University of Basel

Swiss Nanoscience Institute

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

Annual Report 2022
Swiss Nanoscience Institute

Scientific supplement
Scientific reports from all the Nano-Argovia and SNI PhD School projects from 2022 can be found on our website or by scanning the QR code.

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Dear colleagues and interested parties,

This annual report looks back on another eventful year. After two years of the coronavirus pandemic, we were able to resume our work in the lab with almost no restrictions and return to meeting up again in person. Although virtual formats helped us to stay in touch during the pandemic, it has become clear to us all that they cannot replace personal interactions altogether.

Among other things, we used the first half of the year to prepare for a change in leadership at the Swiss Nanoscience Institute. For 16 years, Christian Schönenberger led the SNI as its director, building it up into what is now – a recognized center of excellence for the nanosciences and nanotechnology. I myself owe a great deal to this network, having been part of it as an Argovia Professor since 2009. As SNI Director since August 2022, I now have the opportunity to give something back and to help shape the future of this unique network. I'm supported in these efforts by the newly constituted SNI Executive Committee, whose members represent the SNI's network partners, as well as the participating departments at the University of Basel, and have also assumed leadership of areas such as the Nano-Argovia program, the nanoscience curriculum and the newly founded Nano Technology Center. Together, we will continue to expand the SNI and ensure it is well equipped for a future in which nanotechnologies are set to play an increasingly key role.

In 2022, we took an important step in this direction by founding the Nano Technology Center, which includes the already established Nano Imaging Lab and the newly founded Nano Fabrication Lab. The staff of these two service units offer valuable services to customers from academia and industry, as well as making valuable contributions to various lines of research.

Other key areas of the SNI's work include basic scientific and applied research as well as the training of excellent scientists – and this will continue to be the case in the future.

It's now been 20 years since the first students began their bachelor's degrees in nanosciences at the University of Basel and 10 years since we advertised the first projects at the SNI PhD School. Since then, many young researchers have completed their training here in Basel and embarked upon careers in industry and at universities. In this annual report, we look at some of the highlights of the course of studies and the PhD School.

We also outline findings of research carried out within the network and describe applied research projects that were funded in collaboration with industrial companies from the Canton of Aargau or one of the Basel half cantons as part of the Nano-Argovia program in 2022. Our new approach whereby these findings are reported only briefly in this general section of the annual report, while the scientific supplement explores them in greater depth, has proven successful.

In the second half of 2022 especially, numerous events served as an opportunity for the SNI team to attract public interest in the nanosciences, the SNI in general and the nanosciences degree course at the University of Basel. In this regard, I would particularly like to highlight our excellent collaboration with Museum Burghalde in Lenzburg, which allows us to inform broad sections of the general public about the Canton of Aargau's commitment to the nanosciences. Another highlight of our outreach work in 2022 was the SNI's attendance at the Rüeblimärt in Aarau, where we were able to give the many keen visitors there insights into the rich possibilities that the nanosciences offer.

For us, as an interdisciplinary network with colleagues at different research institutions, it was also important that we were able to meet in person again and exchange ideas at the Annual Event and the Nano-Tech Apéro in 2022. It is precisely at events like these that new ideas emerge for innovative interdisciplinary projects that reach across institutional boundaries, and these projects are what makes the Swiss Nanoscience Institute so special.

I hope this report provides you with some entertaining and interesting insights into the SNI's work in 2022, and I look forward to working together again this year.

Kind regards,

Professor Martino Poggio
SNI Director

2022 in brief

Two prizewinning master's theses
In 2022, the two former nanoscience students Vera Weibel and Mathias Claus received prizes for their outstanding master's theses. Vera Weibel investigated a superconducting material and Mathias Claus developed a torsion rocker.
Page 13

Studying at renowned universities abroad
Nanoscience students again had the opportunity to complete part of their master's studies abroad in 2022. Four students took up Argovia Travel Grants in order to fulfil their dreams of studying in the USA or Australia. The students wrote their master's theses at various renowned universities and took this unique opportunity to get to know other cultures and to begin building their international network.
Page 14

Swiss Nanotechnology PhD Award for young researchers from the SNI network
Former nanoscience student Claudia Lotter and former SNI doctoral student Dr. Thomas Mortelmans received the Swiss Nanotechnology PhD Award. In her master's thesis, Claudia Lotter investigated how lipid nanoparticles developed for gene therapy can be optimized by tweaking the lipid composition. In his doctoral dissertation at the SNI PhD School, Thomas Mortelmans built a new platform for antibody tests.
Pages 14 and 20

The well-attended Nano-Tech Apéro at FHNW was an ideal opportunity to learn about applied Nano-Argovia projects and to make new contacts.
Page 51

Informal conference for doctoral students
The year 2022 also saw the return of the "Nanoscience in the Snow" Winter School for doctoral students at the SNI. Surrounded by breathtaking scenery in Zermatt, the young scientists used the time to exchange ideas about their wide-ranging research projects and to get to know each other better.
Page 21

Varied topics
In 2022, seven doctoral students successfully completed their doctoral dissertations at the SNI PhD School, having carried out the corresponding practical work at the Department of Physics and the Biozentrum at the University of Basel and at the Paul Scherrer Institute.
From page 17

Former SNI doctoral student Thomas Mortelmans won one of the Swiss Nanotechnology PhD Awards.

Former SNI doctoral student Alexina Ollier received a Young Researcher Award.

Former SNI doctoral student Thomas Karg won an SPS Award.

Detecting coronavirus and flu
Researchers from the University of Basel and the Paul Scherrer Institute have developed a rapid test for Covid-19 based on a novel functional principle. The test could be used to determine the status of the disease or to detect other diseases and different variants of Covid-19.
Page 25

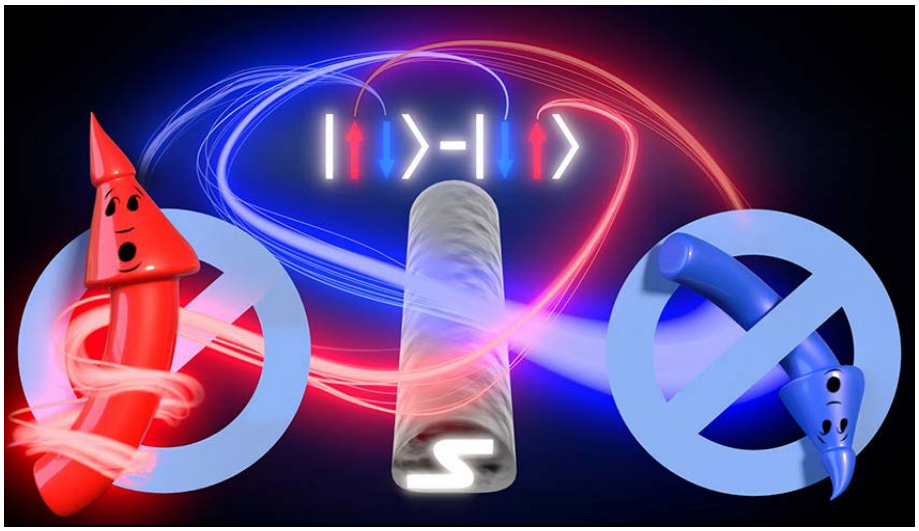
New approach to biosensor technology
Researchers from the SNI network have developed a new coating – made of a polymer and carbon nanotubes – that is suitable for coating miniaturized electrodes. Electrodes of this kind feature conductive nanomaterials embedded in a repellent matrix and have applications in point-of-care laboratory diagnostics.
Page 25

Time-saving due to early diagnosis
Nanomechanical sensors are ideally suited to quickly and reliably detect even a few bacteria in the blood.
Seite 25

Cooling matter from a distance
Researchers from the University of Basel have used laser light to form a control loop consisting of two quantum systems separated by a distance of one meter. Within this loop, a vibrating membrane is cooled by a cloud of atoms. Interfaces of this kind will play a role in future quantum technologies.
Page 27

Floating thanks to sound waves
Sound waves can be used to keep tiny rotating sample holders floating in mid-air – for example, for crystallographic analyses. Researchers from the SNI network have shown how this effect is influenced by the size and shape of the rotors.
Page 31

Dancing molecules
Cycloalkanes adapt their shape if they are enclosed in tiny pores. In response to an increasing lack of space and at low temperatures below 5K, the molecules start to move in a surprising way.
Page 27



Spin filters can be used to demonstrate a negative correlation between the two spins of an entangled electron pair from a superconductor. (Image: SNI/ Scixel)


2 µm

The best of both worlds

Basic and applied research are key pillars of the SNI's work.

Whereas the SNI PhD School primarily deals with questions of basic science, the Nano-Argovia program is all about applied projects. Here, researchers from the SNI network work closely with industrial companies from Northwestern Switzerland and support the process of knowledge and technology transfer. More information from page 34 onward.

Working with vVardis (formerly credentis), researchers from the FHNW School of Life Sciences treated the surfaces of teeth with fluoride paste and exposed them to artificial saliva. (Image: L. Kind, FHNW)

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

The Swiss Nanoscience Institute (SNI) at the University of Basel is a center of excellence for nanosciences and nanotechnology, 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. Moreover, the SNI actively supports knowledge and technology transfer to industrial companies from Northwestern Switzerland through the Nano-Argovia program and is a founding member of the ANAXAM technology transfer center.

Two SNI service units — the Nano Imaging Lab and the Nano Fabrication Lab — provide researchers from academia and industry with services relating to imaging and analysis, as well as nano and micro fabrication, and also support research projects.

The SNI offers not only a bachelor's and master's degree program but also a PhD School, providing interdisciplinary training to early career researchers. Finally, the SNI also engages in public relations work with a view to generating interest in the natural sciences among various target groups and supporting collaboration between academia and industry.

20%

20% of SNI members are women.

4+8+7

In 2022, 4 students successfully completed their bachelor's program, 8 completed the master's program. Seven PhD students successfully defended their PhD theses.

40

In 2022, 40 PhD students were enrolled in the SNI PhD School.

166

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

48

The SNI supported financially 48 research projects, 12 in the applied Nano-Argovia Programm and 36 in the SNI PhD School.

84

In 2021, 59 students were enrolled on the bachelor's program and 25 on the master's program.

77+120

Since its foundation in August 2022, the Nano Fabrication Lab had 77 users. In 2022, the Nano Imaging Lab received more than 175 orders, which often take several days, from 120 different customers.

15

Fifteen of the 48 PhD students who had completed their PhDs by the end of 2022 work at a federal or research institution.

33

Thirty-three of the 48 PhD students who had completed their PhDs by the end of 2022 work in industry.

44

In 2022, a total of 44 peer-reviewed papers with participation of SNI members were published in renowned science journals.

9

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

8.08 M

In 2022, the SNI had expenditures of approximately CHF 8.08 million (without building costs) of which CHF 5.14 million were covered by the Canton of Aargau and CHF 2.94 million by the University of Basel.

>4300

The SNI social media channels on Instagramm, LinkedIn, Twitter and YouTube have more than 4,300 followers.

The SNI developed from the National Center of Competence in Research "Nanoscale Science" on the initiative of the Canton of Aargau and the University of Basel.

Commitment from the Canton of Aargau and the University of Basel

The SNI was founded in 2006 by the Canton of Aargau and the University of Basel in order to drive forward research and training in the nanosciences and nanotechnology in Northwestern Switzerland. Nanotechnologies play a key role in research and industry in the Canton of Aargau and are one of the focal areas of the Hightech Aargau innovation-support program, with which the Canton seeks to bolster not only the competitiveness of companies but also value creation. Researchers from various disciplines and institutions work together on numerous successful SNI research projects, which support this strategy in the Canton of Aargau and provide companies from Aargau, Solothurn and the two Basel half cantons with access to new scientific findings and technologies.

In 2022, the SNI spent approximately 8.08 million Swiss francs, of which some 5.14 million were provided by the Canton of Aargau and 2.94 million by the University of Basel.

Its success is based on an ever-expanding interdisciplinary network of committed researchers.

An interdisciplinary and agile network

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

One key objective of the SNI is to train outstanding scientists.

Excellent early career researchers

The SNI's precursor institution set up a bachelor's and master's program in nanosciences at the University of Basel 20 years ago. Students on the bachelor's program are first given a solid grounding in biology, chemistry, physics and mathematics and can then choose more courses that suit their personal interests as they progress through this demanding program. They have the opportunity to participate in various research groups and gain insights into applied projects in industry at an early stage in their education. So far, a total of 273 students have earned a bachelor's degree in nanosciences at Basel, and 211 students have successfully completed the master's program in nanosciences. At the end of 2022, there were 59 students enrolled on the bachelor's program and 25 early career researchers enrolled on the master's program.

Some students on the nanoscience program then continue their training at the SNI PhD School, which was founded in 2012, although most of the 40 doctoral students enrolled in the PhD School in 2022 came from other universities in Europe, Asia or America. The PhD School also provides young researchers with insights into subjects outside of their own area of research. In particular, this interdisciplinarity is further enhanced at events such as the "Nanoscience in the Snow" Winter School, the Annual Meeting and various courses developed specifically for the PhD School. In 2022, seven doctoral students successfully completed their doctoral dissertations at the SNI PhD School, bringing the total number to 48. A further seven new projects were approved and will begin in 2023.

Leaders in their field

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

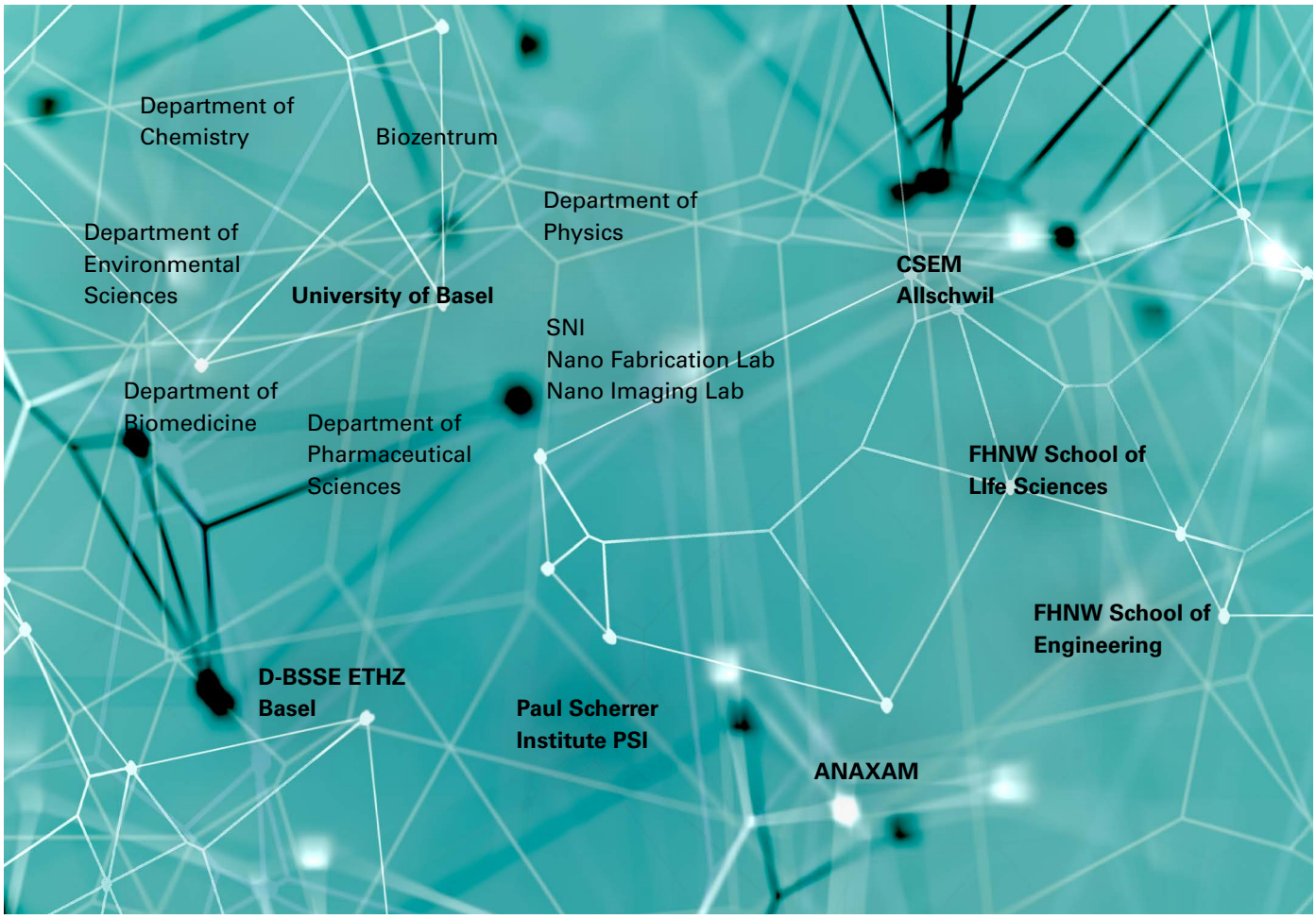
In addition to the Argovia professors, the SNI supports three titular professors: Professor Thomas Jung teaches and researches at the Department of Physics of the University of Basel and leads another team at the Paul Scherrer Institute PSI. Professors Frithjof Nolting and Michel Kenzelmann also lecture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

Knowledge and technology transfer to industry

The SNI supports the transfer of scientific findings to industry through the Nano-Argovia program, which has been promoting collaboration between companies from Northwestern Switzerland and research institutions since the SNI was founded. In total, 12 of these applied research projects were funded in 2022. Half of the partner companies came from the Canton of Aargau, while the other half came from one of the two Basel half cantons. Collaboration with industry is also supported by the new ANAXAM technology transfer center, of which the SNI is a founding member. ANAXAM provides companies throughout Switzerland with access to state-of-the-art analytical methods.

Expanded range of services

The SNI is also on hand as a provider of various services to partners in academia and industry. As part of the SNI since 2016, the Nano Imaging Lab (NI Lab)



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

The Nano-Argovia program supports knowledge and technology transfer.

has a six-person team and offers comprehensive services relating to surface imaging and analysis. In 2022, a second service unit was added in the form of the Nano Fabrication Lab (NF Lab), which brought together existing activities and infrastructure from the Department of Physics in order to offer professional and effective services in the promising area of nanofabrication.

The Nano Imaging Lab and Nano Fabrication Lab service units assist researchers with various questions.

Fostering an interest in the natural sciences

It's important to the SNI team not only to train excellent scientists, conduct excellent research and act as a sought-after partner and service provider, but also to inform the general public about its various activities and foster an interest in the natural sciences. For example, the SNI team takes part in science festivals and exhibitions and provides school classes and groups of interested visitors with insights into everyday laboratory life. The SNI also collates information in the form of videos, brochures, press releases and an online magazine. News on research findings, events and awards is shared via various social media channels, thereby reaching different target groups.

The nanosciences program in Basel: A challenging course in a familiar environment

The nanosciences program at the University of Basel boasts a high degree of interdisciplinarity as well as excellent supervision and a strong team spirit amongst students.

Across Switzerland, Basel is the only university to offer a bachelor's and master's degree program in nanosciences. As part of the bachelor's program, students receive a broad grounding in biology, chemistry, physics and mathematics as well as an insight into the scientific work of various research groups and industrial companies. Students on the master's program choose two subjects from the available specializations — chemistry, medical nanosciences, molecular biology and physics — in which they then complete two projects and a master's thesis.

At the end of 2022, there were 59 students enrolled on the bachelor's program and 25 on the master's program. Four students successfully completed the bachelor's program, and eight completed their studies with a master's degree.

Nanoscience students at the University of Basel support one another. (Image: F. Moritz)

Excellent master's theses
Awards for two young students

In 2022, Vera Weibel and Mathias Claus were awarded a prize for the best master's thesis in nanosciences from the University of Basel.

