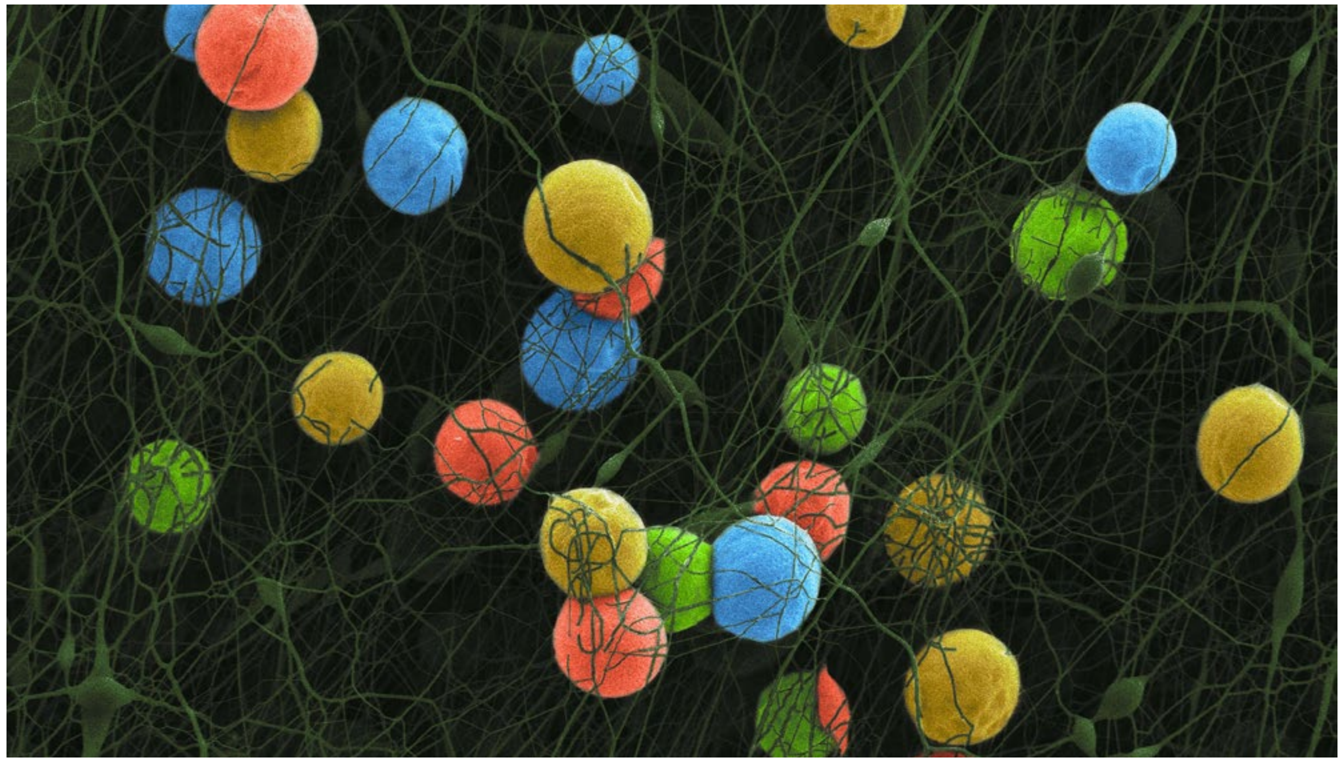
Dr. Maya Zigler, NCT Nano project manager and Head of Research at TargImmune Therapeutics

Two effects with a single product: In the Nano Argovia project PERIONANO, inflammation around dental implants is combated and tissue regeneration is supported

In the Nano Argovia project PERIONANO, scientists from the FHNW School of Life Sciences, the Hightech Research Center of Cranio-Maxillofacial Surgery (University of Basel), and industrial partner credentis AG (Windisch) jointly develop a new drug delivery system for the local application of active ingredients into the bed of a dental implant.

This drug delivery system is designed to release compounds in a controlled manner to fight local bacterial infections while supporting tissue regeneration of bone and soft tissue.

Peptides that form a fibrous network are used to this end. Different particles are integrated into this network that are capable of releasing active compounds in a controlled manner.



Drug-loaded microparticles that fight bacterial infections and support the tissue regeneration of the implant bed are integrated into a network of peptides. (Image: F. Costanzo from the University of Basel, O. Germershaus, J. Föhr from the School of Life Sciences, FHNW)

"PERIONANO is one of the '1+1=3' projects where the sum of the output is more than the individual project partners could achieve."

Michael Hug, CTO at credentis AG

"The UltraNanoGRACO project is a unique opportunity for Menhir Photonics to work with excellent Swiss partners. It allows us to combine our different know-how and strengths to develop innovative concepts in order to stay competitive worldwide."

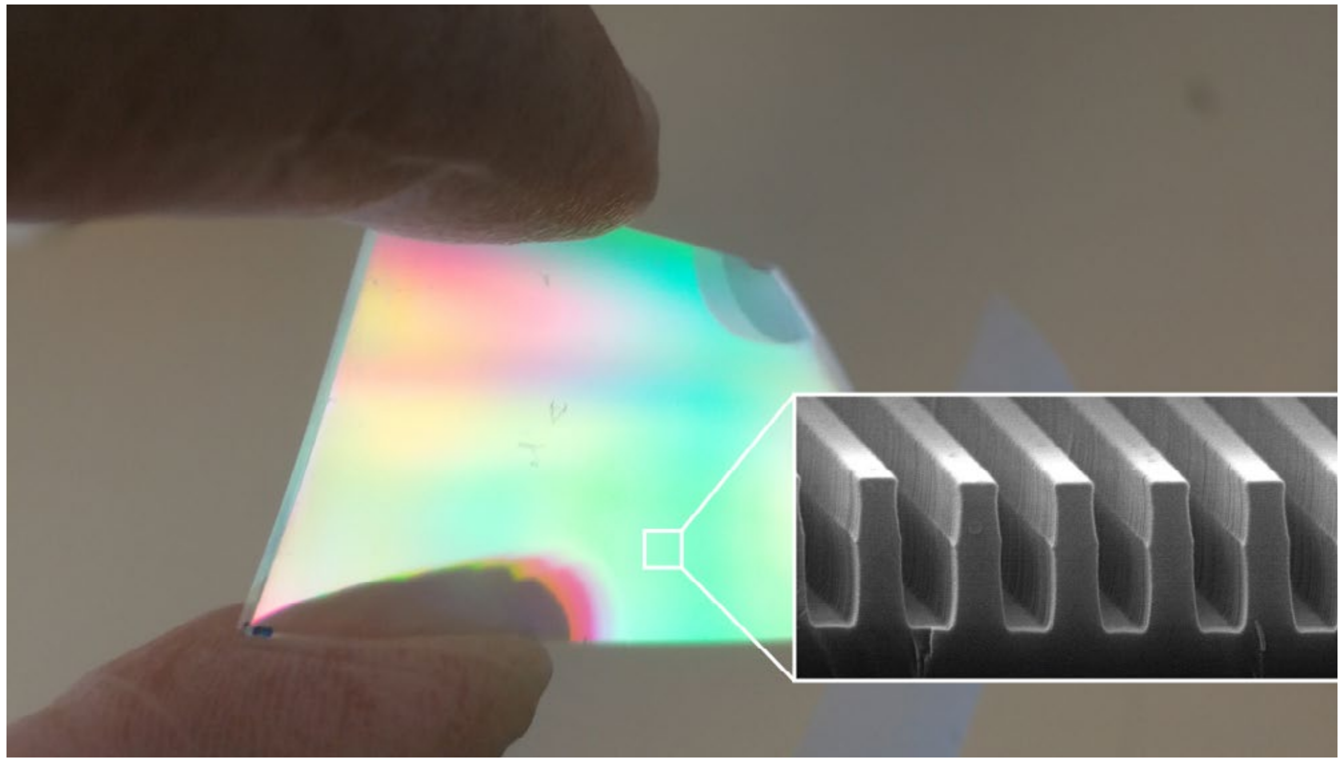
Dr. Florian Emaury, CEO and co-founder of Menhir Photonics AG

Shorter light pulses thanks to nanostructured gratings: In the Nano Argovia project UltraNanoGRACO, a novel laser system is tested

In the Nano Argovia project UltraNanoGRACO, a team of scientists from CSEM Muttenz, the University of Applied Sciences Northwestern Switzerland (FHNW) and the start-up Menhir Photonics AG (Basel) is investigating a novel laser pulse compressor to be combined with an ultrafast laser.

The laser system will provide extremely short light pulses that last only 10^{-13} seconds, that is less than a trillionth of a second, but have high energy.

Menhir Photonics AG is relying on an innovative, robust design in the development of such a laser system and intends to "compress" the laser pulses as far as possible with the help of CSEM and FHNW. Such super-short pulses are already used in laser surgery, welding or for processing various materials.



Nanostructured gratings are used to generate extremely short light pulses with high energy. (Image: CSEM Muttenz, FHNW, Menhir Photonics)

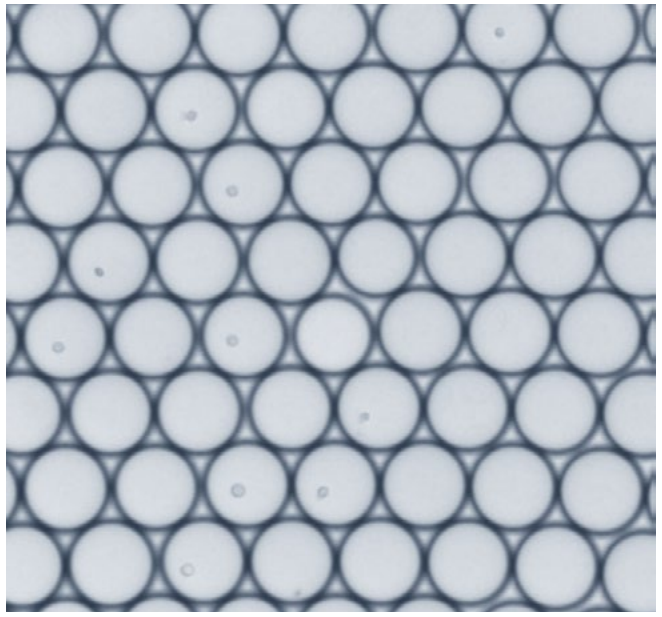
Extended projects in applied research

Seven Nano Argovia projects originally launched in 2018 or 2017 were extended into 2019. For the projects MIPIS and 3D Cellophil, the extensions were cost-neutral. The project managers of all the extended projects submitted detailed scientific reports, just as for newly launched projects. These can be found in the supplement.

Targeting messenger RNA: Nano Argovia project ecamist improves single cell analysis

In the Nano Argovia project ecamist, a team of scientists has developed a method that allows the isolation of messenger RNA (mRNA) from single cells. Researchers from the School of Life Sciences at the FHNW, the Department of Biosystems Science and Engineering at ETH Zurich in Basel (D-BSSE), and Memo Therapeutics AG (Basel) were able to improve the yield and quality of the isolated mRNA using a newly developed reaction.