In her prizewinning thesis, which she wrote at EPFL, Vera Weibel studied a superconducting material that does not occur in nature and that features highly unusual properties.

For his master's thesis at the Department of Physics of the University of Basel, Mathias Claus developed a torsion rocker that can be used to study the magnetization of tiny magnets in precise detail.

Report about Vera Weibel: http://bit.ly/3RRsL1r
Report about Mathias Claus: http://bit.ly/3S1mlwU
Video: https://youtu.be/DyoPupfgaMs

Vera Weibel

"What particularly impressed me about Vera Weibel's work was the amazing agreement between the theoretical predictions and the experiment."
Professor Christian Schönenberger, Department of Physics, University of Basel

Mathias Claus

"Mathias initially began working on an idea for the ideal magnetic torque sensor at the nanoscale. Over the course of his project, he developed a state-of-the-art fabrication process and, after testing the sensor, showed that it actually outperforms some of the previously used sensors."
Professor Martino Poggio Department of Physics, University of Basel

Gaining experience
Studying abroad expands your horizons

During their master's studies, numerous students on the nanoscience program gain experience abroad and apply for financial aid in the form of Argovia Travel Grants. Due to the coronavirus pandemic, however, many students were unable to go ahead with their plans to study abroad.

In 2022, a degree of normality returned, allowing students to complete their master's theses at international universities and receive financial aid through the Argovia Travel Grant program.

Milan Liepelt wrote his master's thesis in the field of quantum biology at the University of California, Los Angeles (USA). Philippe van der Stappen went to Monash University in Melbourne (Australia) to study regions of the cell that are responsible for cellular movement. As part of her master's thesis at the University of California, San Francisco (USA), Tamara Utzinger is studying immune cells that can cross the blood-brain barrier and trigger inflammation in the event of neurodegenerative diseases in the brain. Lastly, through his research at Harvard University (USA), Nicolai Jung contributed to the development of vaccines against malaria parasites.

Mobility nanoscience program: http://bit.ly/3Jss64m
Report about Nicolai Jung: http://bit.ly/3IuCiQ2

"I would recommend that all students do the same and spend some time abroad. It might involve some extra work at first, but it's definitely worthwhile!"
Nicolai Jung
former nanoscience student and now research assistent at the Walter and Eliza Hall Institute of Medical Research in Melbourne (Australia)

A solid grounding
Claudia Lotter received Swiss Nanotechnology PhD Award

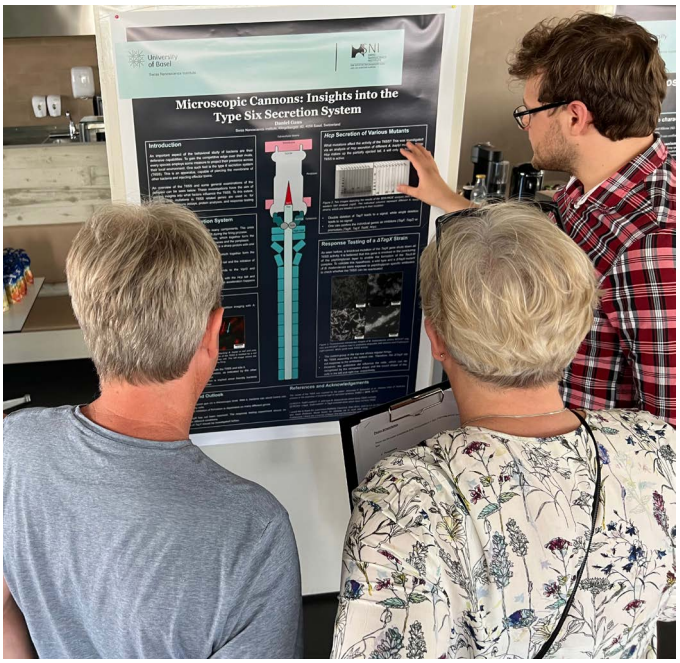
As part of her master's thesis at Basel University's Department of Pharmaceutical Sciences, former nanoscience student Claudia Lotter investigated how lipid nanoparticles developed for gene therapy can be optimized by varying the lipid composition.

She completed this work in the first year of her doctoral dissertation and published the results in the *European Journal of Pharmaceutics and Biopharmaceutics*. In recognition of this publication, Claudia was awarded a Swiss Nanotechnology PhD Award sponsored by the Hightech Zentrum Aargau at the Swiss NanoConvention in summer 2022.

Report: http://bit.ly/3HSdh8V

At the Swiss NanoConvention 2022, Claudia Lotter was presented with a Swiss Nanotechnology PhD Award by Marcus Morstein (Hightech Zentrum Aargau). (Image: T. Byrne)

The master's degree ceremony is the grand finale of the nanosciences degree program. (Image: K. Schad)



Talking to researchers from the SNI network, Daniel Gaus explains his experiments in relation to a bacterial nanoharpoon, which he carried out as part of a block course at the Biozentrum.

Working at a high level

Annual conference to present results from the block courses

In the fifth and sixth semesters of the bachelor's program, nanoscience students complete eight block courses. As part of these highly popular internships, the students work on their own small projects in various research groups. Here, they learn about scientific work based on current research and make new contacts. The courses are an ideal opportunity for them to explore their interests in greater depth so that they can then choose two specializations for the master's program.

Results from the block courses are presented by the students at a conference known as SmallTalk, which is organized by the students themselves. Here, each student gives a talk and presents another topic in the form of a poster for an interdisciplinary audience comprising researchers from the University of Basel.

SNI PhD School: Experts with interdisciplinary training

Doctoral students at the SNI PhD School carry out their work at various departments of the University of Basel, the Paul Scherrer Institute, the University of Applied Sciences Northwestern Switzerland or the Department of Biosystems Science and Engineering of ETH Zurich in Basel. In their various working groups, they research current problems in the nanosciences and are trained as specialists in a wide range of fields.

As these doctoral students also attend joint SNI events, they benefit from regular interaction with researchers from other disciplines and gain a broad overview of numerous current research projects in the nanosciences and nanotechnology.

Moreover, in courses developed specially for the SNI PhD School, the young scientists learn to present their work professionally and familiarize themselves with the initial steps involved in founding a startup.

At the end of 2022, there were 40 doctoral students enrolled in the SNI PhD School of whom 25% percent are women. Seven doctoral students have successfully completed their dissertations and seven new dissertation projects are set to begin in 2023.

Of the 48 SNI doctoral students who have completed their dissertations so far, 69% are employed in industry, while 31% continue to pursue an academic career.

Mehdi Heydari conducted research for his doctoral thesis at the Paul Scherrer Institute.

During his doctorate, Thomas Mortelmans worked at the Paul Scherrer Institute. He is now employed as a StepIn Trainee at the healthcare organization Johnson & Johnson.

Alexina Ollier wrote her doctoral thesis at the Department of Physics at the University of Basel. She is currently working there as a postdoc until she will start a postdoc position in South Korea at the Center for Quantum Nanoscience.

Magnetic properties of metal organic networks

For his doctoral thesis, Dr. Mehdi Heydari synthesized and subsequently characterized various metal organic networks with rare and exotic physical properties on surfaces.

Metal organic networks are porous sheets that are built up by connecting organic molecules via inorganic atoms. The self-assembly and structure of these networks are determined by the choice of linker atoms and their coordination chemistry – in conjunction with the reactive ends or functional groups of the molecules. In addition to the structure, the choice of components also has a decisive impact on the magnetic and electrical properties.

After synthesizing several of these metal organic networks, Mehdi Heydari showed that the magnetism typically observed in such networks is annihilated in those with triangular connectivity in a phenomenon referred to as "frustration" of a physical system. Frustrated metal organic networks serve as interesting models for the complex behavior of systems exhibiting statistical fluctuation, such as spin glasses. Coordination chemistry offers a unique opportunity to design novel low-dimensional materials with a view to technological developments in spintronics and quantum information technology.

New test system for rapid antibody tests

For his doctoral thesis, Dr. Thomas Mortelmans developed a novel test principle for rapid antibody tests. He used the new system to detect antibodies against SARS-CoV-2 and influenza A viruses in blood samples.

Unlike other rapid tests, which detect specific virus components, the test developed by Thomas Mortelmans reacts to antibodies formed by patients against the virus. The test involves mixing a blood sample with nanoparticles that bind to specific structures on the antibody surface. Other additives in the form of fluorescent particles bind specifically to the patients' antibodies. The blood sample prepared in this way is then dripped onto a Plexiglas chip into which nanochannels have been etched in a sophisticated pattern. During their passage through the nanochannels, which takes place without technical aids, the antibody-nanoparticle aggregates become trapped at particularly narrow sites that correspond to the size of the nanoparticles. Thanks to the fluorescent appendages, this can be observed under the microscope.

The system can be adapted to antibodies against all kinds of viruses and provides not only sensitive detection of an infection, but also information about the immune system's response based on different signal strengths.

Publication: https://bit.ly/40hHmH9
Video: https://youtu.be/7VKskNZCoMc

Tracking energy losses with a pendulum

For her doctoral thesis, Dr. Alexina Ollier investigated energy losses and quantum effects in two-dimensional materials. To do this, she worked with a special atomic force microscope (AFM) whose cantilever acts as a tiny pendulum that swings back and forth and can indirectly measure energy losses during current flow.

Alexina studied single-layer graphene as well as molybdenum disulfide and graphene bilayers, which have special electrical properties when one layer is twisted at a magic angle relative to the other. She was able to show that the three different 2D materials differ greatly in terms of energy loss and their quantum mechanical effects.

The free-floating single-layer graphene behaved similarly to quantum dots. In the twisted graphene bilayer, Alexina observed oscillations in the energy losses as a function of the external magnetic field – probably as a result of quantum mechanical interference effects. In an atomic layer of molybdenum disulfide, she detected a phase transition between ferromagnetism and paramagnetism.

Video: https://youtu.be/gzIXDVMMDd0
Report in SNI INSight: http://bit.ly/3Iv3Tk7

Mehdi Ramezani is now employed as an Application Scientist at Chemspeed Technologies.

Lukas Sponfeldner is currently working as a postdoc at the Department of Physics at the University of Basel.

Shubham Singh wrote his doctoral thesis at the Biozentrum of the University of Basel. He is now doing research at the Karolinska Institute in Sweden.

Superconducting contacts

For his doctoral thesis, Dr. Mehdi Ramezani developed a novel method for equipping a two-dimensional layer of the semiconductor molybdenum disulfide with superconducting electrical contacts for the first time.

For future applications in electronics, researchers are studying semiconductors made of single atomic layers. They can stack such monolayers in order to develop new materials with special properties. In part, these are based on complex quantum mechanical phenomena that can be put to use in quantum technology. The method developed by Mehdi Ramezani is very helpful when it comes to better studying these phenomena.

It was important to protect the sensitive atomic semiconductor layer because impurities and defects strongly affect the transport of electric charge. In his research approach, Mehdi Ramezani therefore encapsulated this layer in thin layers of insulating boron nitride. Beforehand, however, he embedded the vertical superconducting contacts into this protective layer. In principle, these newly developed vertical contacts to the semiconductor layers could be applied to a variety of different semiconductors.

Publication: https://bit.ly/3WNxW3e
Media release: http://bit.ly/3RRk3Ak
Video: https://youtu.be/CsjOtEsh7qA

A combination of good properties

For his doctoral thesis, Dr. Lukas Sponfeldner manipulated and studied the optical and electronic properties of two-dimensional semiconductors. For part of the thesis, he coupled different types of electron-hole pairs in the van der Waals material molybdenum disulfide.

In the two-dimensional material, electrons leave their place in the "valence band" due to excitation with light and enter the "conduction band". This creates a positively charged hole, which forms an electron-hole pair together with the negatively charged electron. In two-layer molybdenum disulfide, two different types of electron-hole pairs can form following excitation with light – depending on whether the hole and electron are in the same layer or adjacent layers.

Lukas Sponfeldner has now carried out experiments in which he coupled these two types of electron-hole pairs, combining the beneficial properties of both types. Depending on the purpose, he was therefore able to create fused particles that were not only very bright but also interacted strongly with each other. This method could also allow researchers to produce a novel source of single photons, which play an important role in quantum communication. In addition, the investigation and modelling of coupling are important in order to improve our understanding of fundamental semiconductor physics.

Publication: https://bit.ly/3HkYrre
Media release: http://bit.ly/3HWTd5b
Video: https://youtu.be/Sq_KVBM_Wzl

Unnatural amino acids for protein screening

In his doctoral thesis, Dr. Shubham Singh developed and tested a screening toolset for incorporating unnatural amino acids at specific sites in proteins. Fluorescent dyes or other biophysical probes can covalently bind to these amino acids, allowing the detailed examination of proteins.

Proteins are biological nanomachines that are fundamental to the survival of an organism. Understanding how they work is therefore of great interest for combating diseases or for protein engineering, for example. To study proteins in detail, researchers transfer the "blueprint" of the proteins (genes) into mammalian cells and then let them produce the proteins. When this transferred genetic material is modified in a particular way and the genetic code is expanded for the mammalian cells, the ensuing protein biosynthesis results in a protein that contains unnatural amino acids at the target sites.

Shubham Singh has now developed a cell-based assay to determine the incorporation efficiency of the unnatural amino acids via a high-throughput screening approach. He has also developed and tested a systematic strategy for the simultaneous incorporation of different unnatural amino acids into proteins produced by mammalian cells, thereby providing a tool for studying protein dynamics.

Jann Ungerer is currently a postdoc at the Department of Physics at the University of Basel.

"I would recommend the SNI PhD School to anyone who's interested in interdisciplinary science. Personally, I'd choose the SNI PhD School in Basel again every time."
Dr. Thomas Mortelmans, former SNI doctoral student and now a StepIN Trainee at Johnson & Johnson

"Because everyone got along so well, the courses as part of the SNI PhD School were also an opportunity to give each other open and honest feedback, which I found very helpful. As a result, I'm now able to present my work with certainty and self-confidence."
Dr. Alexina Ollier, former SNI doctoral student and now a postdoc

Coupling of a light quantum and a spin qubit

For his PhD thesis, Dr. Jann Ungerer has coupled a single light particle (photon) with a spin qubit, the smallest information unit of a future quantum computer. With his work, he contributes to the realization of a spin-based quantum computer by demonstrating the possibility of using photons to couple clusters of spin qubits.

Jann Ungerer has used single light particles with a wavelength in the microwave range for this purpose. Normally, there is little interaction of photons with the intrinsic angular momentum (spin) of an electron. However, if the researchers use a special superconducting resonator that stores single photons, the interaction between photon and spin is enhanced. In this way, Jann Ungerer has succeeded in coupling a single light particle with an electron spin in a double quantum dot.

Quantum dots are tiny structures in which the charge carriers are restricted in their mobility, allowing single electrons to be captured and manipulated. In his work, Jann Ungerer used a nanowire made of the semiconductor material indium arsenide, in which two different crystal structures give rise to a double quantum dot and make the coupling between photon and spin possible.

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

At the SNI Annual Event, the doctoral students present their work to the SNI network. Josh Zuber won the prize for the best presentation, and Ajmal Roshan won a prize for his poster.

Excellent
Prizes for outstanding SNI doctoral students

Swiss Nanotechnology PhD Award

Dr. Thomas Mortelmans, a former doctoral student at the SNI PhD School, was presented with one of five PhD Awards at the Swiss NanoConvention 2022.

Mortelmans received the award, which was sponsored by Sensirion, in recognition of a first-author publication in the journal *ACS Applied Nanomaterials* in which he described the development of a novel functional principle for rapid Covid-19 tests. The principle can also be used to determine the status of the disease or to detect other viruses, such as influenza A.

Report: http://bit.ly/3YMgmy8
Video about publication: https://youtu.be/7VKskNZCoMc
Video about the SNI PhD School: https://youtu.be/9dqX_vimmcY

SPS Award

In 2022, the Swiss Physical Society (SPS) presented the SPS Award related to Metrology, which was sponsored by METAS, to the former SNI doctoral student Dr. Thomas Karg.

Karg and his colleagues observed strong coupling between a nanomechanical oscillator and an atomic spin ensemble for the first time. They did so by adopting an innovative approach that used light to couple the two systems over a macroscopic distance. Published in the journal *Science*, these results pave the way for new applications ranging from quantum metrology and networking to quantum feedback experiments and coherent links between quantum processors.

Report: http://bit.ly/3xlznvD

Young Researcher Award

Former SNI doctoral student Dr. Alexina Ollier was presented with a Young Researcher Award at the International Vacuum Congress 2022 in Sapporo (Japan). She received the award, which is sponsored by Canon Anelva Corporation, for her presentation on the electronic properties of single-layer free graphene sheets. As part of her SNI-supported doctoral dissertation, Alexina worked with atomically thin compounds of this kind and investigated energy losses in various two-dimensional materials.

Report: http://bit.ly/3lv3Tk7
Video: https://youtu.be/gzlXDVMMDd0

In 2022, former SNI doctoral student Thomas Mortelmans won one of the Swiss Nanotechnology PhD Awards.

Former SNI doctoral student Alexina Ollier received a Young Researcher Award.

Former SNI doctoral student Thomas Karg won an SPS Award.

SNI Winter School
Nanoscience in the Snow

The SNI Winter School "Nanoscience in the Snow" is always a highlight for SNI doctoral students and invited guest lecturers alike.

Participants in this annual event come from a wide range of disciplines and have the opportunity to gain new insights from leading scientists, to discuss their own projects in an informal setting and to spend a few hours together in the snow in different regions of the Swiss mountains.

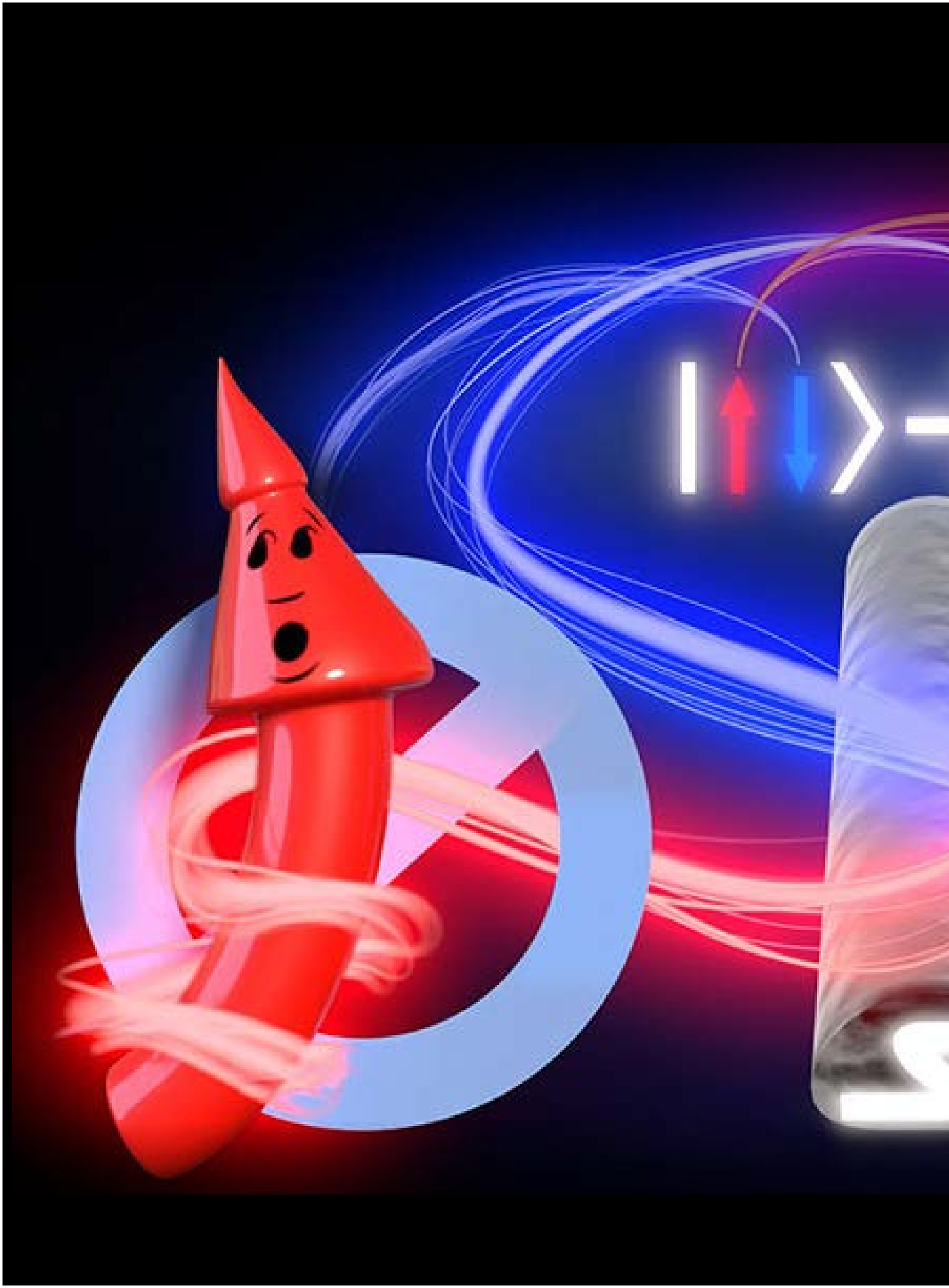
After a forced hiatus due to the coronavirus pandemic, "Nanoscience in the Snow" was held as a face-to-face event again in January 2022 – this time, in Zermatt. Despite the great weather and breathtaking scenery, the participants had no trouble concentrating on the many fascinating scientific talks or taking advantage of the opportunity for scientific exchange.