Among other applications, the information about mRNA present in a cell can be used to derive conclusions about the development of diseases. It is also important for studying cell lines used in antibody production, for example. The improvements achieved can therefore facilitate the generation of monoclonal antibodies.



Cells are separated in individual droplets of a water in oil emulsion. Afterwards, the cell are lysated and the mRNA is purified. (Image: S. Schmitt, Memo Therapeutics)

"The work within the project team was very inspiring, and I would like to thank all partners for their high motivation and commitment".

Dr. Simone Schmitt, Head of Antibody Development at Memo Therapeutics AG

"The Nano Argovia project 3D Cellophil® was a successful collaboration between industry and science, one which we are keen to pursue."

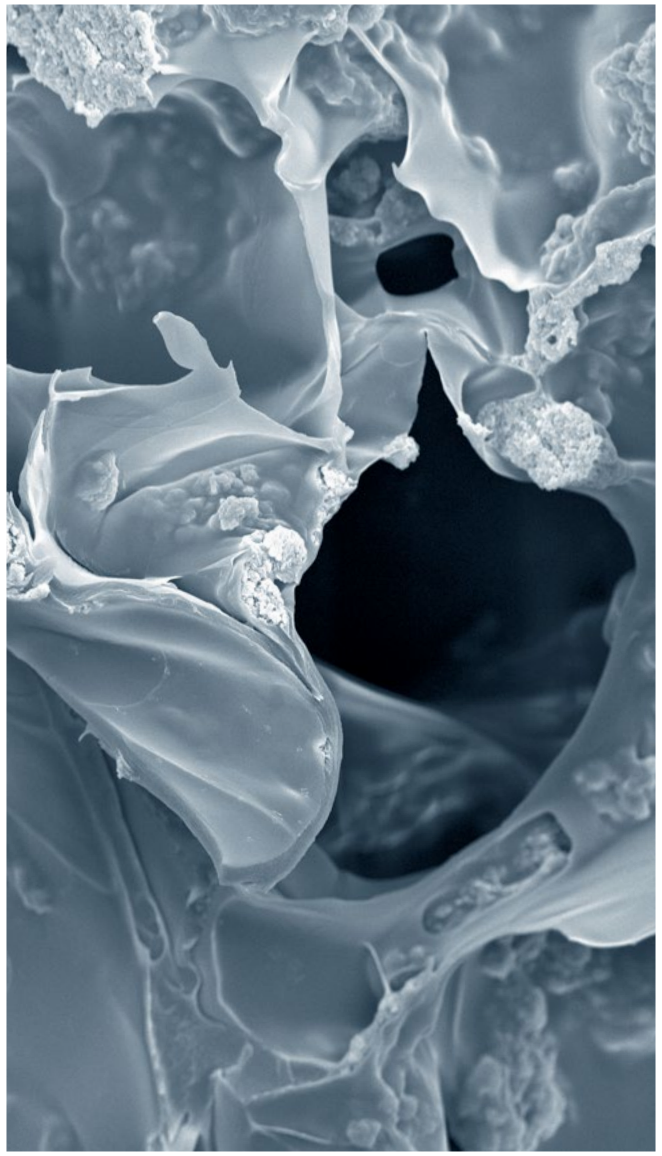
Dr. Christian Geraths, CSO at CIS Pharma AG

Patient-specific and tailored to conditions in the mouth: Nano Argovia project 3D Cellophil® investigates novel nanostructured implants

In the Nano Argovia project 3D Cellophil®, a team of scientists from the School of Life Sciences (FHNW), the Hightech Research Center of Cranio-Maxillofacial Surgery at University Hospital Basel and CIS Pharma AG (Bubendorf) are developing implants that are intended to support the regeneration of bone and soft tissue in the jaw and mouth area, and can be custom-built for each patient using 3D printing.

To this end, they used a three-layer polymer membrane based on Cellophil® technology developed by CIS Pharma. Hydroxyapatite particles, which are similar to natural bone material, are embedded in the membrane to support the wound healing process. They support bone regeneration and prevent rapidly multiplying soft tissue cells from extending over the slower growing bone cells, thus negatively influencing the healing process.

Despite the different composition of the three layers, they can be individually tailored to the patient and printed in a single step. The project delivered key parameters needed for the further adjustment of the membrane to the target tissue and showed which parameters need to be further optimized before a prototype can be developed for preclinical studies.



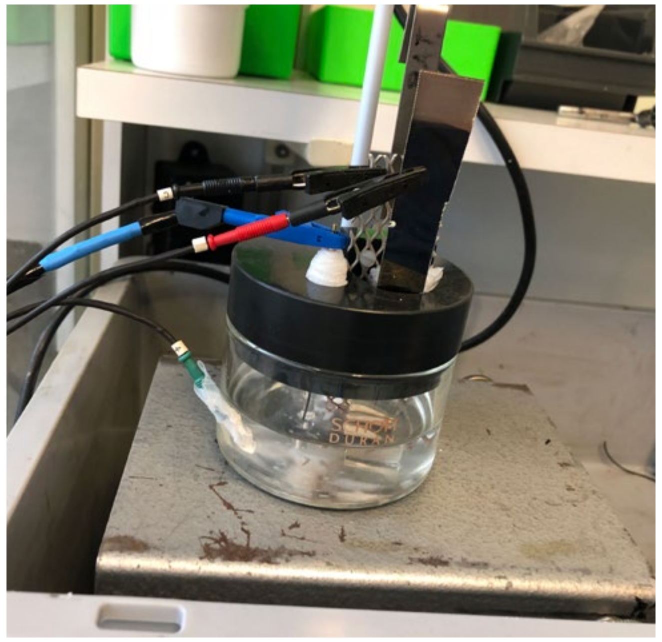
The specially developed membrane contains hydroxyapatite particles that support the wound healing process.(Image: F. Costanzo, Department of Biomedical Engineering, Universität Basel, in cooperation with School of Life Sciences, FHNW)

Nanoparticles for mega power: In the MEGAnano-Power project, an innovative energy storage device was optimized

In the Nano Argovia project MEGAnanoPower, scientists from the FHNW School of Life Sciences, the CSEM in Muttenz and the industrial partner Aigys AG (Othmarsingen) have further optimized a redox flow cell battery (PowerCell®) patented by Aigys.

Redox flow cell batteries are rechargeable batteries in which the electrical energy is stored in the form of dissolved chemical components, so-called electrolytes. By using liquid electrolytes, the battery capacity can be adjusted quite easily by increasing the electrolyte volume.

However, the energy density of electrolytes still needs to be increased. The researchers therefore investigated how the energy density could be increased using finely dispersed nanoparticles and how the materials currently used could be replaced by cost-effective, environmentally friendly and sustainable materials.



The experimental setup for a novel flow cell battery developed in the Nano Argovia project.

"The team from FHNW and CSEM is very inspiring. Their complementary skills have enabled us to overcome certain challenges that arose during the project."

Dipl.-Ing. Andreas Schimanski, CEO Aigys Ltd.

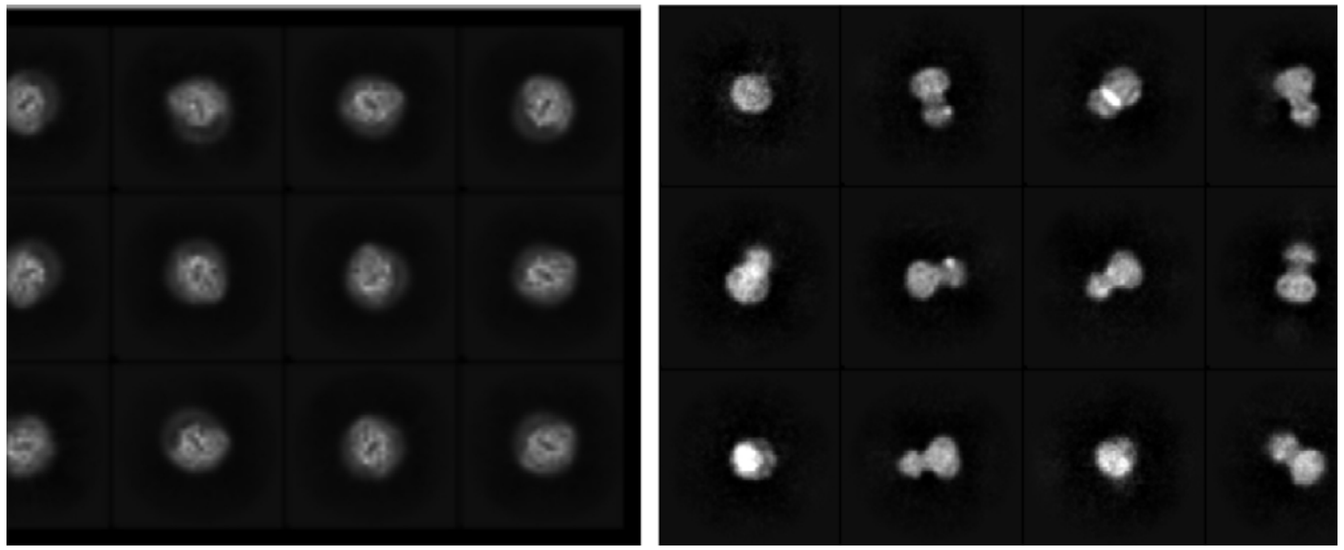
Fast and gentle processing of proteins: A microfluidic system for sample preparation by cryo-EM developed in the Nano Argovia project MiPIS

In the MiPIS project, scientists from C-CINA (Biozentrum, University of Basel) and the School of Life Sciences (FHNW) together with their industrial partner leadXpro (Villigen) have developed a microfluidic system to process proteins and prepare samples for analysis using cryo-electron microscopy (cryo-EM).

First, the cell lysate is incubated together with an antibody that binds to the protein under investigation. Subsequently, paramagnetic particles that bind to the antibody are added. The lysate is placed in a microcapillary where two electromagnets form a magnetic field gradient. The bound magnetic particles immobilize the desired proteins, while all other lysate components can be washed away. The magnetic particles are then split and the proteins are applied directly to a cryo-EM grid using the cryoWriter.

The newly developed method allows proteins to be purified, stabilized and prepared for cryo-EM analysis within two hours while retaining their spatial structure.