Report: http://bit.ly/3lxbwXd
Video: https://youtu.be/KfnFZbJneOc

"I was really impressed by the quality of all the talks. It really pays dividends that we not only provide our doctoral students with scientific training but also offer them courses on public speaking."
Dr. Andreas Baumgartner, coordinator of the SNI PhD School

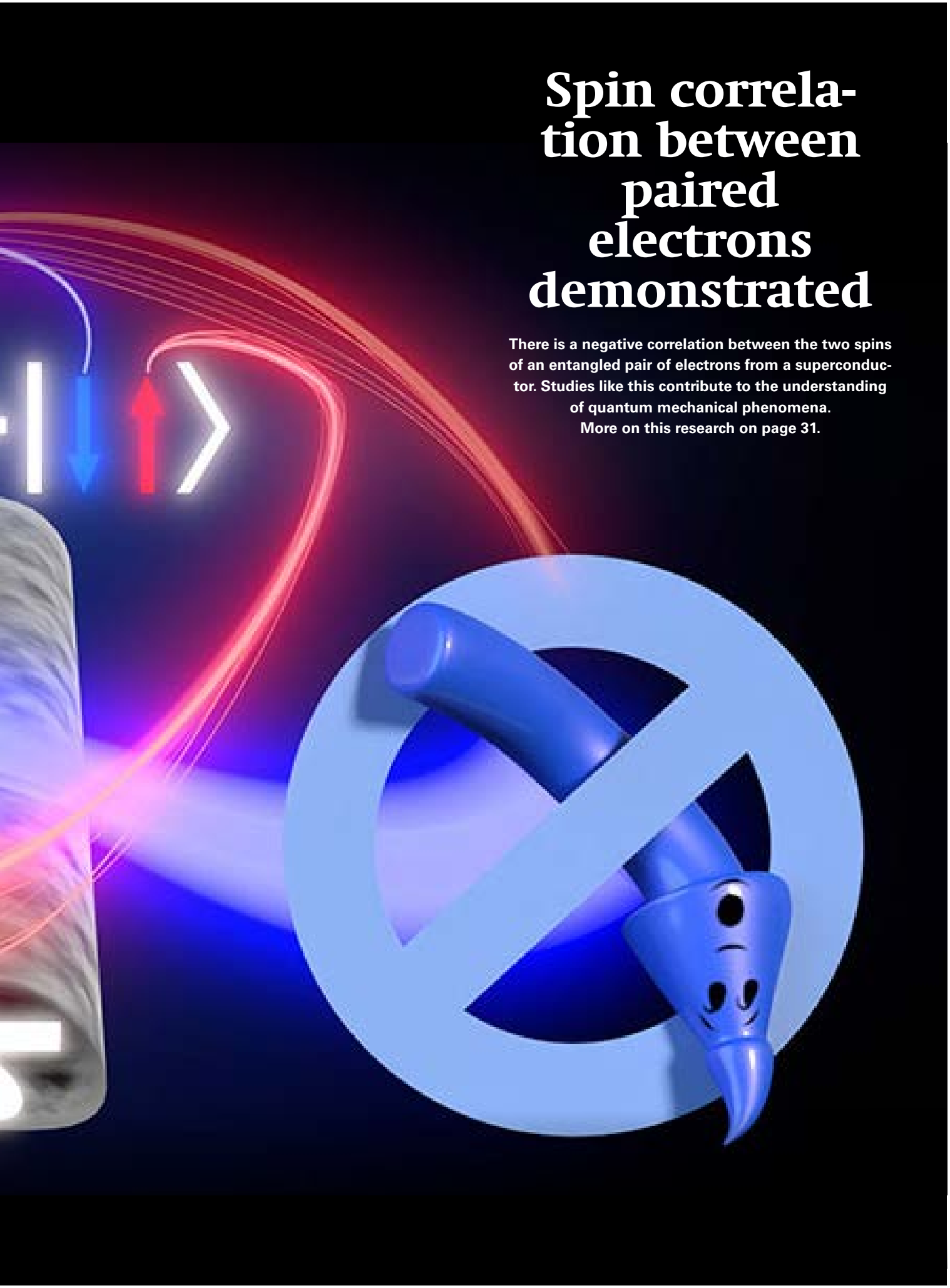
"Events such as the Winter School and the SNI Annual Event are real highlights and taught me a great deal about various subject areas. Today, these insights allow me to consider problems from various perspectives."
Dr. Thomas Mortelmans, former SNI doctoral student

At the SNI Winter School, doctoral students from the SNI and researchers from various disciplines engage in intensive scientific exchange. In 2022, "Nanoscience in the Snow" was held in Zermatt.



Spin correlation between paired electrons demonstrated

There is a negative correlation between the two spins of an entangled pair of electrons from a superconductor. Studies like this contribute to the understanding of quantum mechanical phenomena.
More on this research on page 31.



Research findings: The basis for various applications

Basic research has always played an important role at the SNI. Only when we understand the underlying principles is it possible to develop sensible applications.

Members of the SNI network carry out this kind of research in a wide range of areas. As part of their work, they investigate phenomena in the often difficult to understand world of quanta, develop new methods for the analysis and imaging of tiny nanostructures, analyze novel materials or attempt to understand how natural nanomachines operate.

In 2022, researchers from the SNI network published 44 publications in respected scientific journals. For the most part, these publications related to quantum mechanical or physical phenomena, as the SNI traditionally has many members with a background in physics. The following examples demonstrate, however, that the nanosciences also contribute to new insights and applications in other disciplines.

New rapid test could detect coronavirus and flu simultaneously

Researchers from the University of Basel and the Paul Scherrer Institute have developed a rapid test for Covid-19 with a novel functional principle. Although it requires further testing and improvements, the initial results are promising: As well as determining whether a Covid-19 infection is present, the test also promises to provide information on the status of the disease. It could also detect other diseases and different coronavirus variants.

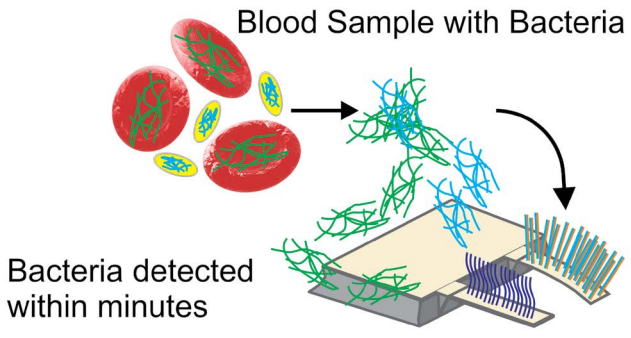
Media release: http://bit.ly/3YOrYRh
Video: https://youtu.be/7VKskNZCoMc

The former SNI PhD student Thomas Mortelmans developed a rapid test for infections with SARS-CoV-2 during his PhD thesis at the SNI PhD School. (Image: Paul Scherrer Institute/Mahir Dzambegovic)

Time-saving due to early diagnosis

Researchers from the SNI network have shown that nanomechanical sensors are ideally suited to quickly and reliably detect even a few bacteria in the blood. The interdisciplinary team describes in the scientific journal *Biosensors* how the method can be used to diagnose sepsis at an early stage – which allows more time for successful treatment.

Original publication: http://bit.ly/3Rjk2VF



A nanomechanical sensor can detect bacteria in a blood sample (Image: Department of Physics, University of Basel)

Better sample preparation with the cryoWriter

Researchers from the SNI network have presented an improved microfluidic technique for preparing samples for electron microscopy. The method allows them to avoid paper blotting, which results in a considerable loss of proteins. On the other hand, the researchers also optimize the conditions so that there is significantly less damage to the sample at the air-water interface.

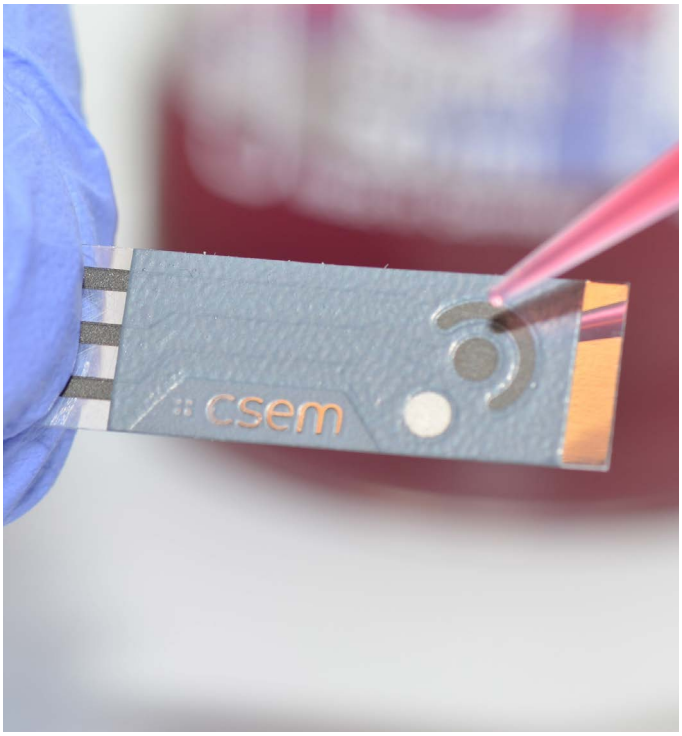
Original publication: https://bit.ly/3HlCnrQ

New approach in biosensor technology

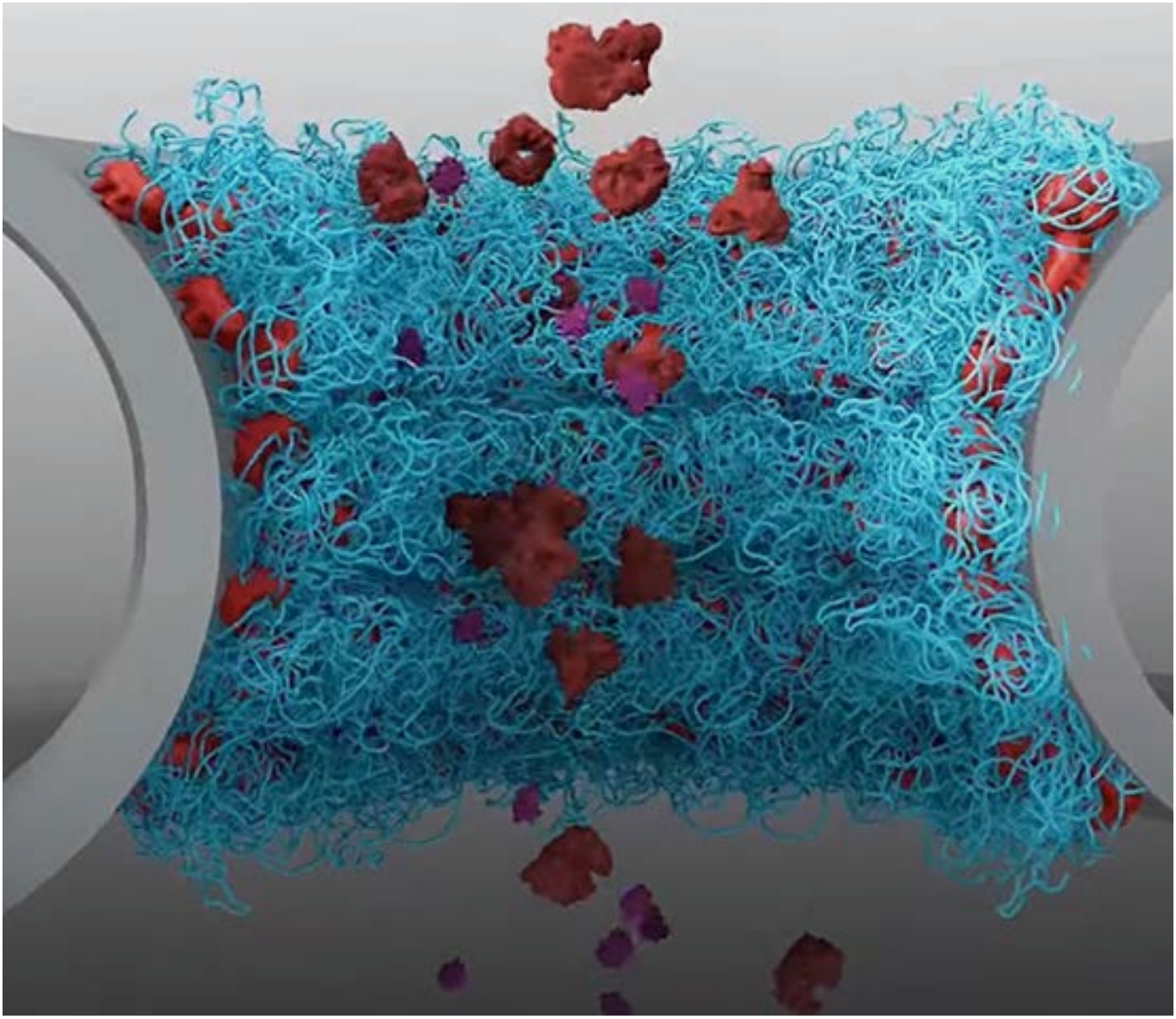
Researchers from the SNI network have developed a novel coating of a polymer and carbon nanotubes that is suitable for coating miniaturized electrodes. Such electrodes, in which conductive nanomaterials are embedded in an antifouling matrix, can be used in point-of-care diagnostics. The novel coating protects the electrodes from contamination – which is always a problem with complex samples such as blood serum. In a paper published in *ACS Applied Materials & Interfaces*, the researchers used a protein associated with inflammatory responses to show that they could produce the assay within a few hours and quantitatively detect the protein in undiluted blood serum in the nanogram range.

The Swiss Nanoscience Institute has funded this collaboration between researchers from CSEM, the FHNW School of Life Sciences and the company MOMM Diagnostics as part of its applied research program, Nano-Argovia.

Original publication: https://bit.ly/3HkESPA



A novel coating for miniaturized electrodes in point-of-care diagnostics prevents contamination — a problem when complex samples like blood serum are analyzed. (Image: CSEM Allschwil)



Safeguarding the cell nucleus

The nucleus is guarded by a highly secure door, the so-called nuclear pore, that controls the transport of substances from the cytoplasm to the cell nucleus and back. A research group of Argovia professor Roderick Lim of the University of Basel has now shown that different shuttle proteins occupy the nuclear pore to prevent unsolicited leakage of molecules. These proteins form an escape-proof, fail-safe mechanism by compensating for one another to fortify the pore.

Media release: http://bit.ly/4142QYL

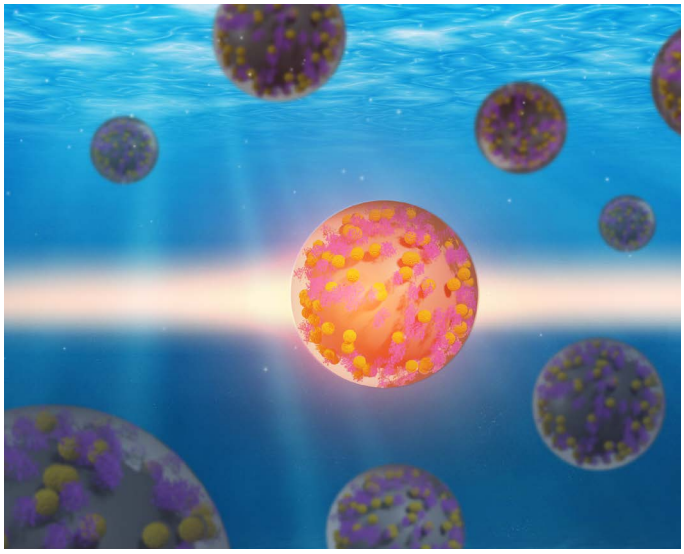
Illustration of the nuclear pore.
(Image: Biozentrum, University of Basel)

Nanoheating allows enzymes to operate at subzero temperatures

Researchers from the SNI network have developed a strategy to allow the activity of a natural biocatalyst to continue at temperatures down to -10°C.

To do so, a team from the SNI network from the FHNW School of Life Sciences immobilized enzymes isolated from an Antarctic yeast together with gold nanoparticles on the surface of particles of silica. When optically excited, the gold particles begin to radiate nanoscale heat. These tiny amounts of heat are sufficient for the neighboring enzymes, which are already adapted to cold temperatures in nature, to perform their catalytic work at temperatures down to -10°C. The system only works, however, if the embedded gold nanoparticles and enzymes are shielded from the environment by a nanometer-thin layer.

Original publication: http://bit.ly/3D0y7kN

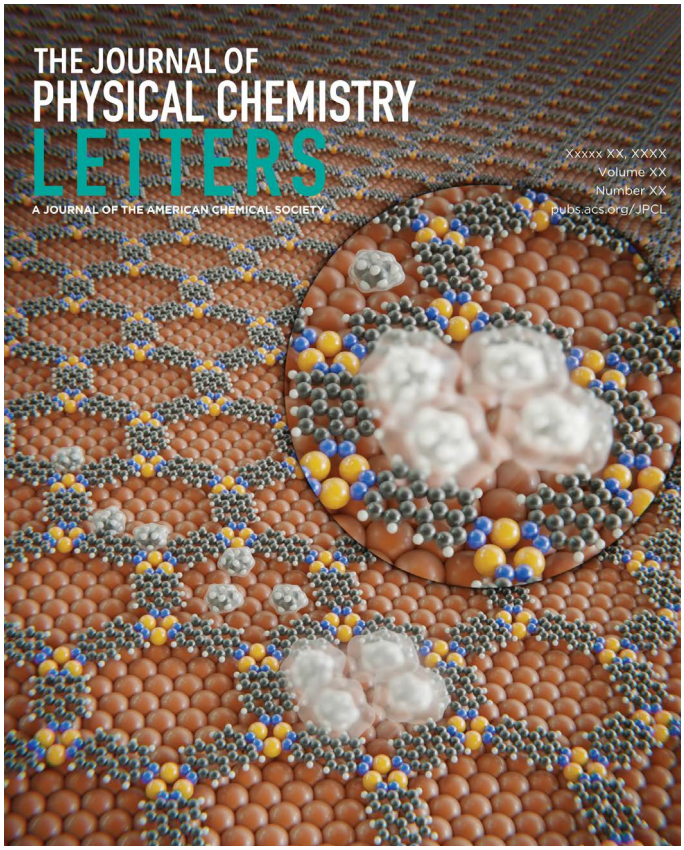


Nano-heating enables enzymes to work at sub-zero temperatures (Image: FHNW)

Dancing molecules

When cycloalkanes are enclosed in nanometer-sized pores, they adapt their shape – in a manner similar to the induced fit concept described in biochemistry. The molecules do not all behave the same way. With increasing lack of space and low temperatures below 5K, the molecules start to move in a surprising way. Researchers from the SNI network from the Department of Physics at the University of Basel and the Paul Scherrer Institute have demonstrated this using scanning tunneling microscopy images and published the results in the *Journal of Physical Chemistry Letters*.