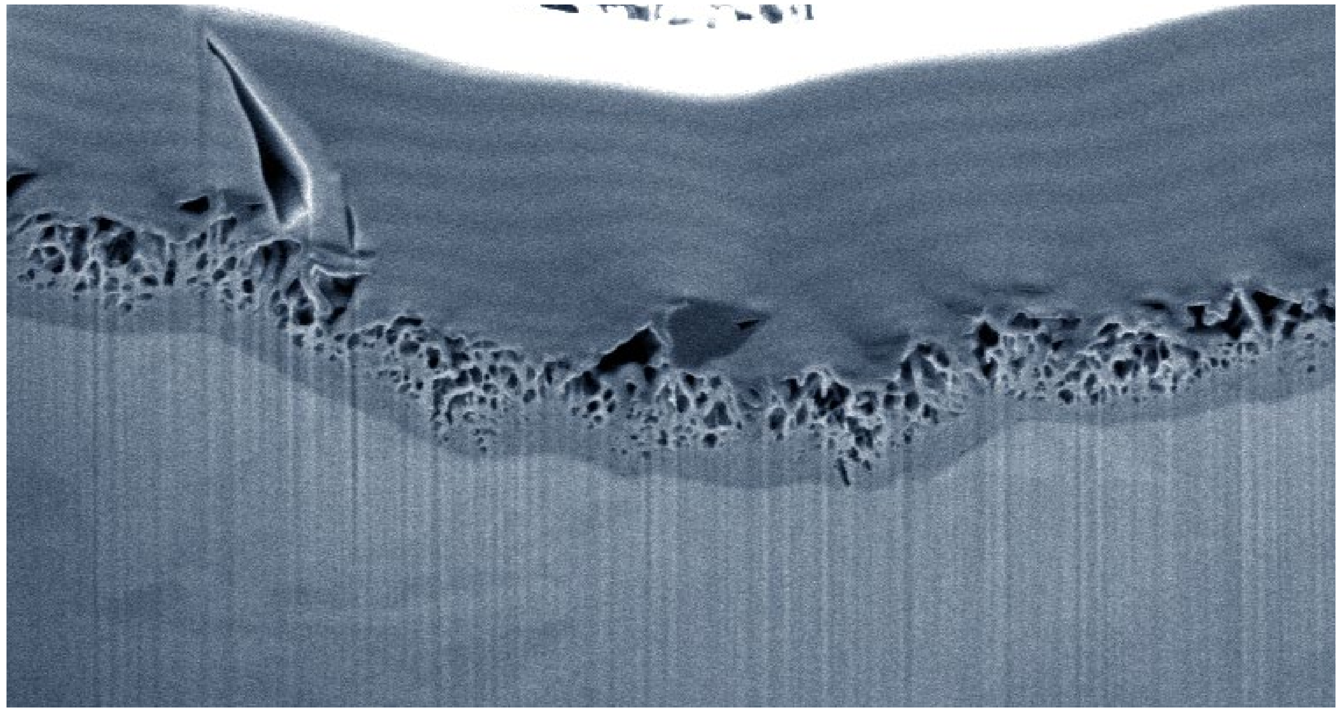
classical sample preparation | preparation with the cryoWriter



An often encountered problem with cryo-EM is the "preferential orientation" of the protein-particles in the vitreous ice. If the protein is not imaged from various directions, the three-dimensional structure of the protein cannot be calculated. In the example shown, this problem was eliminated with the cryoWriter system for sample preparation. (Image: Luca Rima and Dongchun Ni, C-CINA, and Jaroslaw Sedzicki, Biozentrum, University of Basel)

"MiPIS enables the extraction of very small amounts of protein followed by cryo-electron microscopy analysis and the visualization of the active structure. Herewith, we are able to get important information about the biology of proteins relevant in medicine."

Prof. Dr. Michael Hennig, CEO leadXpro AG



Even after inserting a dental implant into the bone, the NanoCoat layer is clearly visible in cross-section and is free of defects. (Image: A. Carino, PSI)

Ceramic coatings for bone implants: A cost-effective process developed in the Nano Argovia project NanoCoat

In the Nano Argovia project NanoCoat, an interdisciplinary team from the Paul Scherrer Institute (PSI) and the University of Applied Sciences Northwestern Switzerland (FHNW), together with three industrial partners, has modified the surface of dental implants to achieve better biocompatibility. To this end, titanium implants were coated with a ceramic calcium phosphate. This improves the integration of the implant into new bone growth and therefore ensures better stability of the implant.

In cooperation with Medicoat AG (Mägenwil), Atesos Medical AG (Aarau) and Hager & Meisinger GmbH (Neuss, Germany), the new nano surface has been optimized and analyzed in detail.

The project partners assume that this new method will mean that a new class of medical implants is soon available that is even more reliable and durable than the current state of the art.

"The NanoCoat project with PSI and the FHNW as scientific partners is progressing as planned. The results obtained show that the new method has great potential to improve the integration of dental implants in the short and long term."

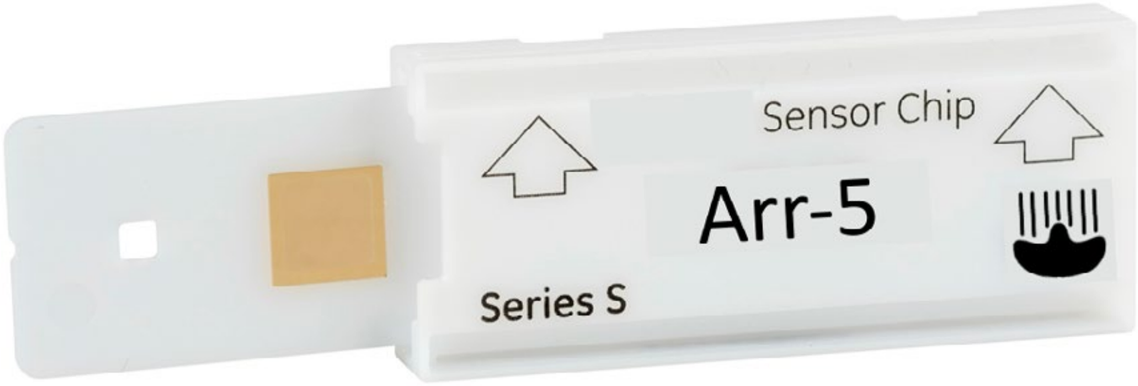
Philipp Gruner, CEO Medicoat AG

Detecting tiny changes using biosensors: Nano Argovia project NanoGhip has developed a biochip prototype for drug discovery

In the Nano Argovia project NanoGhip, an interdisciplinary team from InterAx Biotech AG (Villigen), the Paul Scherrer Institute, and the Department of Chemistry and the Biozentrum at the University of Basel investigated a new screening method for pharmaceutical substances. The scientists developed a novel biochip that can examine the reaction of certain chemical and biological molecules with G protein coupled receptors in real time and also provide information about the safety profile of the compounds tested.

Initially, the team produced the biological receptors and intracellular signalling proteins of these receptors and synthesized organic polymers that mimic the cellular surface environment of these receptors. These materials were then characterized and their biological activity demonstrated.

In a second step, the synthetic polymers were assembled with the biological receptors and the functionality of the biological nanomachines was demonstrated in a synthetic environment.



On a chip measuring approximately 10 x 10 mm (gold square), tiny artificial vesicles with integrated protein complexes are placed in four small channels (volume: 0.06 μl). Then, biosensors are used to observe how various test substances affect the protein complexes. (Image: InterAx Biotech/Biozentrum)

"In this project, we've brought together a unique combination of experts that allows us to exploit synergies and explore a new approach to the biological screening of substances on a chip."

Dr. Martin Ostermaier, former CEO of InterAx Biotech AG and project leader of NanoGhip

Light yield improved: In the Nano Argovia project NQsense, the sensitivity of quantum sensors for the nanoscale was optimized

In the NQsense project, the nanofabrication of a recently developed, novel quantum sensor for high-precision measurements and the imaging of magnetic fields in the nanometer range was optimized.

These sensors consist of single electron spins embedded in diamond nanostructures. They find applications in material sciences, physics and, ultimately, also in the life sciences and healthcare. For this project, the Basel Quantum Sensing group, the Laboratory for Micro- and Nanotechnology at the PSI, and the Basel-based start-up Qnami joined forces to bring performance and production yield for these quantum sensors to a new level.

The results of the NQsense project have led to significant improvements in sensor performance for nanoscale magnetic field imaging and have created a path for their scalable production.

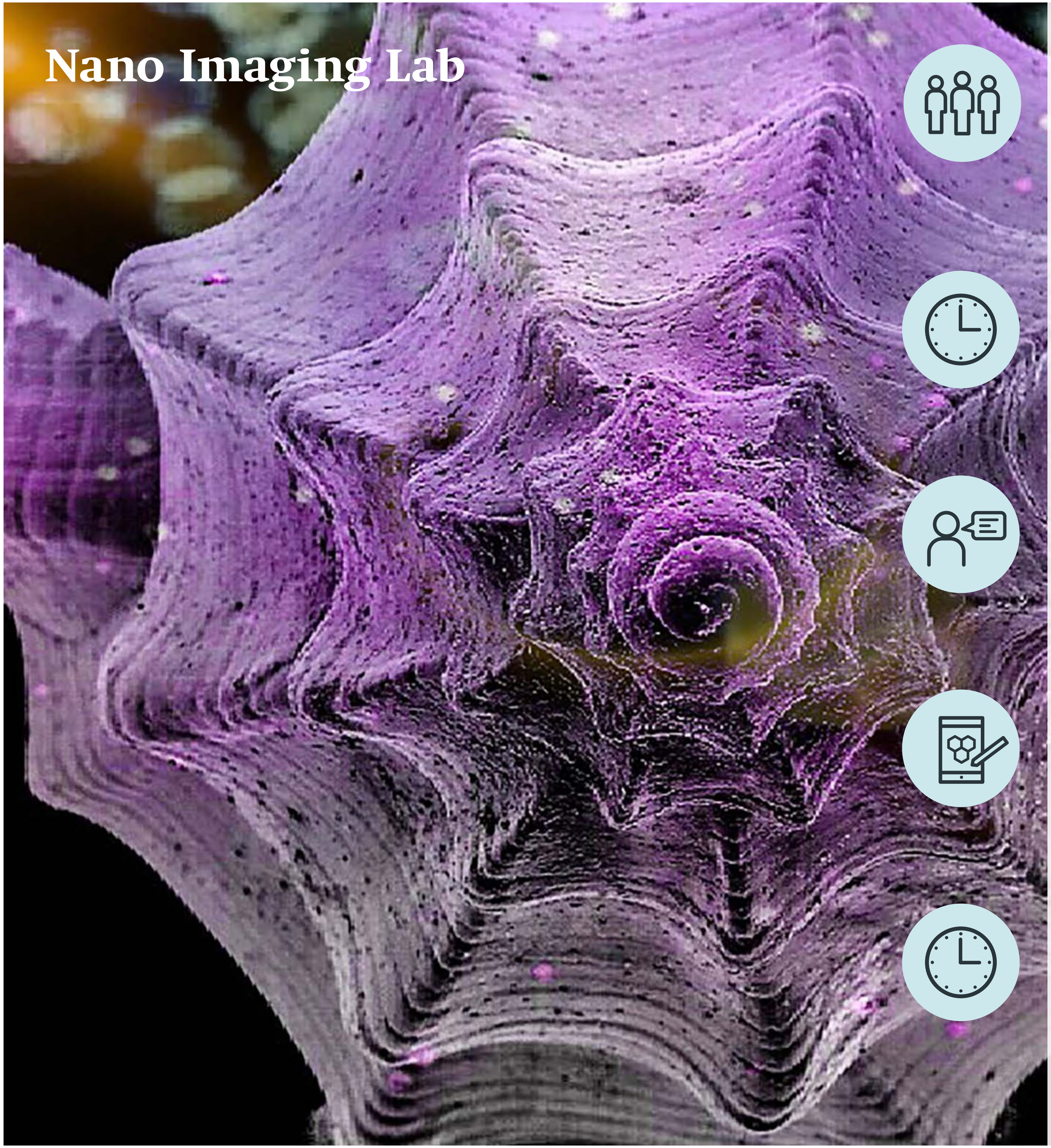
This represents an advance not only in technological possibilities but also in Qnami's leading position in the commercialization of quantum sensors. The new generation of sensors commercialized by Qnami is already in use in several laboratories worldwide, which is a significant milestone for the young start-up and provides the necessary feedback to further establish and advance the technology.

The NQsense project helped Qnami to present the ProteusQ – the first commercial quantum platform for material analysis at nanometer resolution – at the end of 2019. (Image: Qnami)

"The NQsense project has not only led to significant improvements in the performance and production yield of one of Qnami's core products, it has also helped to create two jobs at Qnami."

Dr. Matthieu Munsch, CEO Qnami

Nano Imaging Lab



5

At the Nano Imaging Lab, a team of five experienced, expert staff work to fulfill customer requests as well as advising on and researching a variety of topics.

3600

The various microscopes in the Nano Imaging Lab were working about 3600 hours.

110

In 2019, the NI Lab worked for 110 different customers.

160

The Nano Imaging Lab was involved in 160 projects in 2019.

2500

In 2019, the Nano Imaging Lab spent about 2500 hours supervising students and preparing block courses as well as training customers in the use of high-tech microscopes.

Scanning electron microscope image of a tiny snail of the genus Neogastropoda.
(Image: D. Mathys, Nano Imaging Lab, Swiss Nanoscience Institute, University of Basel)

Achieving more together
New laser scanning microscope in the Nano Imaging Lab

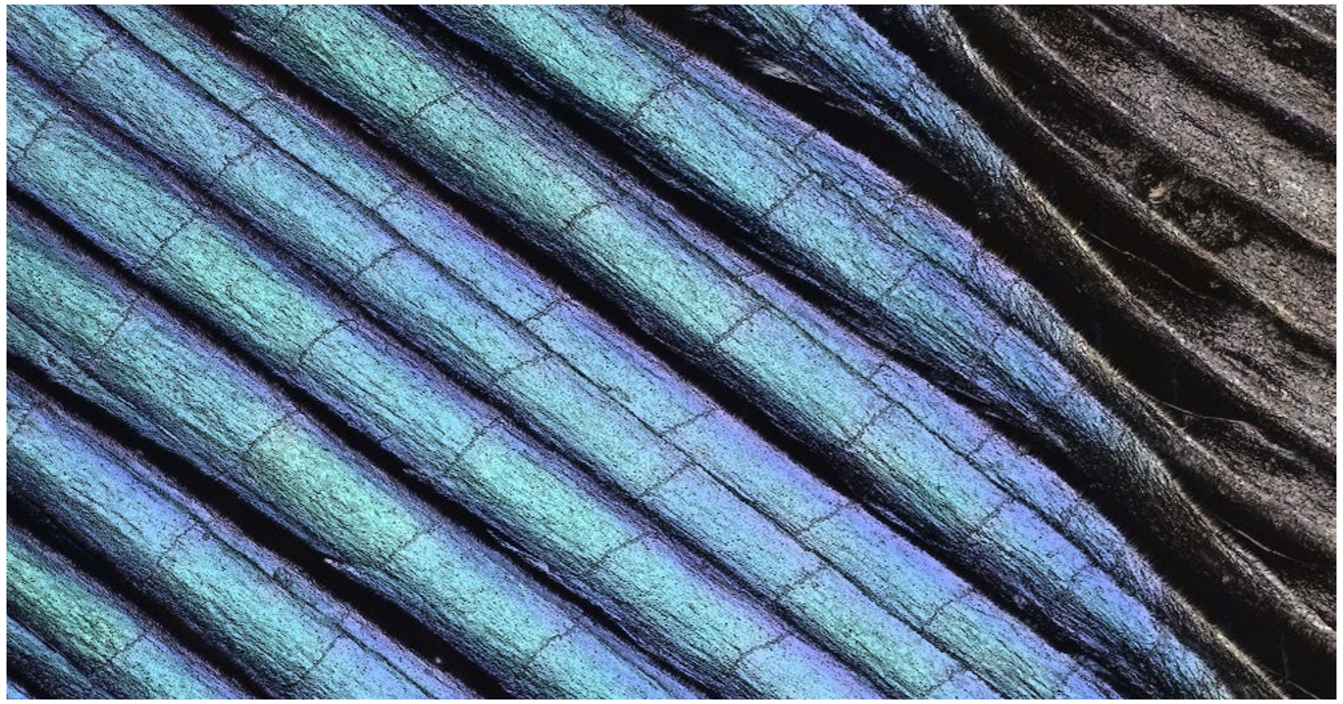
In 2019, the Nano Imaging Lab gained a new and significantly improved 3D laser scanning microscope. It was able to acquire this apparatus thanks not only to an attractive offer negotiated by Professor Richard Warburton from the Department of Physics but also to quick and unbureaucratic involvement on the part of the SNI and various working groups at the Department of Physics. This highly effective collaboration means that the scientists now have access to an outstanding, modern instrument that meets the high demands of their work.

Three-dimensional imaging of surfaces
The 3D laser scanning microscope is an optical microscope in which the specimen is scanned using a focused laser beam. By moving the lens around in order to examine a succession of different focal planes, the microscope can generate three-dimensional images of surfaces, volumes and roughness. The combination of the laser with white light paves the way not only for three-dimensional analyses but also for the detection of surface color.

Problems with the old model
Since 2012, Dr. Monica Schönenberger had been using the older version of a 3D laser scanning microscope from KEYENCE in the Nano Imaging Lab (NI Lab) to create three-dimensional images of the surfaces of a wide range of samples, as well as to train students and demonstrate imaging capabilities to visitors.

However, measurements of the height and depth of structures were sometimes inaccurate, as Professor Richard Warburton's team discovered. "Above all, we use the laser scanning microscope to accurately characterize our micro-optics and etched diamonds," he says.

Quick acceptance was crucial
With a view to solving this problem, Richard Warburton had contacted the company KEYENCE, which then performed a series of test measurements on the aforementioned sample types. They reached the conclusion that our model was not suitable for samples of this kind and recommended switching to an up-to-date unit, since laser scanning technology has developed enormously in the intervening period. Thanks to a long-standing collaboration with the Department of Physics, KEYENCE offered to supply a trade-fair display model at a significantly reduced price. The only condition was that the offer was accepted quickly.



The new microscope is ideally suited to showing visitors and students the beauty of the micro and nanoworlds – as shown here with the example of a bird's feather. (Image: M. Schönenberger, Nano Imaging Lab, Swiss Nanoscience Institute, University of Basel)

"The process of acquiring the new laser scanning microscope demonstrates how much we can achieve together."

Prof. Dr. Christian Schönenberger, SNI Director

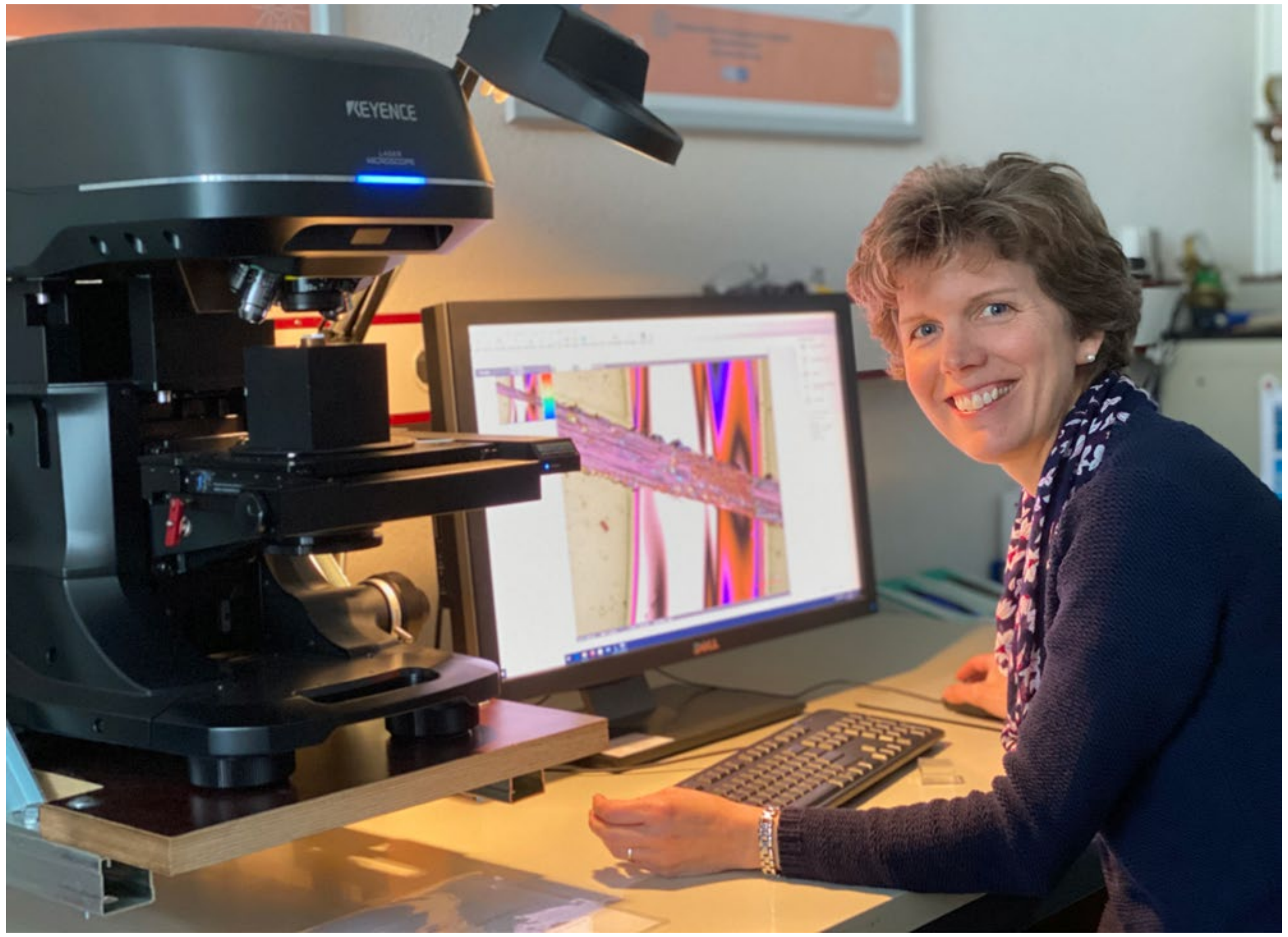
With that in mind, Richard Warburton wrote to the SNI and to his departmental colleagues. "I was able to confirm that the laser scanning microscope is used by numerous groups, and that an upgrade would not only expand the circle of users but also massively improve the scope and accuracy of the analyses," reports Monica Schönenberger from the NI Lab.