Original publication: https://bit.ly/3kT76cS

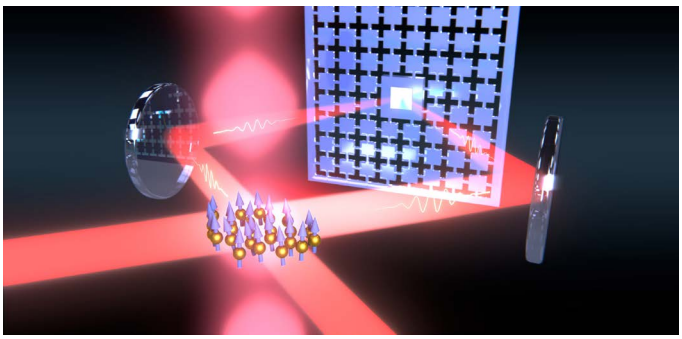


Cycloalkanes adapt their shape when trapped in tiny pores. (Image: Department of Physics, University of Basel)

Cooling matter from a distance

Researchers from the University of Basel have succeeded in forming a control loop consisting of two quantum systems separated by a distance of one meter. Within this loop, one quantum system – a vibrating membrane – is cooled by the other – a cloud of atoms, and the two systems are coupled to one another by laser light. Interfaces such as this allow different kinds of quantum systems to interact with one another even over relatively large distances and will play a key role in quantum technologies of the future.

Media release: http://bit.ly/3XwRmcV
Video: https://youtu.be/gWER3ToDqNo

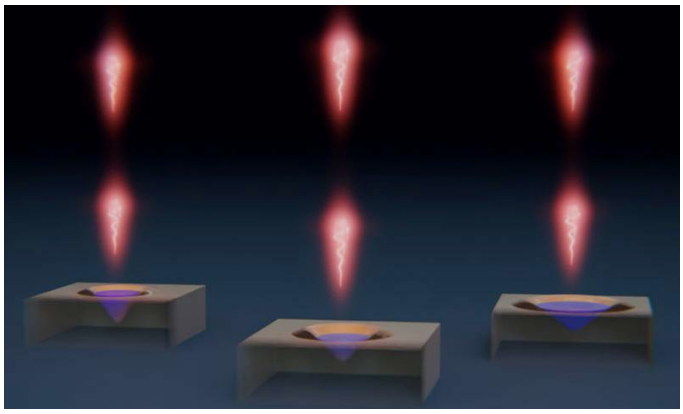


Light is used to couple a vibrating membrane to a cloud of atoms in order to form a control loop. The two different quantum systems — consisting of the membrane and the spins — therefore regulate one another's temperature with no need for external measurement. (Image: Department of Physics, University of Basel)

Twin photons from unequal sources

Identical light particles (photons) are important for many technologies that are based on quantum physics. A team of researchers from Basel and Bochum has now produced identical photons with different quantum dots – an important step towards applications such as tap-proof communications and the quantum internet.

Media release: http://bit.ly/3IyR9Jj
Video: https://youtu.be/VluqCm5PFAY

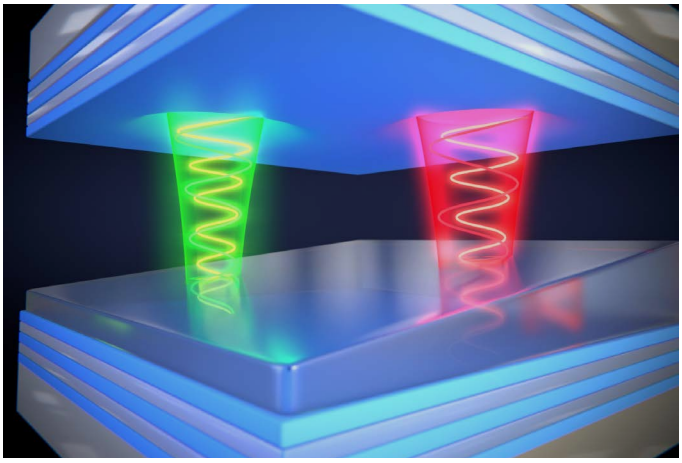


Although the quantum dots of the Basel researchers are different, they emit exactly identical light particles. (Image: Department of Physics, University of Basel)

Laser light of any wavelength

Researchers from the SNI network have developed a platform for the resonant enhancement of so-called nonlinear optical processes which could help to produce laser light of any wavelength. They combine a wedge-shaped diamond membrane with two narrowly spaced, highly reflective mirrors (a Fabry-Perot microcavity). In this way, the researchers can regulate the resonant frequencies of the microcavity, and thus the wavelengths involved in the nonlinear optical process, by tuning the distance between the mirrors and the thickness of the diamond membrane. In the scientific journal *Optica*, the team of scientists from Stanford, Calgary and Basel report that their approach could pave the way for a universal frequency shifter for laser light.

Media release: http://bit.ly/3Ih2ipR

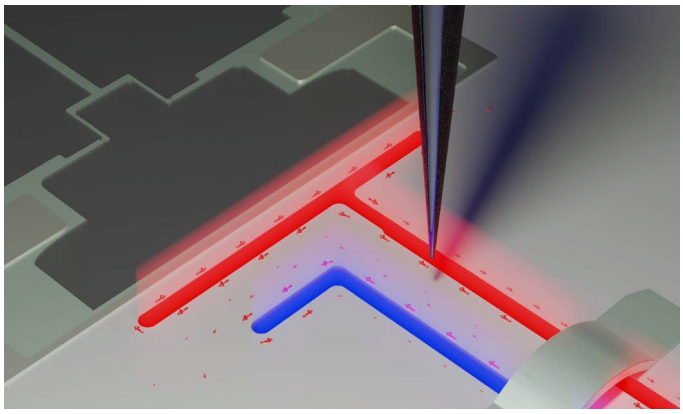


The platform with two closely spaced, highly reflective mirrors and a wedge-shaped diamond membrane paves the way for a universal, low-threshold frequency shifter for laser light. (Image: Flågan, Riedel and Scixel)

Quantum interference device images current flow in qubit circuits

Physicists from the SNI network at the University of Basel and the ETH Zurich have used a scanning superconducting quantum interference device (SQUID) to image the current flow of a superconducting device developed for quantum computing. The data will help to optimize qubit control. The article was published in *Applied Physics Letters*.

Original publication: https://bit.ly/3jevmFM

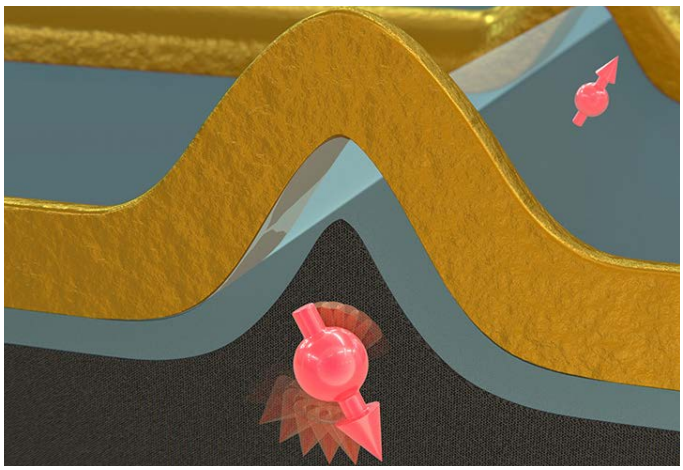


Map of the circuits magnetic field, showing the flow of current density within the device. (Image: Department of Physics, University of Basel)

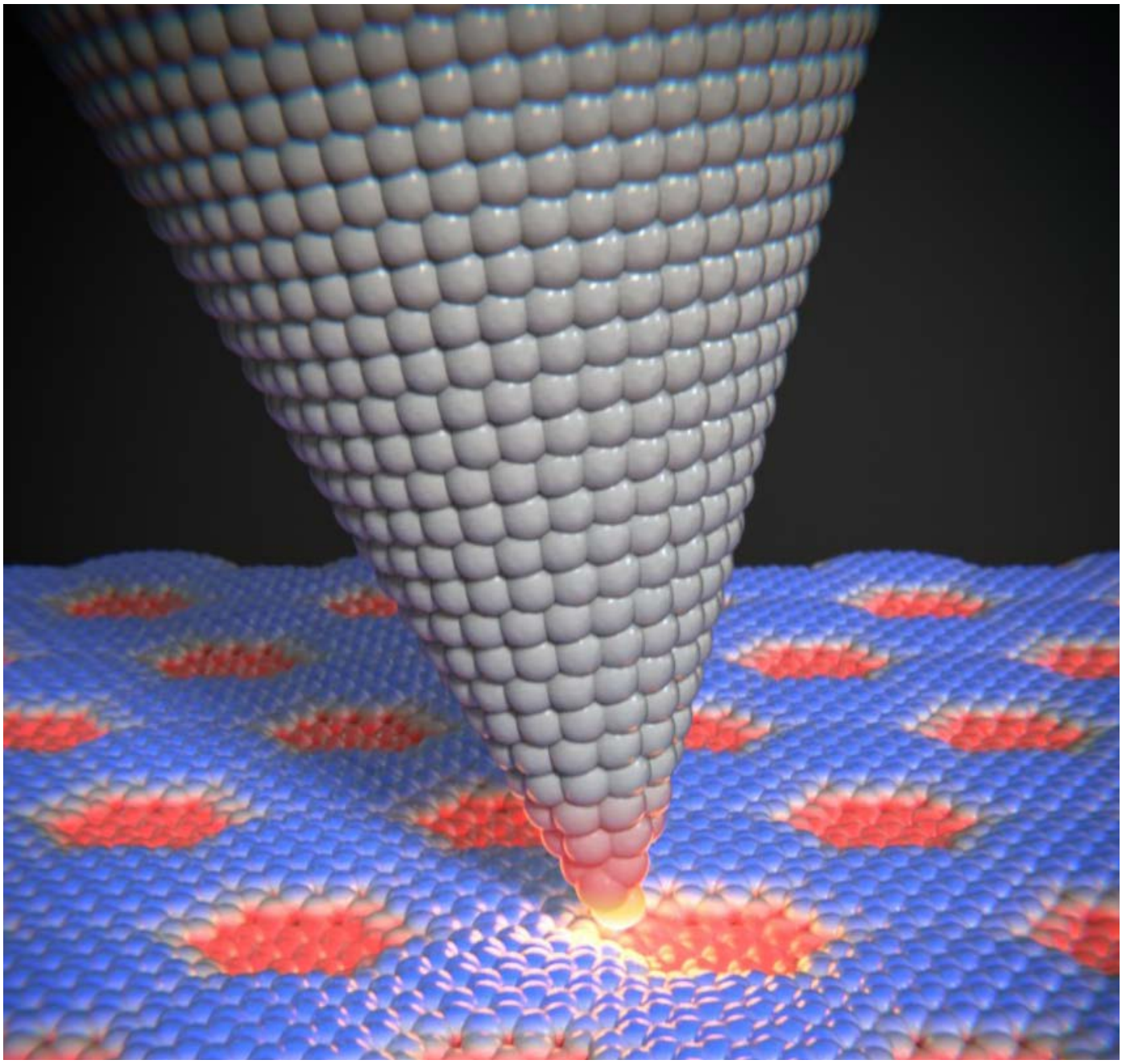
"Hot" spin quantum bits in silicon transistors

Quantum bits (qubits) are the smallest units of information in a quantum computer. Currently, one of the biggest challenges in developing this kind of powerful computer is scalability. A research group at the University of Basel, working with the IBM Research Laboratory in Rüschlikon, has made a breakthrough in this area.

Media release: http://bit.ly/3HZEQgt



The newly developed qubits are based on so-called holes (red) whose spin (arrow) in one or the other direction stores the information. They are arranged in an architecture based on silicon transistors. (Illustration: NCCR Spin)



Unexpected speed-dependent friction

In the macro world, friction doesn't depend on the speed at which two surfaces move past one another, but researchers from Basel and Tel Aviv have now observed precisely this effect in special graphene structures on a platinum surface.

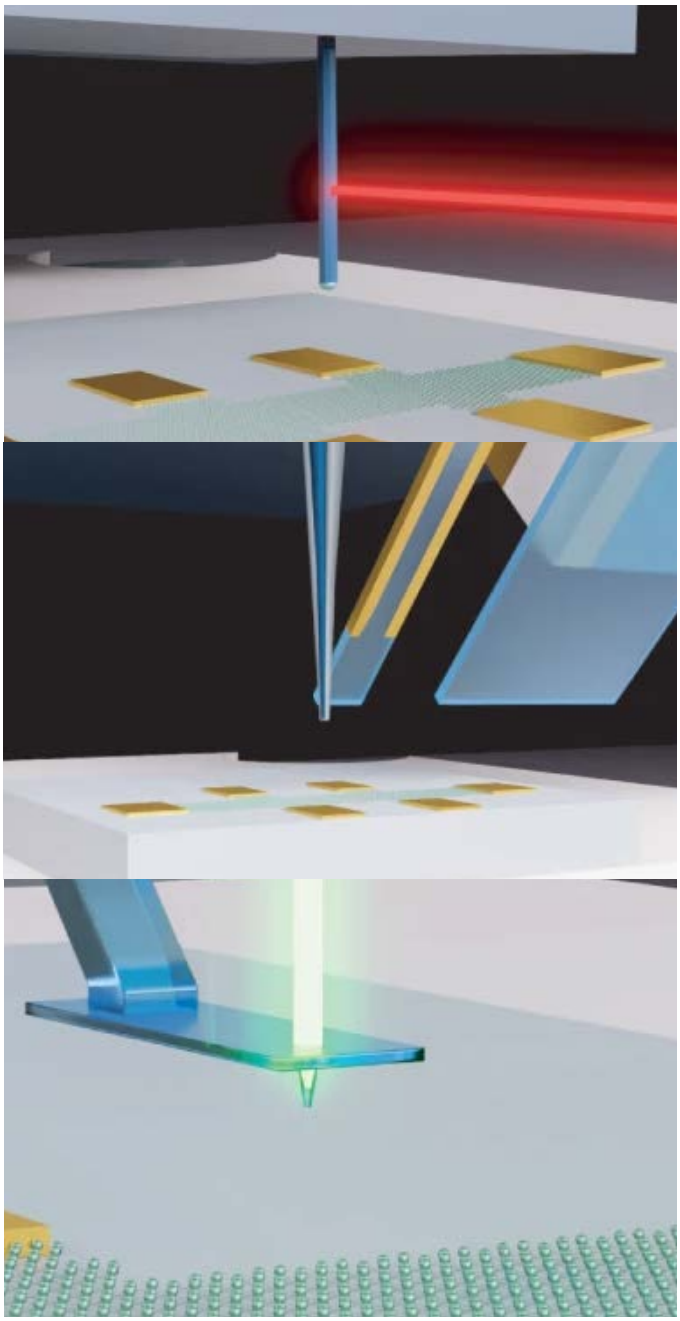
Media release: http://bit.ly/3Yz7495

Surprisingly, the friction between the tip of an atomic force microscope and the Moiré superstructures depends on the speed at which the tip is moved across the surface. (Image: Department of Physics, University of Basel and Scixel)

Methods for the investigation of two-dimensional materials

In a review article in the scientific journal *Nature Reviews Physics*, researchers led by Argovia professor Martino Poggio published an analysis of imaging methods for weak magnetic fields. The publication provides a technical overview of various methods suitable for studying 2D materials, offering opportunities to investigate phenomena such as superconductivity.

Original publication: https://bit.ly/3HMy2DX

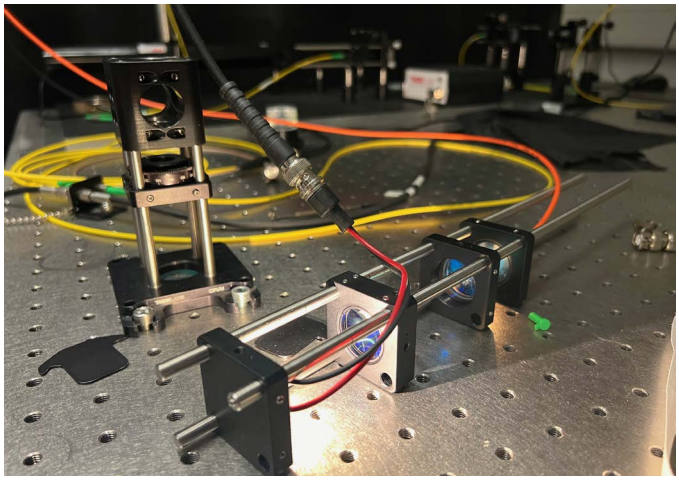


Researchers from the SNI network have compared different imaging methods for weak magnetic fields that enable nanometer-scale resolution. (Images: Department of Physics, University of Basel)

Coupling of electron-hole pairs

For the first time, physicists from the University of Basel have succeeded in coupling different types of electron-hole pairs (excitons) in the van der Waals material molybdenum disulfide. This successful coupling allows them to utilize and control the different properties of the two types of electron-hole pairs – and could pave the way for the production of a novel source of individual particles of light (photons). Moreover, the study and modeling of exciton-exciton coupling is key to gaining a better understanding of the underlying semiconductor physics. In collaboration with colleagues from the University of Toulouse, the researchers published their findings in the journal *Physical Review Letters*.

Media release: https://bit.ly/3HWTd5b
Video: https://youtu.be/Sq_KVBM_Wzl

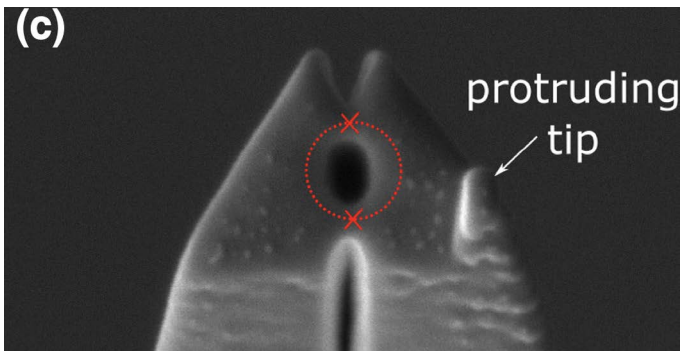


The work on the coupling of electron-hole pairs was part of a doctoral thesis at the SNI PhD School.

New probe for imaging magnetic fields

Argovia professor Martino Poggio's team has developed a new scanning probe for nanometer-scale superconducting quantum interference device (SQUID) microscopy based on a non-contact atomic force microscopy cantilever. The probe enables imaging of magnetic fields with nanometer spatial resolution. The publication in the scientific journal *Physical Review Applied* is a contribution to a FET Open project led by the Poggio team.

Original publication: https://bit.ly/3YwAZyj

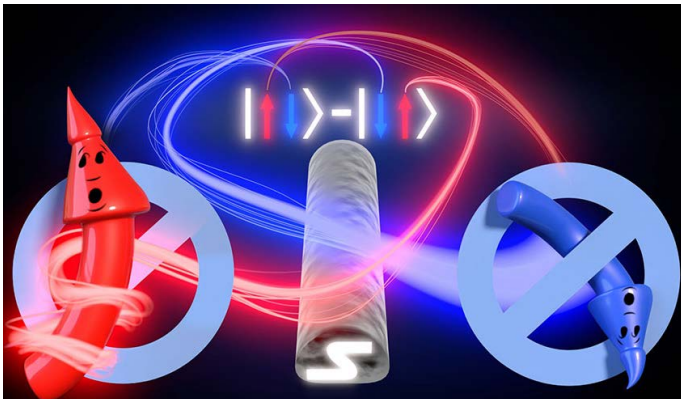


The new probe enables high-resolution imaging of weak magnetic fields. (Image: Department of Physics, University of Basel)

Spin correlation between paired electrons demonstrated

Physicists at the University of Basel have experimentally demonstrated for the first time that there is a negative correlation between the two spins of an entangled pair of electrons from a superconductor. For their study, the researchers used spin filters made of nanomagnets and quantum dots, as they report in the scientific journal *Nature*.

Media release: http://bit.ly/3HXn8dn

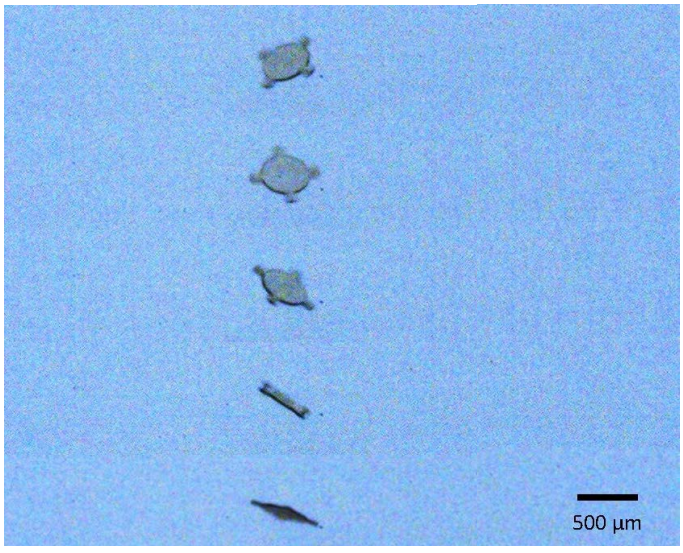


Electrons leave a superconductor only as pairs with opposite spins. If both electron paths are blocked for the same type of spin by parallel spin filters, paired electrons from the superconductor are blocked and the currents decrease. (Image: Department of Physics, University of Basel and Scixel)

Floating thanks to sound waves

Researchers from the SNI network are investigating methods to keep particles in the air using sound waves (acoustic levitation) – for example, for crystallographic studies of proteins. In a paper in *Applied Physics Letters*, they investigate ultrasonic rotors as sample holders. They show the influence of the size and shape of the rotors, which help to achieve controlled rotation of the samples held acoustically in suspension. The shape and size of a rotor affect how the rotor is levitated and rotates with the help of ultrasonic waves.

Original publication: https://bit.ly/3HiP2QW

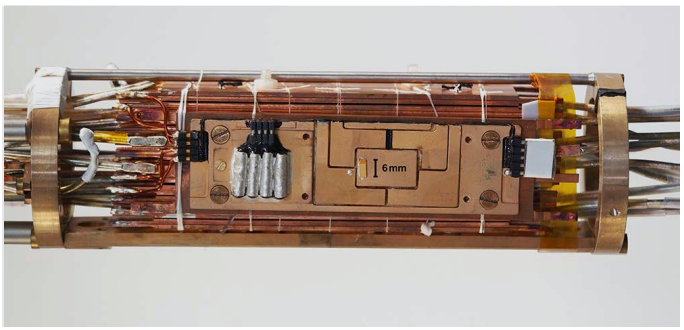


Tiny rotors can be kept in suspension by acoustic waves. (Image: S. Jia, Biozentrum, University of Basel)

Ultracold circuits

Cooling materials to extremely low temperatures is important for basic physics research as well as for technological applications. By improving a special refrigerator and a low-temperature thermometer, Basel scientists have now managed to cool an electric circuit on a chip down to 220 microkelvin – close to absolute zero.

Media release: http://bit.ly/3luYc5x

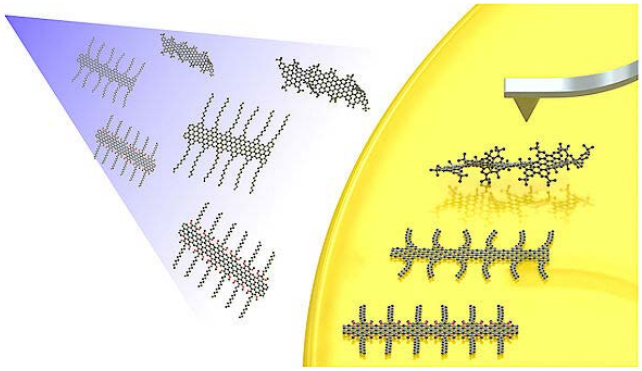


The cryostat used by the Basel physicists to reach a record temperature of 220 microkelvin. The special thermometer along with a scale bar can be seen in the centre of the image (golden rectangle). (Image: Department of Physics, University of Basel)

Electrospray method expands range of different graphene ribbons

Researchers from the SNI network have accessed various graphene nanoribbons using high-vacuum electrospray deposition. They succeeded in investigating longer graphene nanoribbons with properties that are difficult or impossible to achieve with surface synthesis. For example, various temperature-sensitive functional groups can be integrated in solution, or twisted graphene ribbons can be produced. The high-vacuum electrospray method also allows the deposition of graphene nanoribbons on substrates that were previously unavailable for on-surface synthesis.

Original publication: https://bit.ly/3jewl3k



With high-vacuum electrospray deposition, extended graphene nanoribbons with special properties can be accessed for high-resolution studies. (Image: S. Scherb, Department of Physics, University of Basel)


csem

New electrodes for complex samples

Researchers working on the Nano-Argovia project PEPS have developed a new type of coating for miniature electrodes in point-of-care laboratory diagnostics. The coating contains conductive nanomaterials and prevents contamination.

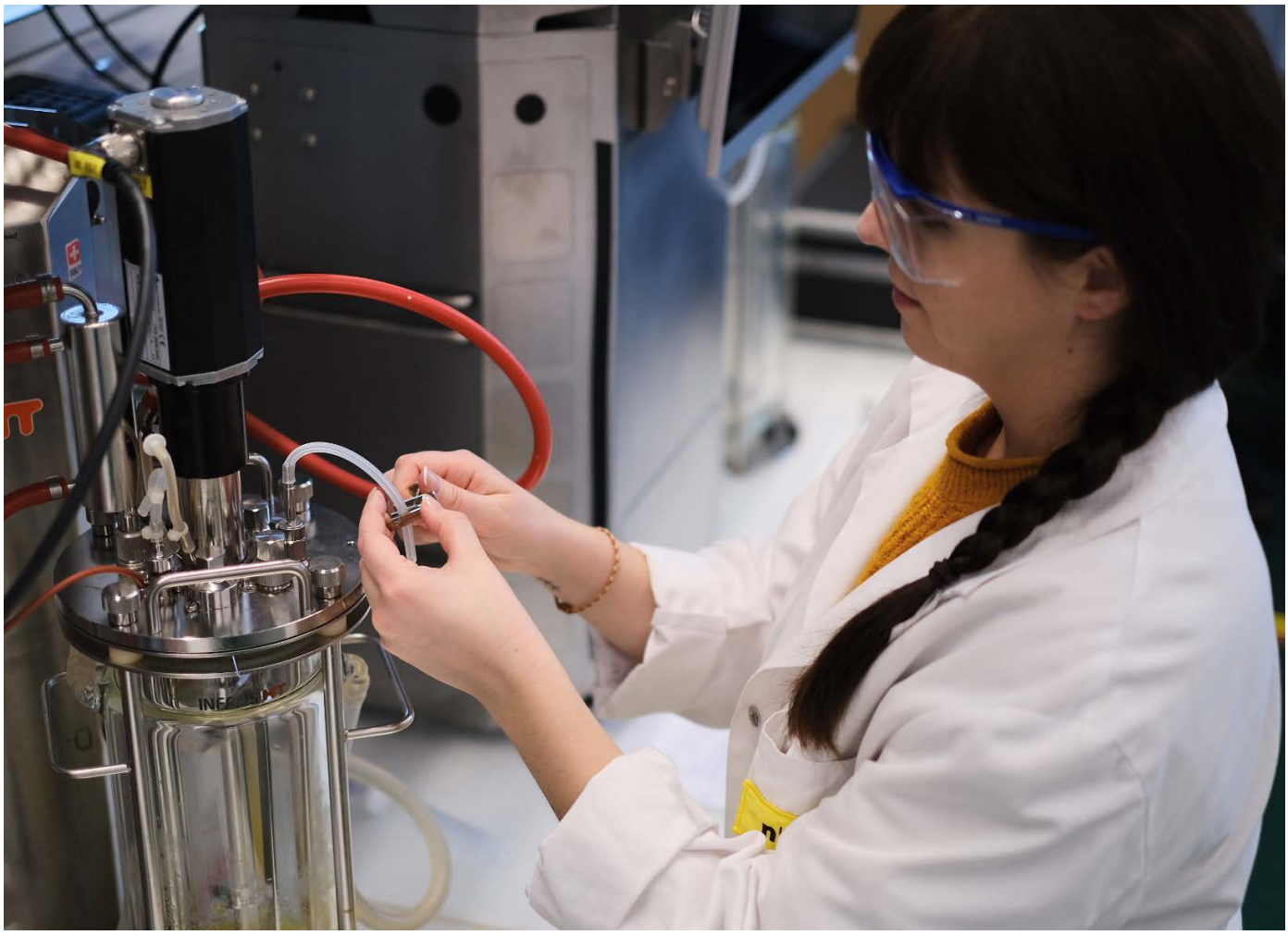
Working within the framework of the SNI's Nano-Argovia program, interdisciplinary teams of researchers investigate applied research topics in collaboration with at least one partner from industry. One of the participants in the Nano-Argovia project PEPS was MOMM Diagnostic — a startup founded by a former nanoscience student.
More information on page 40

Nano-Argovia program: Applied interdisciplinary projects in collaboration with companies from Northwestern Switzerland

Since the SNI was founded, it has promoted technology and knowledge transfer as part of the Nano-Argovia program. In 2022, the SNI supported a total of 12 applied research projects in collaboration with industrial companies from Northwestern Switzerland.

A wide range of topics were addressed, with some projects investigating medical or diagnostic applications and others focusing on improved methods for analyzing or processing various materials.

Half of the partner companies in 2022 came from the Canton of Aargau, and the other half came from one of the two Basel half cantons. Partners included not only young startups but also established companies from the region. In 2022, the ANAXAM technology transfer center, of which the SNI is a founding member, also took part in one project as part of the Nano-Argovia program.



The nanobodies are produced in a bioreactor at the FHNW School of Life Sciences and then combined with a polymer. (Image: O. Germershaus, FHNW)

Innovative combination to combat cancer

In the Nano-Argovia project B7H3 Nanobody PC, researchers are developing a novel nanobody-polymer conjugate to image and treat malignant tumors. It is a combination of a cell-specific nanobody, which acts very similarly to antibodies but is much smaller and which binds specifically to certain cancer cells, and a polymer that can be loaded with different compounds. The nanobody-polymer conjugate will be designed to cross the blood-brain barrier and then bind to the specific target molecule on the surface of cells of malignant brain tumors. Depending on the active substance that is bound to the nanobody-polymer conjugate, cancer cells in the brain may be combated or imaged.

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

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

"We are optimistic that our modularly applicable technology with its high degree of flexibility is also suitable for diagnosing and treating cancers that require a crossing of the blood-brain barrier."
Dr. Christian Geraths, CSO at CIS Pharma AG

Foldable and rollable

In the Nano-Argovia project META-DISPLAYS, researchers were developing a component for foldable and rollable screens that specifically alters and controls the propagation of light. This so-called metasurface phase retarder has tiny structures on its surface that can effectively control the phases of the electromagnetic field emitted by the light source. The phase retarder must also be color-neutral, allow light to pass through it easily and reduce back reflection. The team has now identified a combination that achieves high transmission and color neutrality, and reduces the thickness of the phase retarder, making it suitable for foldable and rollable screens.

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

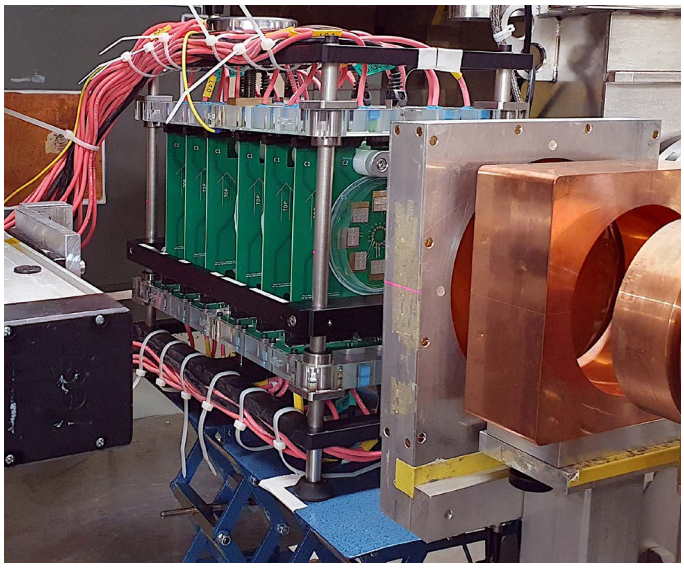
Project description: http://bit.ly/3Xw9YtE

Influence of cosmic radiation

In the Nano-Argovia project CRONOS, an interdisciplinary team of scientists has been investigating the effect of cosmic radiation on power semiconductors designed for high electrical currents and voltages. The team irradiated the power semiconductors with protons in a controlled manner while simultaneously applying an electrical voltage. Electrical and thermal stress tests of the gate oxide layers provided information on how physical processes can lead to failures and support the development of more robust power semiconductors.

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

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



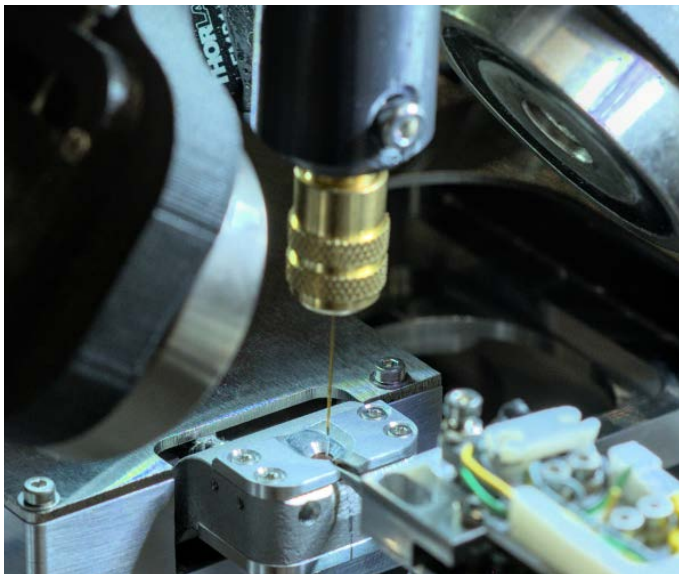
In the Nano-Argovia project CRONOS, researchers are investigating the effect of cosmic radiation on power semiconductors. (Image: FHNW)

Functional test before shock freezing

In the Nano-Argovia project FuncEM, researchers have been developing an extension to the cryoWrite system. This system can be used to flash-freeze tiny quantities of samples – with no loss of material – before they are examined using cryo-electron microscopy. The extension module enables imaging of the "living" samples using fluorescence and dark-field light microscopy immediately before the freezing process. The interdisciplinary team initially focused on the investigation of thin cilia, which also play a crucial role in numerous diseases. The upstream light microscopic examination provides relevant information about the functionality of the cilia examined.

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

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



In the Nano-Argovia project FuncEM, researchers are developing a supplementary module for the cryoWrite system. (Image: Biozentrum, University of Basel)

"For us, the Nano-Argovia project CRONOS is an ideal opportunity to collaborate with experts in the field of power semiconductors and materials analysis and to benefit from their know-how."
Dr. Arnost Kopta, CTO SwissSEM Technologies AG

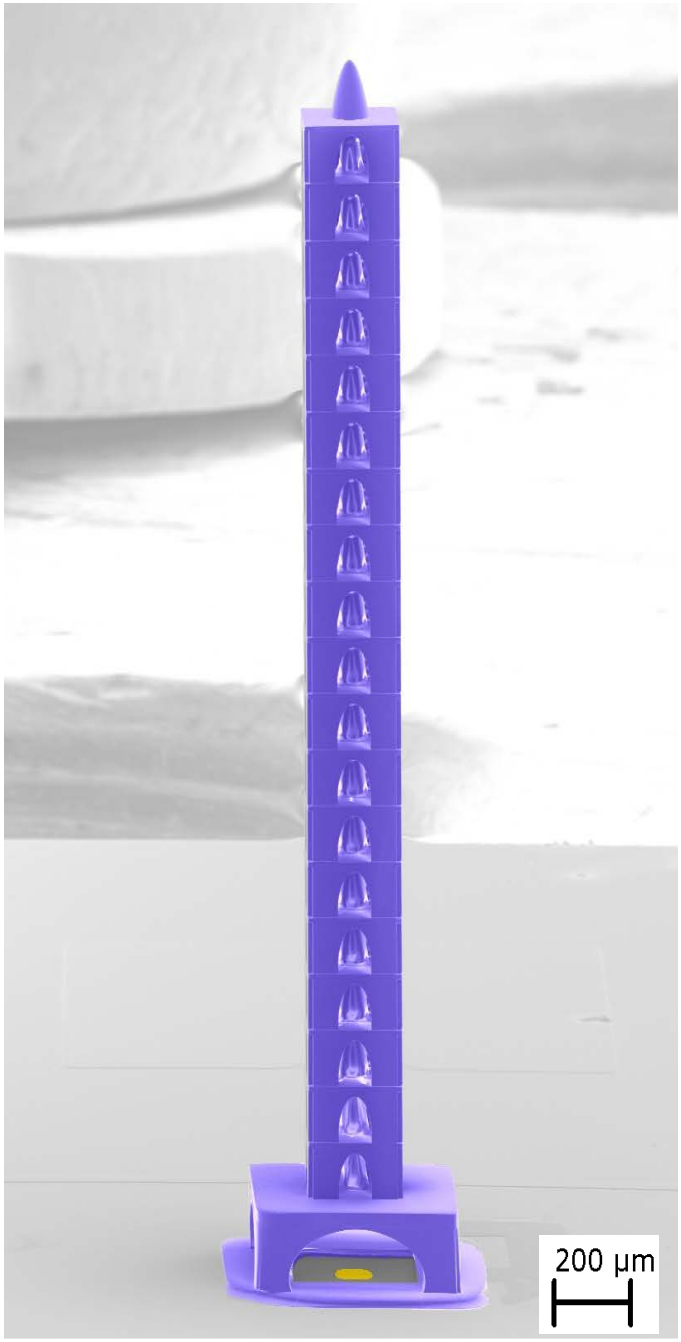
"A metasurface device will allow Rolic to strengthen its competitive advantage as a material supplier to the display industry."
Dr. Richard Frantz, head of development, Rolic Technologies Ltd

Lens combination for biomedicine

In the Nano-Argovia project ACHROMATIX, an interdisciplinary team has developed a novel lens system that can be used for transmission X-ray microscopy. The lens combination is intended to compensate for the so-called chromatic aberration of different lenses and should be suitable for biomedical analyses. The researchers first calculated theoretically which lens combination was best suited for the X-rays used. Using state-of-the-art nanofabrication techniques, they manufactured, characterized and tested the different X-ray lenses in order to identify the optimal combination.