After that, everything happened very quickly. Within a week, six more working groups from the Department of Physics had agreed to pay their share of the costs. Richard Warburton could then accept KEYENCE's offer, and the microscope arrived in the Nano Imaging Lab just two weeks later.

"This is a great example of how strong we are when we work together," says Professor Christian Schönenberger, who made the case for purchasing the new equipment both as Director of the SNI and on behalf of his working group at the Department of Physics.

Numerous improvements
"The new model range presents a series of advantages over the old version," confirms Monica Schönenberger. For example, a quick surface measurement feature provides much faster measurement of a larger area than point-based sampling. The accuracy has improved, and the instrument can even examine complex shapes and steep slopes. With the new microscope, it is possible to determine the height of surface steps with nanometer resolution. If a single scan is not sufficient, the intensity of the laser is adjusted automatically and the sample is scanned again. Moreover, the new software includes numerous valuable extensions.

If you want to analyze surface profiles quickly and accurately, need information about the volume or roughness of a sample, or want to determine the thickness of transparent objects, the new 3D laser scanning microscope in the Nano Imaging Lab is the instrument of choice.

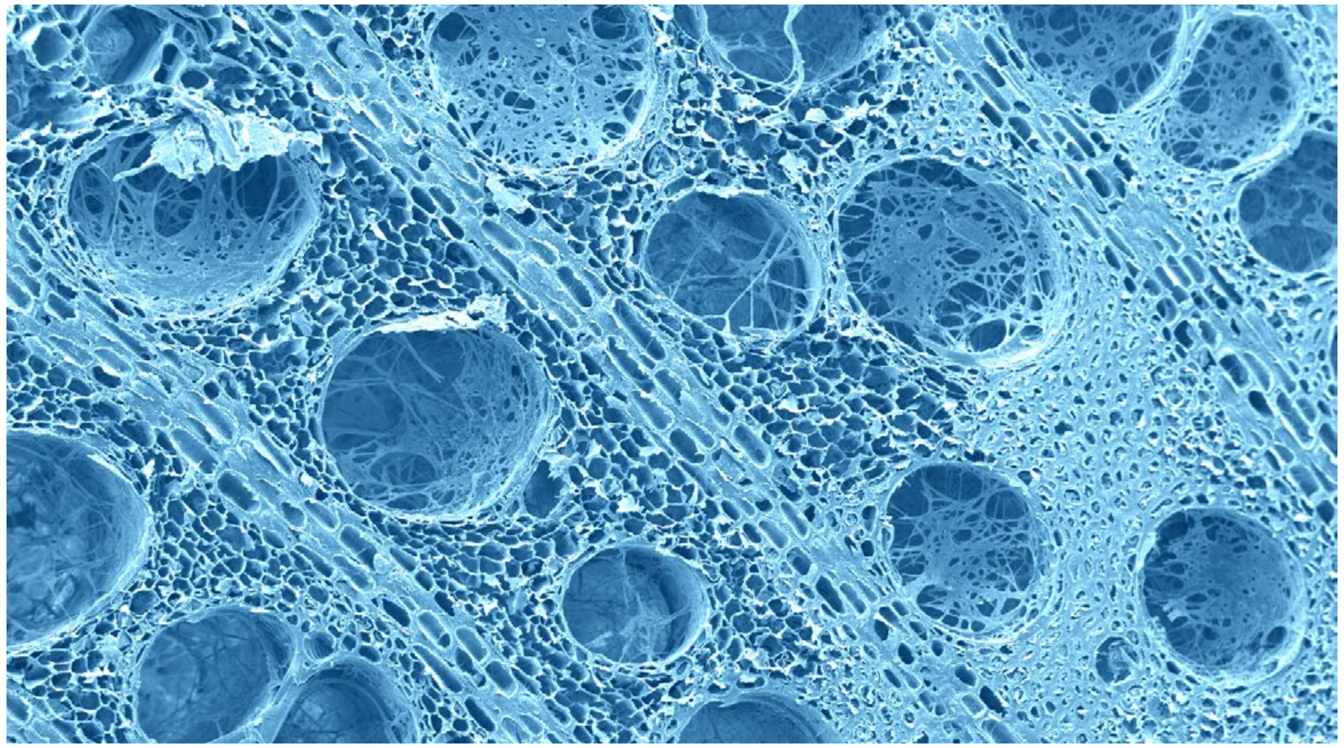


Monika Schönenberger is convinced of the advantages of the new 3D laser scanning microscope, which is now available to the Nano Imaging Lab for a wide range of analyses – thanks to the support of several research groups at the Department of Physics.

A well-polished surface for a higher-quality image

New polishing machine simplifies and optimizes sample preparation

In 2019, the Nano Imaging Lab (NI Lab) acquired a new polishing machine. This precision instrument allows the NI Lab team to saw, mill, grind and polish samples in a manner that is tailored to the respective material. The new sample preparation method comes in useful for the Vitifutur project, for example, where cuts of wood treated in this way produce remarkable images that aid the detection of pathogenic fungi.



Mycelium is growing in all of the vascular bundles of this sample of vine stem. (Image: E. Bieler, Nano Imaging Lab, Swiss Nanoscience Institute, University of Basel)

Tailored to the sample material

The new precision instrument for sample preparation from Leica Microsystems has a wide range of applications. Adapting to different sample properties, the machine saws, mills, grinds and polishes to produce smooth, grooveless surfaces. Preparation of this kind is required before the modification of atomic surfaces by ion etching, for example. Moreover, the smooth surfaces provide ideal conditions for detailed imaging with direct-light and scanning electron microscopy.

In the Vitifutur project, Evi Bieler from the Nano Imaging Lab uses the machine to study samples of wood collected from grapevines. The samples originate from the State Viticulture Institute in Freiburg im Breisgau, Germany, and are intended to provide information about how fungi damage the structure of wood that is infected with the grapevine disease esca.

Worsening damage

This disease is not a new phenomenon. Indeed, the lignified sections of vines have always been colonized by wood-destroying fungi. In recent years, however, the infection has led to increasingly frequent loss of the entire vine. According to the State Viticulture Institute, sometimes up to 10% of vineyards are affected. As there is little difference between the fungus populations of infected plants and those of healthy vines, it is not yet clear which fungi are responsible for the death of these plants. Nevertheless, different grape varieties do show differing degrees of susceptibility.

The plan is to use controlled infections of vines to underpin these observations with a view to responding by planting more resistant varieties – and it is for these analyses that the NI Lab comes into play. "The NI Lab analyzes very specific sections of the vine stem, where we can already see differences in infestation at the macroscopic level," explains Professor Hanns-Heinz Kassemeyer of the State Viticulture Institute.

Meaningful insights

Examination with a scanning tunneling microscope provides information about the spread of fungi within the sample and the resulting damage to the wood structure, but the samples must first be prepared. "With the new device, we can precisely remove the uppermost layer of the sample before using a diamond milling tool to produce a smooth, grooveless surface," says Evi Bieler.

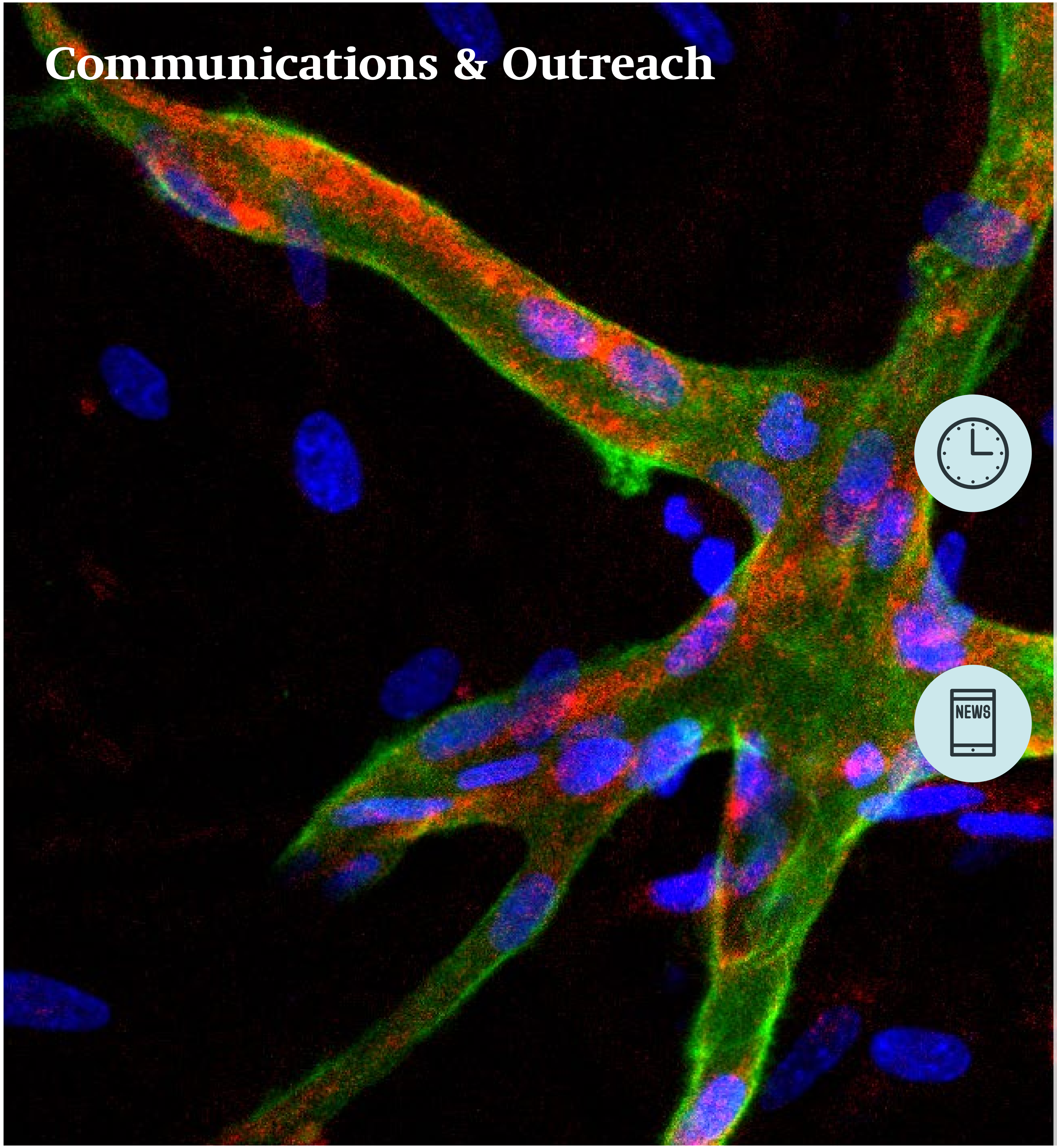
The quality of the images speaks for itself, giving a clear depiction of the spread of mycelium into all of the vascular bundles of the vine stem. By comparison with fungal cultures and molecular biological analyses, researchers can draw conclusions about the varieties of fungi that have become so widespread within the vine stem.