Cooperation with: XRnanotech GmbH // Paul Scherrer Institute // Biomedical Science Center, University of Basel

Project description: http://bit.ly/3HY8XVs



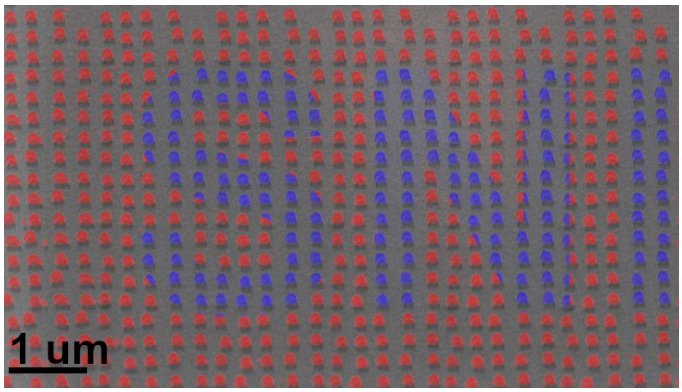
The lens combination developed in the Nano-Argovia project ACHROMATIX optimizes transmission X-ray microscopy. (Image: J. Vila Comamala, Paul Scherrer Institute)

Tiny magnetic field sensor with great potential

In the Nano-Argovia project Nanocompass, researchers have developed a novel, nanoscale magnetic field sensor that can be manufactured industrially and is expected to find applications in numerous fields such as quality control or medical technology. The magnetic field sensor is tiny, measuring less than 100 x 100 nanometers. Therefore, many of these sensors can be combined on a single chip along with their conditioning and processing electronics. In addition, the power consumption is low for a tiny sensor like this. In their approach, the researchers combined the so-called fluxgate principle, which has so far been used mainly for macroscopic sensors, with a spintronic device based on the rules of quantum mechanics.

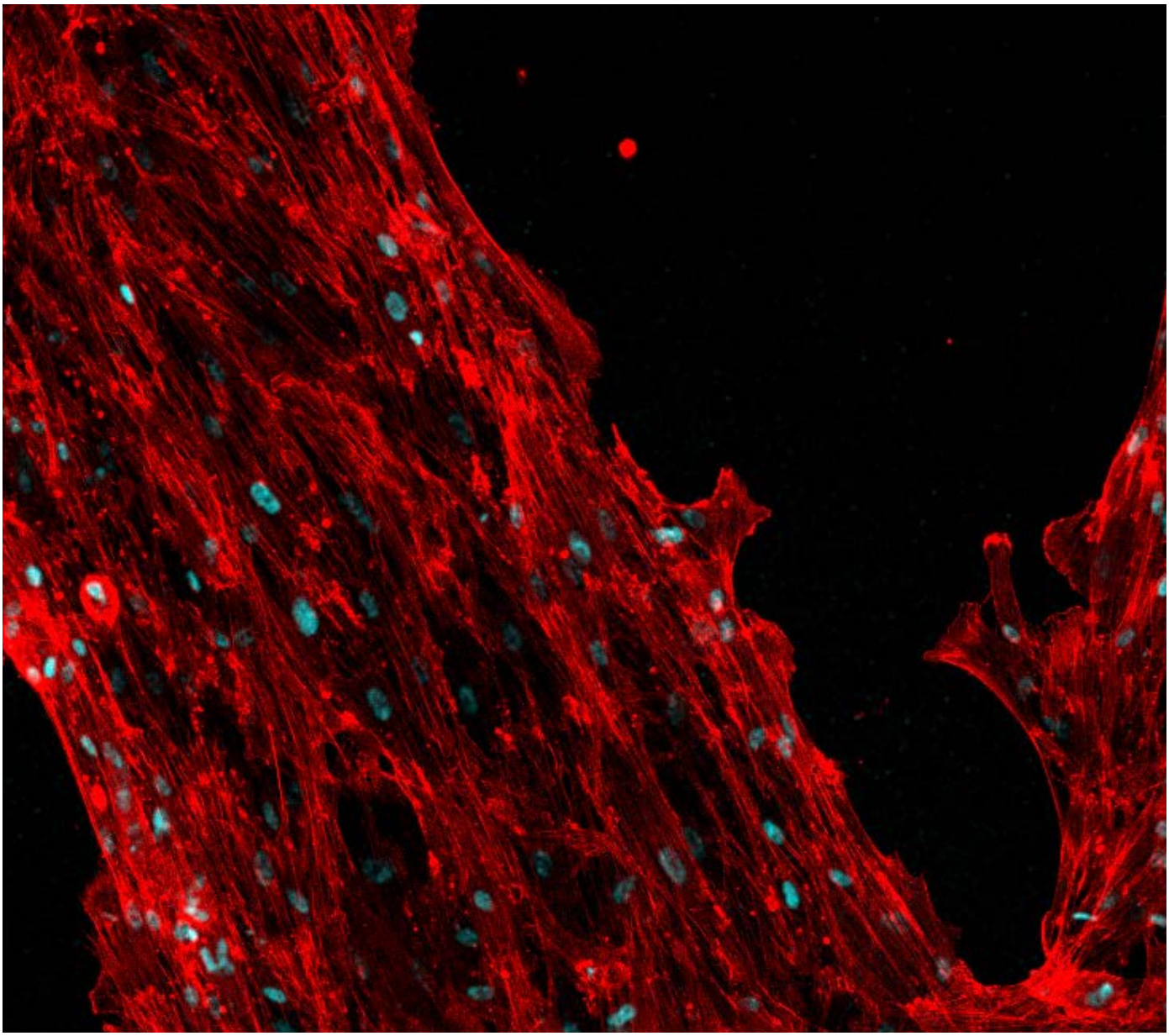
Cooperation with: Camille Bauer Metrawatt AG // FHNW School of Life Sciences // FHNW School of Engineering

Project description: http://bit.ly/3Yq17ed



Colorized scanning electron micrograph of a high-density array of 100 nm magnetic tunnel junctions used as nanoscale magnetic sensors. (Image: FHNW)

"The Nanocompass project has opened up new perspectives for us in energy measurement technology, especially in the contactless determination of electrical currents."
Max Ulrich, Managing Director
at Camille Bauer Metrawatt AG



In the Nano-Argovia project LIGARECO, the interdisciplinary team has cultivated ligament-forming cells in hydrogels patterned with channels. The aim is to increase soft tissue strength and thereby prevent inflammation of dental implants. (Image: FHNW, UZB, NovoNexile)

Template against inflammation

In the Nano-Argovia project LIGARECO, researchers have developed a microstructured, resorbable hydrogel template that prevents inflammation of dental implants. Similar to a natural tooth, the template stimulates the formation of collagen fibers around the implant neck and thus supports the anchoring of the implant in the surrounding soft tissue. This creates a barrier to prevent bacterial invasion and thus protects the implant from bacterial infection.

The researchers first focused on the fabrication of the hydrogel template and then investigated various micro and nanostructures of the hydrogels to control the settlement of ligament-forming cells and the formation of the desired fibers.

Cooperation with: NovoNexile AG // FHNW School of Life Sciences // University Center for Dentistry at the University of Basel

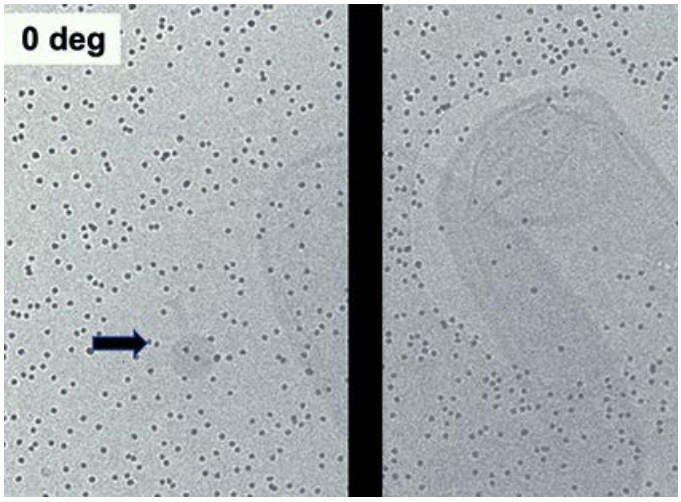
Project description: http://bit.ly/3jTYzWV

Adapted detector for cryo-electron microscopy

Cryo-electron microscopy has made tremendous progress in recent years and nowadays allows three-dimensional imaging of proteins in their natural environment in the cell. In the Nano-Argovia project HPDET-EM, an interdisciplinary team has collaborated to install, test and apply a new detector in an electron microscope that is better adapted to the needs of cryo-electron microscopy (cryo-EM) than detectors used for synchrotron and X-ray analysis. The hybrid pixel detector tested has a high readout speed and sensitivity and is, therefore, particularly suited to further advance cryo-EM technology in the life sciences.

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

Project description: http://bit.ly/3K7PGDM



In the Nano-Argovia project HPDET-EM, researchers are applying a new detector adapted to the needs of cryo-electron microscopy. The image shows *E. coli* bacteria as well as a bacteriophage (marked with the arrow) and gold particles. (Image: M. Er-Rafik, Biozentrum, University of Basel)

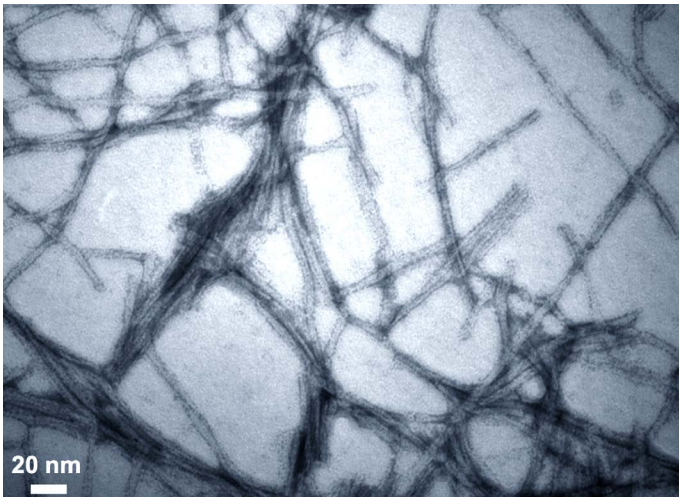
"We are confident that this collaboration will help us to play a critical role in the important new market segment of cryo-electron microscopy."
Dr. Sacha de Carlo,
Global Sales Manager EM at Dectris AG

Patch against ulcers in the mouth

In the Nano-Argovia project Hydrogel Patch, researchers have developed a patch to be used for non-specific ulcers in the oral mucosa. The patch covers the affected areas and can deliver healing agents. The patch, which is made of a self-assembling synthetic peptide hydrogel, adheres well to the soft, moist oral mucosa and is free of animal ingredients. The researchers tested various methods and substances to cross-link and stabilize the hydrogel and investigated biocompatibility and integration of nanocapsules that release active ingredients.

Cooperation with: vVardis AG // FHNW School of Life Sciences // University Center for Dentistry at the University of Basel

Project description: http://bit.ly/3RYWBB5



Electron micrograph of the peptide used in the Nano-Argovia project Hydrogel Patch. (Image: L. Kind, FHNW)

"The Nano-Argovia project supports our efforts to develop innovative and intelligent regeneration systems for oral applications."
Michael Hug, Co-CSO at vVardis AG

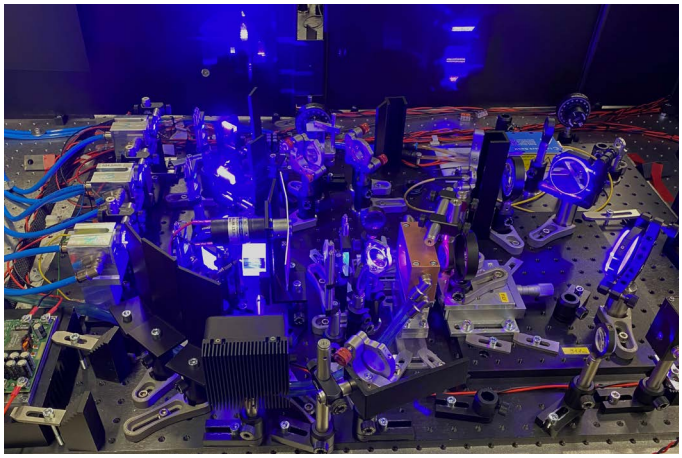
Short laser pulses to process nanomaterials

In the Nano-Argovia project NanoLase, researchers have developed a low-cost, reliable and compact laser source that generates ultrashort pulses. The researchers applied a laser amplifier made of titanium-doped sapphire with a new single-crystal fiber (SCF) geometry. The extremely short laser pulses reduce heat generation to a very small area, enabling processing on the micrometer and nanometer scales.

In addition to industrial materials processing, such a laser source is of great use in the life sciences and numerous other scientific applications.

Cooperation with: TLD Photonics AG // FHNW School of Engineering // Paul Scherrer Institute

Project description: http://bit.ly/3IzbtKe



Experimental setup of the femtosecond laser. Blue light is emitted by the new pump diodes. (Image: B. Resan, Institute for Product and Production Engineering at FHNW Windisch)

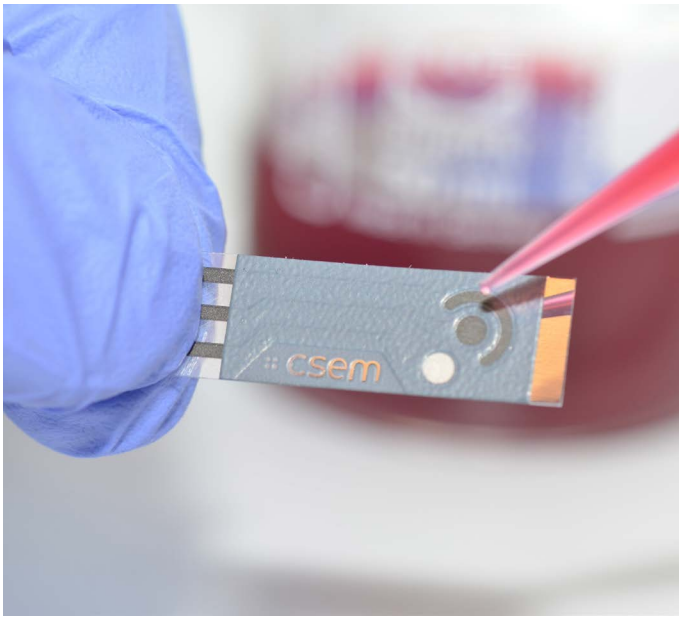
"The NanoLase project is very promising for TLD Photonics as it can bring about a new product line for TLD Photonics, making a breakthrough from laser micro to laser nanomachining."
Stephan von Wolff, CEO of TLD Photonics AG

Rapid test for pregnancy poisoning

The researchers in the Nano-Argovia project PEPS are aiming to provide rapid and precise information on pregnancy poisoning, a complication during pregnancy. To this end, they have produced an electrochemical sensor for certain protein biomarkers using conductive nanocomposite electrodes made of a mixture of carbon nanotubes and a hydrophilic polymer that can be produced at low cost. Thanks to this combination, the electrodes possess high conductivity as well as repellent properties that effectively protect against contamination of the sensor surface. The plan is to integrate the sensor into a novel diagnostic device that is suitable for so-called near-patient laboratory diagnostics without the need for complex diagnostic equipment.

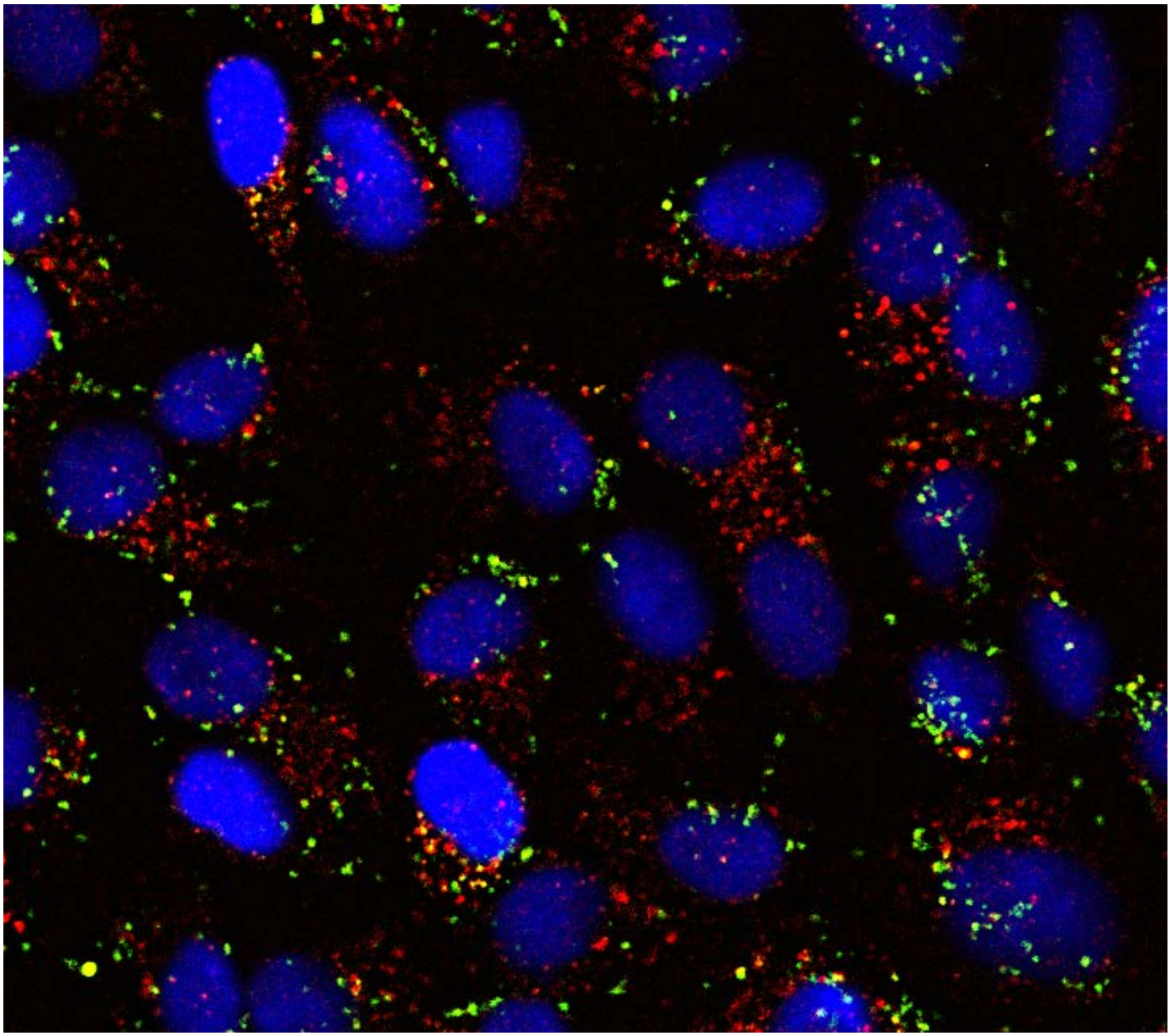
Cooperation with: MOMM Diagnostics GmbH // CSEM Allschwil // FHNW School of Life Sciences

Project description: http://bit.ly/3Yve6vm



A new type of coating on miniaturized electrodes for near-patient laboratory diagnostics prevents contamination – a problem with complex samples such as blood serum. (Image: CSEM Allschwil)

"The Nano-Argovia Project PEPS has enabled us to investigate whether our nanocomposite electrodes are suitable for use in highly sensitive electrochemical POC assays."
Dr. Mathias Wipf, Founder and CEO of MOMM Diagnostics with a master in nanosciences from the University of Basel



In the Nano-Argovia project NANO-thru-BBB, a new platform has been developed for designing nanoparticles with the potential to cross the blood–brain barrier. The image shows immunofluorescence detection of nuclei (blue), lysosomes (LAMP1, red) and NPs (green) in human brain endothelial cells (hCMEC/D3). (Image: N. Santacroce and C. Wu, FHNW)

"The possibility to deliver therapeutic enzymes to the brain would be a major breakthrough for patients of lysomal storage diseases. The Nano-Argovia projects support Perseo pharma's motivation to provide preclinical proof of concept for this approach and to further develop a new generation of enzyme replacement therapies."
Dr. Ing. Yves Dudal, CEO of Perseo pharma AG

Therapy directly in the brain

In the Nano-Argovia project NANO-thru-BBB, researchers have developed a platform for the production of nanoparticles that are able to effectively overcome the selective barrier between the brain and the bloodstream. The nanoparticles will later be applied to package and deliver enzymes to the brain for the treatment of hereditary lysosomal storage diseases. The interdisciplinary research team first investigated experimentally the effect of chemically modified and structured surfaces of the nanoparticles using various *in vitro* and *in vivo* models, and then used computer analyses to calculate the ideal surface structure for passing the blood-brain barrier. In the long term, the project will provide a solid database to conduct clinical trials with optimized nano-formulated enzymes against metabolic diseases.