"The Leica TXP provides optimum versatility and surface quality for the preparation of sample sections for microscopy in materials science. This serves as the basis for further processing on the argon-plasma polishing machine."

Dr. Markus Dürrenberger, head of the Nano Imaging Lab

Evi Bieler and Hanns-Heinz Kassemeyer compare fungal infections in various wood samples.

Communications & Outreach



> 550

In 2019, the SNI outreach team spent over 550 hours engaging closely with pupils, teachers, and interested adults with the assistance of students, doctoral researchers, and the staff of the Nano Imaging Lab. The SNI participated in 27 outreach events.

> 250

In 2019, we collected more than 250 media reports about the SNI's research and activities. For the most part, these were based on the thirteen media releases drafted by the SNI in collaboration with the communications department of the University of Basel.

Self-assembled microvascular network. (Image:A. Banfi, Department of Biomedicine, University of Basel)

Wide-ranging topics and a variety of channels
Communication and outreach activities at the SNI

The aim of the SNI's communication and outreach activities is to provide a variety of target groups with information about the nanosciences and to cultivate an interest in the natural sciences and the exciting research topics at the SNI. It is also important to raise awareness of the SNI as a center of excellence for the nanosciences and nanotechnology, and to build connections between SNI members and keep them informed of the various SNI programs. Furthermore, the SNI team organizes events, distributes information materials and uses social media to get its message across to children, young people and members of the public, as well as to students and researchers.

World of experience in Basel

At the start of 2019, the SNI teamed up with the Departments of Physics and Chemistry and CSEM Muttenz to take part in tunBasel – an interactive world of experience for children and young people that was held as part of the last ever Mustermesse Basel trade fair.

The main attraction was the laser labyrinth, created a few years ago by the electronics lab of the Department of Physics at the suggestion of the SNI. A great many young visitors were quite happy to stand in line for up to 30 minutes, waiting for their turn to make their way through the 15 laser obstacles without touching the beams. Visitors could also marvel at the shimmering effects of chocolate laced with nanostructures and build their own spectrometer in order to split white light into its spectral colors.

Long lines formed outside the laser labyrinth at tunBasel.

Many children and young people built their own DNA models and used them to decorate picture frames. (Image: S. Hüni, Swiss Nanoscience Institute, University of Basel)

Science at Europa-Park

Children and young people were also the target audience for the SNI's annual program at the Science Days at Europa-Park Rust (Germany).

In 2019, the SNI stand was dedicated to the subject of DNA. Visitors were given a number of small colored beads in order to make their own DNA model, which was then used to decorate a picture frame containing a selfie – taken either alone or with their friends or parents.

In the process, the children learned that their hereditary make-up is stored on DNA, as well as discovering how this molecule is structured and that our genetic material isn't all that different from that of our friends.

The scientists and engineers of the future?

At the Future Day 2019, the SNI team provided young visitors with an introduction to the topic of "Light and Microscopy" in collaboration with the Department of Physics. The children learned how an atomic force microscope works and made their own wooden models of the instrument. They also had the chance to solder an unusual LED-illuminated Christmas ornament, gaining an understanding of how an electrical circuit works in the process.

The enthusiasm and dedication of the children taking part in the event is clear from this short video, which also showcases some of the fantastic creations they took home with them. https://www.youtube.com/watch?v=orlvQAIYU6w

Soldering a Christmas ornament called for maximum dexterity on the part of the children.

Florian Kehl took the audience at the SNI Lecture on a journey into the cosmos, offering a vivid description of how scientists can search for life in outer space.

From the nanoscale to the cosmos

In April 2019, members of the public were invited to join students and researchers attending the SNI Lecture with Dr. Florian Kehl. This young nano researcher studied nanosciences at the University of Basel and is now searching for life in space as a Life Detection Technologist at NASA's Jet Propulsion Laboratory. There, he is developing instruments that can detect biological molecules under the specific conditions encountered in space.

Before giving his fascinating talk, which had the entire audience engrossed, Florian Kehl spoke to the students from the nanoscience degree program about his experiences. It was interesting for the students to learn how his knowledge of biology, chemistry and physics along with his joined-up thinking have helped him to act as a bridge-builder between scientists and engineers, as well as how his degree laid the foundation for his exciting career. Florian also sat down in front of the camera to talk a bit about his work and career so that we could make a video.
https://www.youtube.com/watch?v=mKOYNbDBbPw

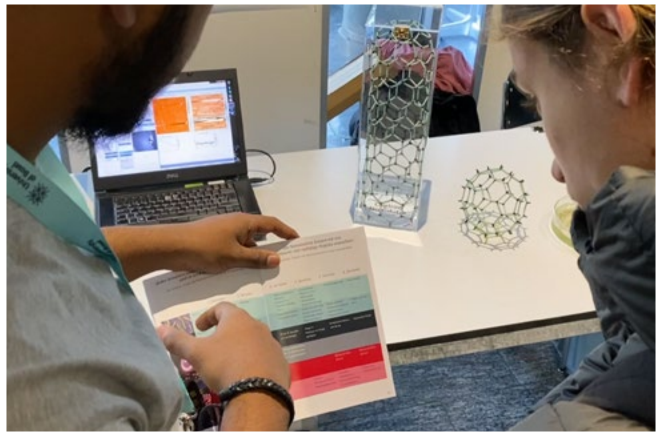
Students listen keenly as Florian Kehl talks about how his nanosciences degree laid the foundation for his career.

Science between carrot stalls
At the Rüeblimärt in Aarau, the SNI team took advantage of an unusual opportunity to inform the public not only about the SNI but also about the nanosciences and their applications.

After being drawn to the SNI stand for a chance to spin the wheel of fortune, many people learned about the SNI's commitment to research and training in Northwestern Switzerland and were given information material about the nanosciences and the various SNI programs.


Many visitors were drawn to the SNI stand at the Rüeblimärt for a chance to try their luck on the wheel of fortune. They were also delighted to learn about the nanosciences.


Those who wanted to try some experiments for themselves could use chromatography to separate different felt-tip pen inks, demonstrating that many different colors make up the black ink, for example.




At the Bachelor Info Day, nanoscience students gave a detailed explanation of the degree course, as well as offering prospective students some home-made SNI and nano cookies.

Contact with future students
The SNI also used opportunities to speak to older pupils about the possibility of doing a degree in the nanosciences. An ideal platform for this comes in the form of the TecDays and TecNights organized by the Swiss Academy of Engineering Sciences (SATW). In 2019, the SNI attended events in Heerbrugg, Trogen, Sursee, Glarus and Zurich.

Once again in 2019, a number of school classes came to Basel to visit the SNI. The pupils were given a general introduction to the nanosciences and taken on laboratory tours in the Departments of Physics or Chemistry, or the Biozentrum, depending on their interests. The program generally concluded with an interactive section in which students could build a model or conduct experiments of their own, as well as a drinks reception where they had the chance to hear from nanoscience students.

When it comes to providing potential students with information about studying at the University of Basel, one of the key events of the year is the General University Info Day, which is held across the university in early January.

At this event, the students once again take the lead, presenting nanoscience experiments and talking to prospective students about all aspects of the degree course. A short video provides viewers with an overview of the Info Day.
https://www.youtube.com/watch?v=RTGzEARxpV8

Information for teachers
At a teacher event held in collaboration with representatives of the physics, chemistry and computational sciences degree programs, teachers from the region received information about current research and the possibility of bringing their classes to visit the various departments and the SNI.

The SNI also took part in the Biovalley Symposium, providing teachers with a workshop all about scanning probe microscopy and its applications. The teachers welcomed the informative discussions at the SNI stand, the clear presentation of scientific applications, and the idea of allowing pupils to build a wooden model of an atomic force microscope (AFM) in their lessons.


A wooden model is a great way of explaining the principle behind the atomic force microscope (AFM).

"Thank you so much for the explanation, the chance to build an AFM model of my own, and the inspirational course! I used the model in class the following Monday, and it was a complete success!"

Dr. Ingrid Wenk-Siefert, Limmattal Cantonal School

Networks are the goal
A network is reliant on cohesion and the mutual exchange of ideas. It is with this in mind that the SNI's communication and outreach team organizes the Annual Event in Lenzerheide every year, as well as at least one Nano-Tech Apéro aimed at both industry experts and members of the SNI. In 2019, the Nano-Tech Apéro was held at Dectris in Baden-Dättwil.

As well as talks and discussions about applied Nano Argovia projects, the participants were treated to a tour of Dectris's premises to provide them with some inspiration. The company has also been involved in the Nano Argovia program itself with its excellent detector technology. A short video of the Nano-Tech Apéro is also available to give viewers an overview of the event.
https://www.youtube.com/watch?v=83tdxh98wZE


Dectris in Baden-Dättwil was the perfect host for the SNI's Nano-Tech Apéro.


After the talks and a tour of Dectris's premises, the Apéro provided ample opportunity to discuss various Nano Argovia projects.

New magazine
The SNI network is also the main target group for the SNI's new digital magazine, SNI INSight.

Published three times a year, this replaces the SNI update newsletter and offers a glimpse of the SNI's research and activities.

In SNI INSight, we take a closer look at various research topics and report on start-ups that have emerged within the SNI network as well as prizewinning SNI members. Other topics in SNI INSight include events and a look at the latest academic publications.

The magazine SNI INSight offers a glimpse of the SNI's research and activities.

"Our aim is to cultivate an interest in the natural sciences and inform people of the SNI's wide-ranging activities."

Dr. Kerstin Beyer-Hans, Sandra Hüni, Dr. Christel Möller & Dr. Michèle Wegmann
SNI communication team


The board of directors of the Hightech Zentrum Aargau was keen to hear about current research at the Department of Physics of the University of Basel.

Hosted by the SNI
In 2019, the SNI also hosted events organized by the Hightech Zentrum Aargau (HTZ). For example, the HTZ board of directors met in Basel to learn about the SNI as part of a board meeting and enjoyed laboratory tours in order to see for themselves the innovative research that is underway at the SNI and the Department of Physics.

Held jointly by the HTZ and the SNI in November 2019, the "Life Sciences" practice circle offered participants an insight into the world of nanocontainers and artificial organelles, which are the subject of research by various groups at the SNI. After a fascinating third talk on nanosensors, participants were given an insight into the practical work in two laboratory tours of the Nano Imaging Lab, which is operated by the SNI and the technology group of the Department of Physics.

"The HTZ board of directors was very impressed by the excellent, cutting-edge research underway at the SNI and at the Department of Physics of the University of Basel. This gave them an impression of various pioneering areas within the nanotechnologies, which will lay the foundation for future innovations as well as new materials and structures."

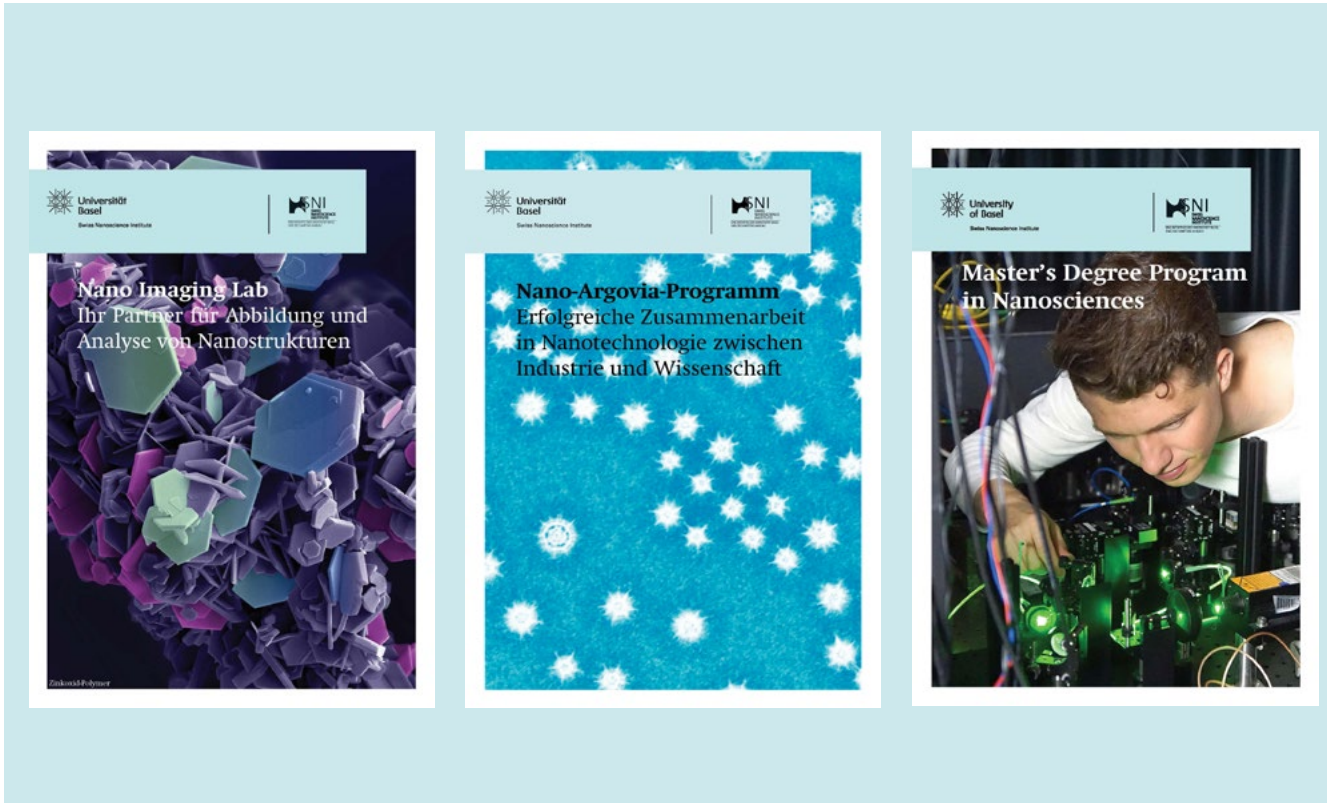
Dr. Martin Bopp, Managing Director, Hightech Zentrum Aargau

Communication materials and social media
In order to provide visual aids and information materials for the various target groups and events, the SNI designs and produces brochures and flyers on a range of subject areas.

In 2019, it designed new brochures on the activities of the Nano Imaging Lab, on the Nano Argovia and master's degree programs. Additional booklets on study options and various alumni career paths, as well as an illustrated introduction to the nanosciences, provide an ideal basis for discussions.

Since 2019, the SNI has also maintained an active presence on social media. With our LinkedIn page, we aim to reach scientists in particular, whereas by posting news items on Twitter, we aim to address a wider audience in Switzerland. At the same time, we hope to use Instagram to reach Swiss high-school and university students. The various different channels are used to post news about our research and to announce events, which we also report on through media such as short videos.

All of this information is also available on our website: www.nanoscience.ch.



Newly designed brochures support the outreach activities of the SNI.

Figures and Lists

7.19 Mio.

In 2019, the SNI had expenditures of 7.19 million Swiss francs, of which 4.68 million were covered by the Canton of Aargau and 2.51 million by the University of Basel.

51

The SNI supported 51 research projects, 13 in the applied Nano Argovia program and 38 in the SNI PhD School.

156

In 2019, the SNI had 156 members.

9

Nine partner institutions belong to the SNI network. This includes the University of Basel, the School of Life Sciences and School of Engineering at the University of Applied Sciences and Arts Northwestern Switzerland (FHNW), the Paul Scherrer Institute, the Department of Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel, the Centre Suisse d'Electronique et de Microtechnique (CSEM) in Muttenz, and the technology transfer center ANAXAM. The Hightech Zentrum Aargau and BaselArea.swiss supplement the network.

Scanning electron microscope image of a diatom. (Image: D. Mathys, Nano Imaging Lab, Swiss Nanoscience Institute, University of Basel)

Financial report

The Swiss Nanoscience Institute (SNI) was founded at the University of Basel in 2006. It was initiated by the Canton of Aargau to educate and encourage talented young people, to gain new insights through scientific research, and to support knowledge and technology transfer in collaboration with industrial companies from Northwestern Switzerland. These core aspects – teaching, basic research, applied research, along with knowledge and technology transfer – are also reflected in the SNI's finances.

Focus on basic research
Basic research plays a central role at the SNI. As part of this, the SNI supports the work of the two Argovia professors at the University of Basel, Roderick Lim and Martino Poggio, and (to a far lesser extent) the three titular professors at the PSI. These funding measures for professors by the University of Basel and the Canton of Aargau amount to almost CHF 1.5 million. In 2019, both Argovia professors were again successful in publishing results from their research groups in prestigious scientific journals. Their active involvement in international conferences contributes significantly to the SNI's positive reputation. Together, Roderick Lim and Martino Poggio secured external funding of CHF 1.2 million from Switzerland and beyond in 2019. Martino Poggio dedicated time to ANAXAM in 2019 and represents the SNI on the board of the association.

Basic research is also performed by the doctoral students in the SNI PhD School, which was founded in 2012. A total of 38 doctoral students were enrolled in the SNI PhD School in 2019. They work at various institutions within the SNI network – often in collaboration with several institutions – but all earn their doctorates within the Faculty of Science at the University of Basel. In 2019, the SNI PhD School had a budget of approximately CHF 1.5 million, significantly less than in previous years. In part, this is because all doctoral students from the first two, very large cohorts completed their doctorates in 2017 and 2018. In addition, more than half of the new projects for 2019 did not begin until November or December 2019.

Knowledge and technology transfer hugely significant
The knowledge acquired through basic research is transferred to industrial companies in Northwestern Switzerland, primarily through the highly successful Nano Argovia program. Together with PR measures, the Nano Argovia program received approximately CHF 1.7 million in 2019 (knowledge and technology transfer: KTT & PR).

Launched in 2007, the Nano Argovia program is tailored to the needs of industrial companies and is now very well established. Numerous teams apply every year to conduct their applied research within this program. It is very gratifying to see more and more companies joining – and thus expanding – the network. Thirteen Nano Argovia projects were conducted in 2019, two of which have been extended on a cost-neutral basis. Eight of the industry partners came from the Canton of Aargau. The project partners contributed more than CHF 1.6 million to the applied Nano Argovia projects via public research funding instruments (e.g. Innosuisse, Swiss National Science Foundation, EU funding) and funding from research institutions themselves. The industrial partners contributed around CHF 1.5 million through in-kind services.

Excellent service
The services and research of the Nano Imaging Lab (NI Lab) have become a fundamental part of the SNI. It provides a valuable service and supports the imaging requirements of research projects. SNI members, companies and academic partners can acquire inexpensive analyses and microscopic images (electron and scanning probe microscopy) of nano samples and obtain advice regarding their research work.

Study and information exchange
In addition to Support (funding at the professorial level), the PhD School, KTT & PR (knowledge and technology transfer), Nano Imaging Lab, and Infrastructure (investment in premises and apparatus), the other spending items are Management & Overheads, Outreach (conferences, brochures, public events and making contact with teenagers and children) and Nano Study (bachelor's and master's programs).

In 2019, 100 students were enrolled in the nano study program; 53 in the bachelor's program, 47 in the master's program. Approximately CHF 0.5 million is posted in the budget for this item. The subject of nanoscience is not taught in schools, which means it is important for the SNI to actively engage with pupils to introduce them to this ambitious program (which remains unique throughout Switzerland) through various event formats. The SNI has therefore invested around CHF 0.1 million in outreach and communication activities, which are largely performed by SNI management representatives.

Temporary surplus
In 2019, the SNI spent less than it received. This is partly due to the Canton of Aargau raising its financial commitment to the contractually agreed CHF 5 million from 2019, while cost-cutting measures have continued to take effect. In addition, more than half of the new doctoral students were not recruited until the last two months of 2019. All doctoral students receive their salary from the SNI over a period of 48 months, meaning that the funding for these projects is tied up for a long period of time. The SNI has also entered into obligations relating to the newly founded ANAXAM technology transfer center for 2019 and subsequent years.

For the reasons stated above, earmarked funds have increased to CHF 8.5 million as of 31 December 2019.

Funding commitments of CHF 1.7 million that will not come into effect until 2020 are to be deducted from this balance. The actual balance is therefore around CHF 6.8 million.

At this point, we would like to thank the Office of Finance and Controlling at the University of Basel for its efficient reporting. Many thanks are also due to the Cantons of Aargau, Basel-Stadt and Baselland for supporting the SNI, allowing us to train excellent young scientists, conduct research at the highest level and transfer our findings to companies in the region.

The following table shows expenses for 2019 by category in accordance with the financial report of the University of Basel dated 25 February 2020.

Expenditure 2019 in CHF

		Univ. Basel	Canton AG	Total
Management	Personnel and operational costs	327’475	232’734	560’209
	Overhead	—	650’000	650’000
Infrastructure	Infrastructure building	—	—	—
	Infrastructure equipment	121’624	124’208	245’832
KTT & PR	Personnel and operational costs	57’024	152’422	209’446
	Argovia projects	—	1’495’401	1’495’401
Outreach	Operational costs	48’840	54’577	103’417
Support	Argovia professorships	525’827	861’474	1’387’302
	PSI-Professors	—	84’320	84’320
Nano Study	Bachelor and master program	305’962	210’454	516’416
Nano Imaging Lab	Personnel and operational costs	450’204	—	450’204
PhD School	Research projects	668’938	817’590	1’486’528
Total expenditure for 2019 in CHF		**2’505’894**	**4’683’181**	**7’189’075**

The following table shows the SNI balance sheet as at 31 December 2019.