Cooperation with: Perseo pharma AG // FHNW School of Life Sciences // Department of Pharmaceutical Sciences, University of Basel

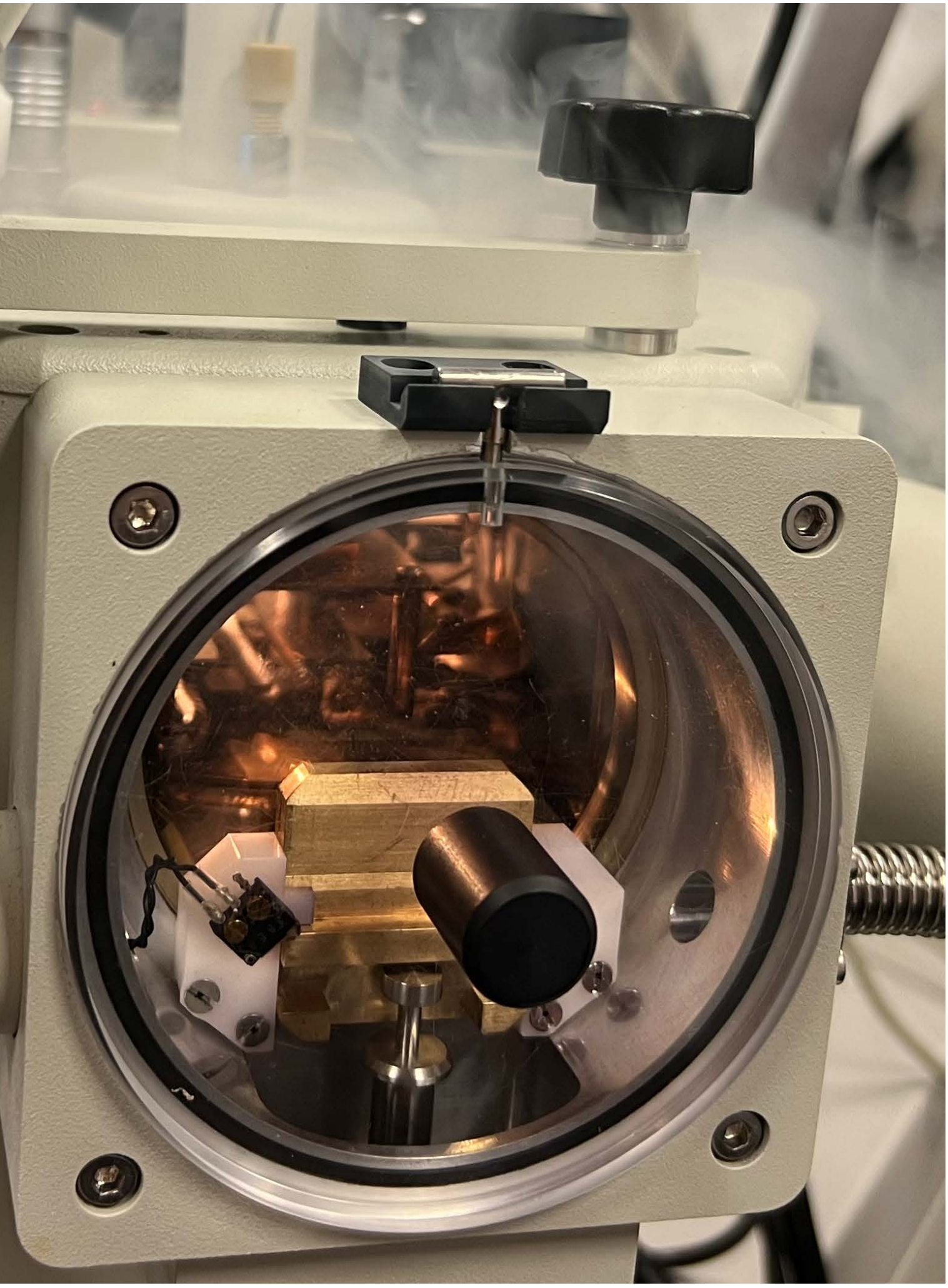
Project description: http://bit.ly/3lk1Ack

Precious insights

The team at the Nano Imaging Lab uses various microscopes to examine tiny structures thereby supporting a wide variety of research projects.

Together with the newly founded Nano Fabrication Lab, the Nano Imaging Lab forms the Nano Technology Center of the SNI. These two service units offer customers from industry and academia a comprehensive service in the field of imaging and processing of surfaces as well as in micro and nanofabrication.

More from page 44 onward



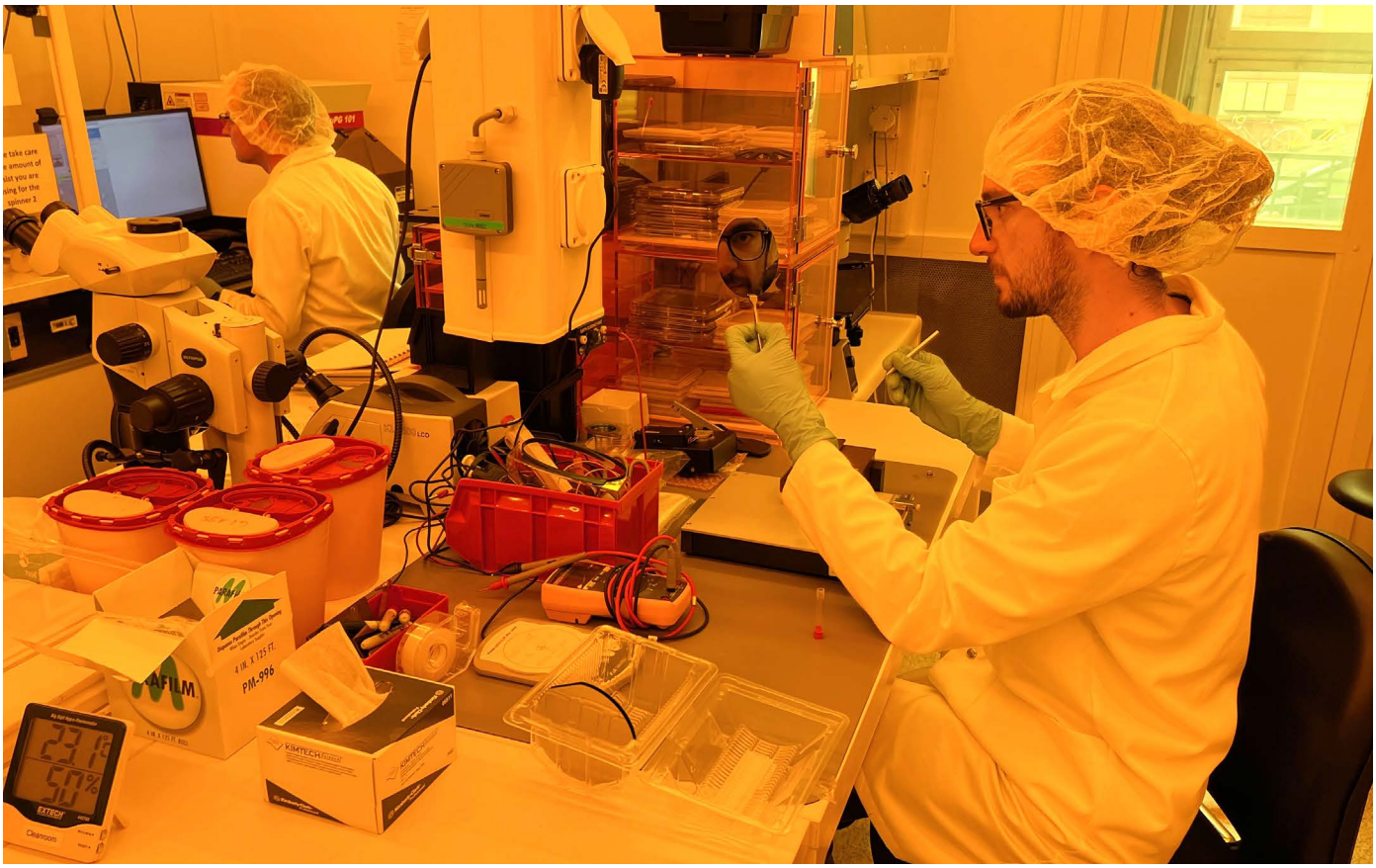
Nano Technology Center: Professional services and research

Alongside education and research, the imaging services provided by the Nano Imaging Lab have become a key element of the SNI's work in recent years. In 2022, the SNI also founded the Nano Fabrication Lab as a new service unit in order to provide professional assistance to research groups and to bring together the various activities relating to micro and nano fabrication at the University of Basel. Together, the Nano Imaging Lab and the Nano Fabrication Lab make up the SNI Nano Technology Center, which is led by Professor of Physics, Dr. Ilaria Zardo.

The Nano Imaging Lab further optimized its outstanding range of equipment in 2022. Thanks to these investments, the six-person team is now even better equipped to provide customers from universities and industry with optimum processing, analysis and imaging techniques. In 2022, the team processed a total of over 175 orders from over 120 different customers and in some cases made key scientific contributions to research projects. Fascinating images from the micro and nano world not only allow scientists to obtain new findings, but also provide non-experts with insights into the world of tiny structures as part of outreach activities.

The SNI's Nano Fabrication Lab (NF Lab) began operating in August 2022 with two members of staff bringing together the necessary technical equipment from various working groups of the Department of Physics at the University of Basel and put organizational measures in place to improve the efficiency and safety of clean room operation. Now, they're setting their sights on expanding the infrastructure. In 2022, the NF Lab's services were used by 11 research groups with a total of 77 users from the University of Basel and made significant contributions to several publications in renowned scientific journals.

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



The Nano Fabrication Lab also includes the clean room at the Department of Physics. Here, Arnold Lücke (left) and Gerard Gadea (right) help researchers fabricate micro and nano structures.

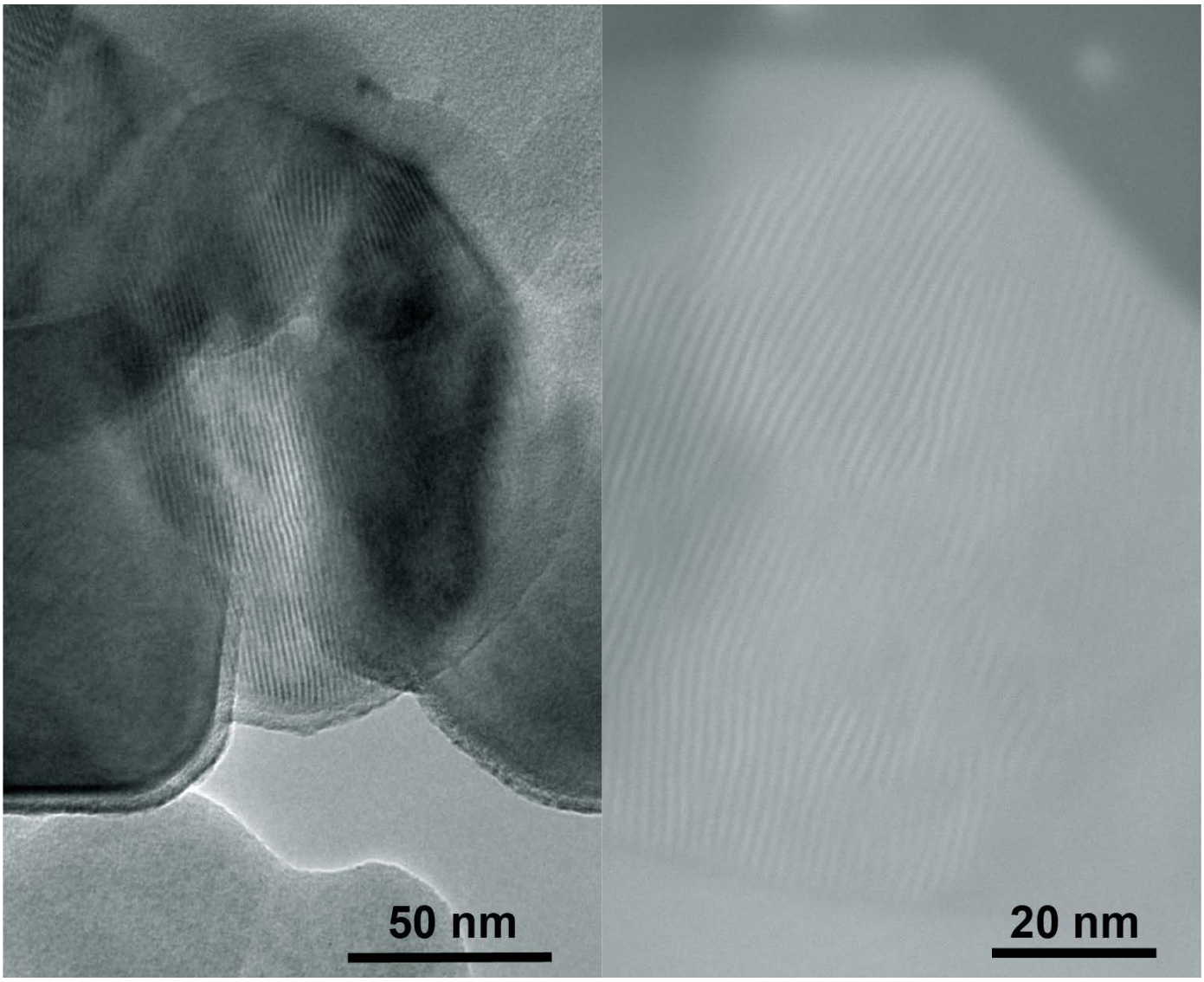
Founding of the Nano Fabrication Lab
Professional nanofabrication at the SNI

Today, the accurate and efficient fabrication of micro and nano structures is a fundamental prerequisite for many questions in the field of nanotechnology. In summer 2022, various existing activities and infrastructure from different laboratories at the Department of Physics were therefore brought together at the Swiss Nanoscience Institute, and the Nano Fabrication Lab (NF Lab) was founded.

Physicist Dr. Gerard Gadea became head of the NF Lab on 1 August 2022 and is supported in his work by technical assistant Arnold Lücke. The two scientists have many years of experience in nanofabrication and are working together to build up this new service unit, which will make the University of Basel fit for the future when it comes to nanofabrication. The team of the NF Lab first improved efficiency and safety in the clean room by implementing organizational changes and are now working to expand the infrastructure with equipment including two new lithography systems (electron- and laser-based), a metal evaporator and chemical exhaust hoods.

The Nano Fabrication Lab also includes the clean room at the Department of Physics and plans to rent a second clean room in the new building of the Department of Biosystems Science and Engineering of ETH Zurich in Basel, providing a further significant improvement in working conditions. Founding the NF Lab will not only make micro and nano fabrication more effective in the future but will also facilitate the implementation of safety concepts, reduce costs through centralized organization, and improve the quality of nanofabrication processes thanks to professional scientific assistance.

"Founding the Nano Fabrication Lab has allowed us to provide effective services in the fields of micro and nano fabrication."
Professor Ilaria Zardo, who is responsible for the SNI Nano Technology Center on the SNI Executive Committee



The NI Lab team has analyzed dye-sensitized solar cells and imaged the cross section of an electrode (TiO_2 with gold nanoparticles) in transmission mode (left) and scanning transmission mode (right). (Image: Nano Imaging Lab, SNI, University of Basel)

Geared toward the future

The Nano Imaging Lab is focused on materials science

In 2022, the Nano Imaging Lab (NI Lab) team presented its new transmission electron microscope (JEM-F200) to the public and successfully used it to address a variety of questions. In scanning mode, the new instrument can be used to image samples at atomic resolution. For example, with a resolution limit of less than 0.2 nanometers, the instrument is able to visualize the crystal structure or interfaces of different materials – and its integrated EDX system also allows it to analyze the chemical composition at different points in the sample.

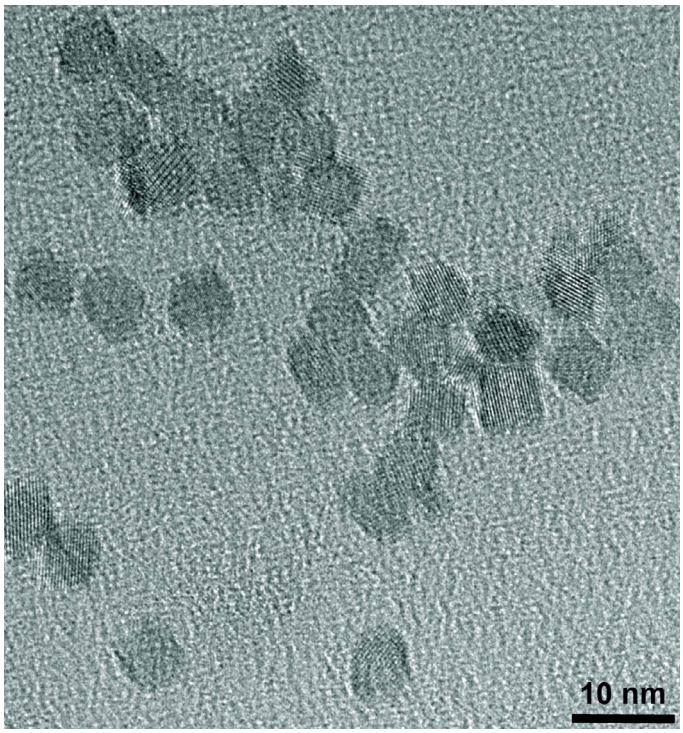
With their work on the JEM-F200, the staff of the Nano Imaging Lab have provided considerable assistance to researchers from various departments of the University of Basel and have been able to clarify key aspects relating to the analysis of various materials, as demonstrated by the four examples below.

In one instance, the NI Lab team analyzed electrodes from new types of solar cells for the group led by Professor Markus Kalberer (Department of Environmental Sciences), obtaining meaningful results using the high-resolution microscope in its

transmission and scanning transmission modes. In collaboration with Professor Jonathan de Roo (Department of Chemistry), the NI Lab team analyzed the morphology of nanocrystals produced in de Roo's group. Nanocrystals such as these have applications in many areas, including in superconducting nanocomposites, in dental medicine, in coatings or as contrast agents for X-ray computed tomography. Control over the size of the nanocrystals is a prerequisite for many such technologies.