SNI balance sheet 2019 in CHF

	Univ. Basel	Canton AG	Total
Grants	2’751’554	5’000’000	7’751’554
Investment income	35’259	281’091	316’350
Income	**2’786’813**	**5’281’091**	**8’067’904**
Expenditure	**2’505’894**	**4’683’181**	**7’189’075**
Balance year 2019	**280’919**	**597’910**	**878’829**
SNI assets per 01/01/2019	**1’716’786**	**5’950’612**	**7’667’398**
Annual balance	280’919	597’910	878’829
SNI assets per 31/12/2019 in CHF	**1’997’705**	**6’548’522**	**8’546’227**

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M. Weegen, Department of Chemistry, University of Basel
C. Zelmer, Biozentrum, University of Basel

Projects of the SNI PhD School

Project	Principle Investigator (PI) and Co-PI	PhD Student
P1304 Folding mechanisms of beta-barrel outer membrane proteins and their catalysis by natural holdases and foldases	S. Hiller (Univ. Basel), D. Müller (D-BSSE)	N. Ritzmann
P1306 Slow-release nano-pills for mosquitoes for interrupting malaria transmission	P. Hunziker (Univ. Hospital Basel), E. Constable (Univ. Basel)	D. Gonçalves
P1307 Optoelectronic nanojunctions	M. Calame (Univ. Basel), M. Mayor (Univ. Basel)	J. Overbeck
P1309 Cooling and control of a nanomechanical membrane with cold atoms	P. Treutlein (Univ. Basel), P. Maletinsky (Univ. Basel)	T. Karg
P1310 Plasmonic sensing in biomimetic nanopores	Y. Ekinci (PSI), R. Y. H. Lim (Univ. Basel)	D. Sharma
P1401 Targeted single cell proteomics using magnetic nanoparticles to study prion-like spreading of amyloid nanoparticles	T. Braun (Univ. Basel), H. Stahlberg (Univ. Basel)	C. Schmidli
P1402 Lightweight structures based on hierarchical composites	C. Dransfeld (FHNW), C. Schönenberger (Univ. Basel)	W. Szmyt
P1403 Tailor-made proteins and peptides for quantum interference experiments	V. Köhler (Univ. Basel), M. Mayor (Univ. Basel)	J. Schätti
P1404 Selective transport of functionalized nanocarriers into biomimetic and natural nuclear pore complexes	R. Lim (Univ. Basel), C. Palivan (Univ. Basel)	C. Zelmer
P1405 Surface-functionalization of diamond nano-magnetometers for applications in nano- and life sciences	U. Pieles (FHNW), P. Maletinsky (Univ. Basel)	M. Batzer
P1406 Charge transfer versus charge transport in molecular systems	O. Wenger (Univ. Basel), M. Calame (Univ. Basel)	S. Neumann
P1407 Coupling a single ion to a nanomechanical oscillator	S. Willitsch (Univ. Basel), M. Poggio (Univ. Basel)	P. Fountas
P1408 Clean zigzag and armchair graphene nanoribbons	D. Zumbühl (Univ. Basel), D. Loss (Univ. Basel)	M. Rehmann
P1501 Nanomechanical mass and viscosity measurement-platform for cell imaging	T. Braun (Univ. Basel), E. Meyer (Univ. Basel)	P. Oliva
P1502 Investigating individual multiferroic and oxidic nanoparticles	A. Kleibert (PSI), M. Poggio (Univ. Basel)	D. M. Bracher
P1503 Watching giant multienzymes at work using high-speed AFM	T. Maier (Univ. Basel), R. Y. H. Lim (Univ. Basel)	S. Singh
P1504 Valleytronics in strain-engineered graphene	C. Schönenberger (Univ. Basel), M. Calame (Univ. Basel)	L. Wang
P1505 A programmable e-beam shaper for diffractive imaging of biological structures at Å resolution	S. Tsujino (PSI), J. P. Abrahams (Univ. Basel)	P. Thakkar
P1601 Optical plasmonic nanostructures for enhanced photochemistry	E. Constable (Univ. Basel), S. Fricke (CSEM Muttenz)	L. Driencourt
P1602 Self-assembly and magnetic order of 2D spin lattices on surfaces	T. A. Jung (Univ. Basel), J. Dreiser (PSI)	M. Heydari
P1603 A mechano-optical microscope for studying force transduction in living cells	R. Lim (Univ. Basel), E. Meyer (Univ. Basel)	T. Kozai
P1604 Selective reconstitution of biomolecules in polymer-lipid membranes	W. Meier (Univ. Basel), U. Pieles (FHNW)	S. Di Leone
P1606 Smart peptide nanoparticles for efficient and safe gene therapy	C. Palivan (Univ. Basel), J. K. Benenson (D-BSSE, ETHZ Basel)	S. Tarvirdipour
P1607 Understanding and engineering of phonon propagation in nanodevices by employing energy resolved phonon emission and adsorption spectroscopy	I. Zardo (Univ. Basel), C. Schönenberger (Univ. Basel)	L. Gubser
P1701 Van der Waals 2D semiconductor nanostructures with superconducting contacts	A. Baumgartner (Univ. Basel), C. Schönenberger (Univ. Basel)	M. Ramezani
P1702 Single organelle size sorting by a nanofluidic device	Y. Ekinci (PSI), H. Stahlberg (Univ.Basel)	T. Mortelmans
P1704 Evolving protease enzymes with new sequence specificity using peptide-hydrogel cell encapsulation	M. Nash (Univ. Basel), S. Reddy (D-BSSE, ETHZ Basel)	J. López Morales
P1705 Genetic selection of nanocatalysts	S. Panke (D-BSSE, ETHZ Basel), T. Ward (Univ. Basel)	E. Rousounelou
P1706 Ultrasensitive force microscopy and cavity optomechanics using nanowire cantilevers	M. Poggio (Univ. Basel), F. Braakman (Univ. Basel)	D. Jäger
P1707 Nano-photonics with van der Waals heterostructures	R. Warburton (Univ. Basel), I. Zardo (Univ. Basel)	L. Sponfeldner
P1708 Non-visual effects of LED lighting on humans	R. Ferrini (CSEM), E. Meyer (Univ. Basel)	T. Aderneuer
P1801 Bioinspired nanoscale drug delivery systems for efficient targeting and safe in vivo application	J. Huwyler (Univ. Basel) C. Palivan (Univ. Basel)	C. Alter
P1802 From Schrödinger's equation to biology: Unsupervised quantum machine learning for directed evolution of anti-adhesive peptides	M. Nash (Univ. Basel) A. von Lilienfeld (Univ. Basel)	V. Doffini
P1803 Nanoscale mechanical energy dissipation in quantum systems and 2D-materials	E. Meyer (Univ. Basel) M. Poggio (Univ. Basel)	A. Ollier
P1804 Picoscopic mass analysis of mammalian cells progressing through the cell cycle	D. Müller (ETHZ D-BSSE) W. Meier (Univ. Basel)	I. Incaviglia
P1805 High-throughput multiplexed microfluidics for antimicrobial drug discovery	E. van Nimwegen (Univ. Basel) V. Guzenko (PSI)	H.A. Hernandez Gonzalez
P1807 Andreev Spin Qubit (ASQ) in GeSi nanowires	C. Schönenberger (Univ. Basel) F. Braakman (Univ. Basel)	J.H. Ungerer
P1808 Quantum dynamics of an ultracold ion coupled to a nanomechanical oscillator	S. Willitsch (Univ. Basel) M. Poggio (Univ. Basel)	M. Weegen

Nano Argovia projects

Projects started in 2019

Project	Project leader	Project partner
A14.04 DeePest – A detector for pesticides in drinking water (DeePest)	J. Pascal (FHNW)	P. Shahgaldian (FHNW), E. Weingartner (FHNW), D. Matter (Mems AG, Birmenstorf)
A14.07 KOKORO – Origami heart model based on nano-patterned paper scaffold for directed cardiac tissue engineering	M. R. Gullo (FHNW)	J. Köser (FHNW), A. Banfi (Univ. Basel), A. Marsano (Univ. Basel), J. Schoelkopf (Omya International AG, Oftringen)
A14.08 LASTRUPOL – Laser-based sub-micron structuring of polymers for advanced origination of micro-optics for physical document security applications	P. M. Kristiansen (FHNW)	R. Holtz (FHNW), H. Schift (PSI), C. Sailer (Gemalto AG, Aarau)
A14.13 NCT Nano – Novel cancer-targeted nanoparticles	M. Zigler (Targ-Immune Therapeutics, Basel)	C. Palivan (Univ. Basel), I. Craciun (Univ. Basel), Y. Benenson (ETH D-BSSE)
A14.15 PERINANO – Nano^2: A bioresponsive nano-in-nano composite for drug delivery and tissue regeneration in peri-implantitis	F. Koch (FHNW), O. Germershaus (FHNW)	U. Pieles (FHNW), J. Laubersheimer (Universität Basel (HFZ), M. Hug (Credentis AG, Windisch)
A14.19 UltraNanoGRACO – Customized, nanostructured grating compressors for high repetition rate ultrafast lasers	F. Lütolf (CSEM)	G. Basset (CSEM), B. Resan (FHNW), F. Emaury (Menhir Photonics AG, Basel)

Prolonged projects (with and without financial support)

Project	Project leader	Project partner
A13.04 ecamist – Efficient capturing of mRNA for single-cell transcriptomics	G. Lipps (FHNW)	M. Held (ETHZ Basel, D-BSSE), S. Schmitt (Memo Therapeutics AG, Basel)
A13.08 MEGAnanoPower – Disruptive power storage technology applying electrolyte nano dispersions and micro/ nano structured electrodes	U. Pieles (FHNW)	S. Fricke (CSEM Muttenz), A. Schimanski (Aigys AG, Othmarsingen)
A13.09 NanoCoat – Biomimetic growth of calcium phosphates ceramics on Ti implants	A. Testino (PSI)	E. Müller (PSI), M. de Wild (FNHW), P. Gruner (Medicoat AG, Mägenwil), J. Moens (Medicoat AG, Mägenwil), W. Moser (Atesos Medical AG, Aarau), B. Höchst (Hager & Meisinger GmbH, Neuss)
A13.12 NanoGhip – Nano-switchable GPCR–arrestin biochip for drug discovery	M. K. Ostermaier (InterAx Biotech AG, Villigen)	G. Schertler (PSI), C. Palivan (Univ. Basel), R. Y. H. Lim (Univ. Basel)
13.15 NQsense – Nanophotonics for quantum sensing technology	P. Maletinsky (Univ. Basel)	C. David (PSI), G. Seniutinas (PSI), F. Favaro (Univ. Basel & QNAMI), M. Munsch (QNAMI)
A12.10 MiPIS: Microfluidic protein isolation, stabilization and cryo-EM preparation for high-resolution structural analysis	T. Braun (Univ. Basel)	M. Hürzeler (FHNW), M. Chami (Univ. Basel), M. Hennig (leadXpro, Villigen)
A12.17 3D Cellophil® membrane: 3D printable nano porose Cellophil® membranes with nano hydroxyapatite gradient for tissue regeneration applications	U. Pieles (FHNW)	S. Stübinger (HFZ, Univ. Basel), C. Geraths (CIS Pharma AG, Bubendorf)

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Scientific part of the Annual Report

If you are interested in detailed reports about the Nano Argovia and SNI PhD School projects, please scan the QR code or send us an email so that we can supply a printed version (c.moeller@unibas.ch).

Scientific supplement

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