The microscopic analyses conducted by the NI Lab were also key to helping researchers working with Professor Christian Schönenberger (Department of Physics) gain a better understanding of why individual tungsten ditelluride layers on palladium contacts exhibit superconducting properties. For the group led by Professor Richard Warburton (Department of Physics), the staff also analyzed quantum dots, which have modifiable optical and electronic properties and are therefore of interest for many future applications.

As well as tasks such as these, which help to address research questions, the NI Lab also carries out work on behalf of companies for the purposes of quality assurance, for example. The companies either interface with the NI Lab directly or access the service via partners such as the ANAXAM technology transfer center.



With the help of the new scanning transmission electron microscope, the team from the NI Lab was able to visualize the structure of nanocrystals. (Image: Nano Imaging Lab, SNI, University of Basel)

"The cross-sectional studies done by Marcus Wyss from the NI Lab with the brand new high-resolution STEM were a game-changer for us. We could now see what happens at electrical contacts to a topological material at the atomic scale."
Professor Christian Schönenberger,
Department of Physics, University of Basel

In 2022, the NI Lab not only began operating the new JEM-F200 but also acquired another high-power microscope. The new instrument is a "dual beam electron microscope" (Versa 3D DualBeam) and was purchased by the SNI from the BioEM Lab at the Biozentrum of the University of Basel.

Equipped with a focused ion beam (FIB), the instrument can also operate as a scanning electron microscope and can therefore be used not to only analyze surfaces but also to modify and cut them. Now that the NI Lab team has put the new FIB into operation, it is used above all to cut samples using the focused ion bean – while the existing FIB is used primarily to deposit various materials and produce high-resolution images.

As with its other microscopes, the Nano Imaging Lab offers a full service, including everything from sample preparation to the provision of measurement data and imaging. Customers working on longer-term projects can also be trained to use the instrument and carry out their own measurements.

Marcus Wyss (center) trains the first customers to use the new transmission electron microscope.

A fascinating and beautiful world of tiny structures

Once a year, researchers from the SNI network submit their most impressive images of the nano and micro world to the Nano Image Award competition. These fascinating images are one way for the SNI team to generate interest in the nanosciences among a wide audience.

This colorful crystal orientation map was one of the images to win the Nano Image Award in 2022. It shows 3D-printed (additively manufactured) stainless steel following surface etching. This technique is used by researchers from the Paul Scherrer Institute to reveal melt pool tracks and thereby to gain a better understanding of the relationship between 3D printing parameters and material structure.

(Image: E. Polatidis and C. Sofras, Paul Scherrer Institute)

Network: Interdisciplinary and dedicated

The basis for all SNI activities is the SNI network, which includes researchers from different Departments at the University of Basel, for example Biomedicine, Chemistry, Environmental Sciences, Pharmaceutical Sciences, Physics, and the Biozentrum, as well as members of research groups from the FHNW Schools of Life Sciences and Engineering at the University of Applied Sciences Northwestern Switzerland in Muttenz and Windisch, the Paul Scherrer Institute PSI, the Department of Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel (D-BSSE), the CSEM (Centre Suisse d'Electronique et de Microtechnique) in Allschwil and the ANAXAM technology transfer center. The wider network also includes the Hightech Zentrum Aargau in Brugg and Basel Area Business & Innovation, which work to promote knowledge and technology transfer.

Change at the top

Martino Poggio becomes new director of the SNI

On 1 August 2022, Professor Martino Poggio took over as director of the SNI from Professor Christian Schönenberger, who had led the Institute for 16 years.

Poggio, a physicist, joined the University of Basel as an Argovia Professor in 2009 and has been involved in the SNI network since then. With his research group at the Department of Physics, he works on topics in nanomechanics, nanomagnetism and nanoimaging. As director of the SNI, Poggio will be supported by Vice Director Professor Patrick Maletinsky and by the SNI Executive Committee as a strategic executive body. Various responsibilities were transferred to members of the Committee at the time of its renewal.

Member of the SNI Executive Committee	Representative of
Prof. Dr. Jörg Huwyler	Pharmaceutical Sciences / Nanoscience Curriculum
Prof. Dr. Roderick Lim	Biozentrum
Prof. Dr. Patrick Maletinsky	Vice Director / Nano-Argovia Program
Prof. Dr. Kirsten Moselund	Paul Scherrer Institute PSI
Prof. Dr. Martino Poggio	Director / SNI PhD School
Prof. Dr. Torsten Schwede	Vice President's Office for Research
Prof. Dr. Oya Tagit	University of Applied Sciences Northwestern Switzerland (FHNW)
Prof. Dr. Oliver Wenger	Chemistry
Claudia Wirth	General Manager
Prof. Dr. Ilaria Zardo	Physics / Nano Technology Center

The new members of the SNI Executive Committee represent partner institutions and departments in the SNI network. Moreover, responsibility for the PhD program, the Nano-Argovia program and the service units of the Nano Technology Center is assumed by one member each of the Committee.

As Vice Director Patrick Maletinsky (left) supports Martino Poggio (right), who has been heading the Swiss Nanoscience Institute as Director since August 2022.

Interdisciplinary exchange
Annual Event and Nano-Tech Apéro

The SNI network includes researchers from different disciplines who work at various research institutes in Northwestern Switzerland. Events such as the Annual Event and the Nano-Tech Apéro are important occasions for promoting active collaboration, including between different disciplines and institutions.

In 2022, the members of the SNI network met in Lenzerheide for their annual scientific conference. After two years of the coronavirus pandemic, it was once again possible to meet without restrictions – which was hugely beneficial for an intensive scientific exchange.

In addition, this year's well-attended Nano-Tech Apéro, which was hosted by the FHNW School of Life Sciences in Muttenz, was all about applied research projects.

The two events highlighted the diversity of projects supported by the SNI and the valuable impetus that applied research projects funded through the Nano-Argovia program can provide for industrial companies in Northwestern Switzerland.

Report and Video Annual Event: http://bit.ly/3K4hLfh
Nano-Tech Apéro: http://bit.ly/40OBkya

The Nano-Tech Apéro provides SNI members and researchers from the world of industry with an opportunity to learn about ongoing Nano-Argovia projects and to make new contacts within the network.

Entanglement
An important topic of research at the SNI – and worthy of a Nobel Prize

In 2022, the Nobel Prize in Physics was awarded to three researchers who have carried out groundbreaking experimental research with entangled photons. Several research groups within the SNI network have also been working with entangled particles, thereby contributing to the development of new methods and technologies in quantum physics.

Report: https://bit.ly/3HYtjy4

Elucidation of 3D structures
Now at the disposal of SNI members

In 2022, ELDICO Scientific – a startup that developed within the SNI network – inaugurated the Electron Diffraction Experience Center at Innovationspark Allschwil. Under the supervision of the ELDICO team, the first electron diffractometer developed by ELDICO, the ED-1, is available for members of the Electron Diffraction Experience Center to carry out their measurements. As an academic partner of the Center, the SNI puts this promising and innovative technology at the disposal of its network.

ELDICO Scientific was founded in 2019 after researchers working on a Nano-Argovia project demonstrated that electron diffraction could be used to analyze the 3D structure of nanoscale materials.

Report: http://bit.ly/3YPW9HL

The Electron Diffraction Experience Center at Innovationspark Allschwil is supported by the SNI and was opened by the CEO of ELDICO Scientific, Eric Hovestreydt, in March 2022. (Image: ELDICO Scientific)

Successful researchers in the SNI network
Numerous grants and prizes

Numerous researchers from the SNI network received honors or grants in 2022.

The physicist Professor Jelena Klinovaja and the biophysicist Professor Michael Nash received an ERC Consolidator Grant. Professor Stefan Willitsch, a chemist, was awarded an SNSF Advanced Grant, and Professor Murielle Delley, also a chemist, received an SNSF Starting Grant.

Murielle Delley was appointed assistant professor of inorganic chemistry, and it was also announced in 2022 that Professors Sebastian Hiller, Timm Maier and Dominik Zumbühl were to be made full professors.

Communications and outreach: Educate and enthrall

What actually are the nanosciences and why is it worth taking a closer look at this world of tiny structures? These are just two of the questions that the SNI communications and outreach team is always ready to answer. On visits to schools, at science festivals, at markets or at the museum, the SNI team has the opportunity to talk to a wide audience about these kind of questions, to provide people with information, and to share its fascination with and enthusiasm for the natural sciences.

These interactions work best in the form of exciting, small-scale experiments that encourage people to participate and reflect. Information about the various areas of the SNI's work is also distributed in print materials, while electronic formats such as videos also provide information on the SNI's various activities.

At the same time, the SNI is reaching a growing audience through its various social media channels, whose followers now number over 4,300 people and organizations.

Various channels

Personal contact and interaction via social media

In early 2022, one of the highlights for the SNI team was the inauguration of the special exhibition "Voller Energie" (Full of Energy) at Museum Burghalde in Lenzburg. The SNI helped to make this exhibition such a huge success by setting up a water laboratory with various explanatory videos and by contributing a chapter to the accompanying book. Subsequently, several workshops offered by the SNI team were a chance to demonstrate the special properties of water to elementary school pupils with the help of various experiments.

During tunBasel, numerous children and young people visited the joint stand of the SNI and the Department of Physics, where they could try their hand at making their own soaps as well as undertaking various soap-related experiments.

The second half of the year once again featured a busy calendar of events, offering ample opportunities to engage with a wide audience and inform them about the SNI's activities. For example, the SNI team talked to numerous visitors at the Rüeblimärt in Aarau and informed people about the nanosciences as part of the SamstagsUni course series offered by the VHSBB, a Basel educational institution. Teaching staff and various school classes had the opportunity to familiarize themselves directly with examples of nanoresearch on visits to laboratories associated with the SNI – or to perform fascinating experiments in various subject areas as part of school visits or the Science Days at Europa-Park.

People with an interest in the SNI who were unable to find out more at one of the numerous events could also access various social media channels. With this in mind, the SNI team produced posts and videos on various subjects, including events, the course of studies, the PhD School and specific research topics. In 2022, the SNI YouTube channel was visited over 110,000 times – with the SNI videos clocking up a total viewing time of 2,600 hours.

The SNI website represents another key source of information. SNI staff spent the second half of the year working on a new website, which was launched in January 2023. In addition to redesigning the website, the SNI team also worked in collaboration with the agency STUDIO NEO to modernize and streamline the SNI logo and to give the print materials a fresh look.

Some of the events in summer focused on light — and above all UV light. These special UV beads offer an entertaining way of making ultraviolet rays visible.
At other events, the SNI used glittering chocolate to attract visitors to the stand. This chocolate is stamped with a special microstructure while still being semiliquid and therefore shimmers in bright colors without the need for dyes.
For the water laboratory at the special exhibition “Voller Energie” (Full of Energy) at Museum Burghalde, the SNI team produced explanatory videos all about water.
As well as information on the course of studies and the PhD School, the SNI team also produced videos about scientific topics.

Further informationen:

YouTube channel: https://bit.ly/3u9XLjv
LinkedIn: https://bit.ly/3rbYP4s
Twitter: https://twitter.com/SNIunibas
SNI web page: www.nanoscience.ch
SNI webpage with experiments: http://bit.ly/3Hw1Flk

The new program at the TecDays invites learners to try their hand at experiments.
Large crowds gathered at the SNI stand at tunBasel and the Science Days at Europa-Park.
At the Rüeblimärt in Aarau, visitors big and small could win prizes if they answered a question about the nanosciences correctly.

Financial report

The Swiss Nanoscience Institute (SNI) was founded at the University of Basel in 2006 on the initiative of the Canton of Aargau. Then, as now, the goal was to advance research in the nanosciences, to support knowledge and technology transfer in Northwestern Switzerland, and to establish a center for the training of young scientists. These core aspects – teaching, basic and applied research, as well as knowledge and technology transfer – are reflected in the SNI's finances.

Founded on basic research

At the SNI, basic research serves as the foundation for innovations. To this end, the SNI supports the work of the two Argovia Professors at the University of Basel, Roderick Lim and Martino Poggio, as well as that of three titular professors at the PSI, Thomas Jung, Michel Kenzelmann and Frithjof Nolting. In total, these professors received funding of some CHF 1.5 million in 2022. Through their participation in national and international collaborations, the two Argovia Professors together secured an additional CHF 1.4 million in funding in 2022. This allows them and their groups to conduct research at the highest level and, through their research findings, to make a significant contribution to the SNI's excellent reputation.

Basic research is also the field in which most doctoral students work at the SNI PhD School, which was founded in 2012. The 40 doctoral students who formed part of the PhD School in 2022 conduct this research at various institutions within the SNI network – but they all earn their doctorates from the Faculty of Science at the University of Basel. In total, the outgoings for the SNI PhD School ran to some CHF 1.8 million in 2022.

Nano-Argovia program supports technology transfer

With the Nano-Argovia program, which has existed since the Swiss Nanoscience Institute was founded, the SNI supports knowledge and technology transfer to industry. The program sees companies from Northwestern Switzerland work with at least two academic partners from the SNI network in order to explore novel lines of research at an early stage. In 2022, four new Nano-Argovia projects were launched, and eight projects from the previous year received an extension for a final year. Six of the industrial partners are headquartered in the Canton of Aargau, while the other half of the companies come from one of the two Basel half cantons.

The SNI's entire budget for knowhow and technology transfer was around CHF 1.4 million in 2022. Project partners contributed approximately CHF 1.1 million via public research funding instruments (e.g. Innosuisse, the Swiss National Science Foundation and EU funding) and funding from the research institutions themselves. The industrial partners contributed around CHF 1.3 million to the various lines of research in the form of in-kind services.

Nano Technology Center offers extended range of services

The Nano Technology Center was founded in 2022 with a view to further expanding the SNI as a service center and establishing the promising field of nanofabrication as a key pillar of the SNI as well as professionalizing its work in this area. The Center brings together the Nano Imaging Lab, which has formed part of the SNI since 2016, and the newly founded Nano Fabrication Lab. With these two service units, the SNI is now in the position

The following table shows expenses for 2022 by category in accordance with the financial report of the University of Basel dated 26 February 2023.

Expenditure 2022 in CHF

		Univ. Basel	Canton AG	Total
Management	Personnel and operational costs	408,936	270,569	679,505
	Overhead	—	650,000	650,000
Infrastructure	Infrastructure equipment	132,143	330,274	462,417
	Personnel and operational costs	21,956	151,123	173,079
Knowhow & Techtransfer	Nano-Argovia projects	—	1,199,433	1,199,433
	Personell and operational costs	93,088	96,791	189,879
Outreach & PR	Argovia professorships	516,727	1,006,773	1,523,500
Support	PSI professors		57,585	57,585
Nano Curriculum	Bachelor and master programs	313,743	234,266	548,009
Nanotechnology Center	Nano Imaging/Nano Fabrication	652,566	161,103	813,669
SNI PhD School	Personnel and operational costs	803,132	981,605	1,784,737
Total expenditure 2022 in CHF		**2,942,292**	**5,139,523**	**8,081,815**

to provide customers from industry and academia with comprehensive services in the area of imaging as well as in micro and nano fabrication. The investments needed to build up these services are largely funded from the SNI's reserves. Although the necessary orders were made in 2022, delivery problems have meant that investments of some CHF 0.9 million will only appear in the 2023 financial report. In total, the budget of the Nano Technology Center ran to CHF 0.8 million. So far, some CHF 0.5 million have been invested in new infrastructure.

Study and outreach

Since the SNI was founded, one of its key objectives has been to train outstanding early career researchers so that they have a broad grounding in the natural sciences and can engage in interdisciplinary work on various topics in the nanoworld. With this in mind, the University of Basel is the only Swiss university to offer a bachelor's and master's degree program in the nanosciences. In 2022, there were a total of 84 students enrolled on the nanoscience program (59 on the bachelor's and 25 on the master's degree course). The SNI contributed some CHF 0.5 million to the program's costs.

To raise awareness of these unique and demanding degree courses, the SNI team participates in various events. It is also important for the SNI to provide broad sections of the population with information about the nanosciences, their possible applications and the Canton of Aargau's commitment to this field. In addition, the SNI shares news on social media and uses print materials to inform the public about its various activities. In terms of the SNI network, key activities also include internal events such as the Annual Event or networking opportunities such as the Nano-Tech Apéro. In 2022, the outgoings for activities of this kind came to about CHF 0.2 million.

Investments in the future

With a view to driving further advances in nanoscience research in the region, the SNI also invested in various projects in 2022 – including the Electron Diffraction Experience Center, for example, which was inaugurated in 2022 and provides the SNI with services for its network. Further investments relate to the ANAXAM technology transfer center, of which the SNI is a founding member, and a collaboration with the Paul Scherrer Institute PSI. Here, the SNI is involved in the realization and commissioning of an experimental station (SOPHIE), which allows experiments to be carried out at the Swiss Synchrotron Light Source.

In the last line of the balance sheet, some CHF 6.6 million are shown as "SNI assets per 31/12/2022 in CHF." However, most of this money has already been committed. Some CHF 1 million have already been committed in previous years, but have not yet been invoiced, including equipment for the Nano Technology Center. This balance also includes funds allocated to individual Nano-Argovia projects that have not yet been spent, as well as reserves used to guarantee a full 48-months of funding for all doctoral students currently enrolled in the SNI PhD school.

We would like to extend our sincere thanks to the Finance department at the University of Basel for its efficient financial reporting. Thanks are also due to the Cantons of Aargau, Basel-Stadt and Baselland for their long-standing and loyal support of the SNI. Their commitment makes it possible for us to train excellent young researchers, obtain new scientific insights and collaborate with companies on innovative projects as we work toward building a better future.

The following table shows the SNI balance sheet as of 31 December 2022:

SNI balance sheet 2022 in CHF

	Univ. Basel	Canton AG	Total
Grants	2,660,800	5,000,000	7,660,800
Investment income	(7,139)	7,736	597
Income	**2,653,661**	**5,007,736**	**7,661,397**
Expenditure	**2,942,292**	**5,139,523**	**8,081,815**
Balance year 2022	**(288,631)**	**(131,787)**	**(420,418)**
SNI assets per 01/01/2022	**1,992,975**	**5,055,548**	**7,048,523**
Annual balance	(288,631)	(131,787)	(420,418)
SNI assets per 31/12/2022 in CHF	**1,704,344**	**4,923,761**	**6,628,105**

Organization

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S. Chambers (Coordination Nano Curriculum)
Dr. K. Beyer-Hans (Communications, outreach)
S. Hüni (Communications, outreach)
Dr. C. Möller (Communications, media contact, social media)
Dr. M. Wegmann (Communications, outreach, social media)

Nano Imaging Lab
Dr. M. Dürrenberger (Head)
Dr. M. Wyss (Deputy head, TEM, FIB-SEM)
E. Bieler (SEM)
S. Erpel (SEM, TEM)
D. Mathys (FIB-SEM, image coloring)
Dr. M. Schönenberger (AFM, LSM)

Nano Fabrication Lab
Dr. Gerard Gadea (Head)
Arnold Lücke (financed by the Department of Physics)

Lists of members and projects 2022

Principal Investigators and associated members
https://bit.ly/3lGLCAk

PhD students
https://bit.ly/3EbvZHv

SNI PhD School projects 2022
https://bit.ly/3YsHcvn

Nano-Argovia projects 2022
https://bit.ly/3YWNqDs

Further information

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

Scientific supplement
Scientific reports from all the Nano-Argovia and SNI PhD School projects from 2022 can be found on our website or by scanning the QR code.
http://bit.ly/3Y5fVht

Cover image:
Analysis of human cells expressing a red fluorescent transgene by confocal microscopy. Cells were transfected using a lipid-nanoparticle (LNP) based gene delivery system.
Bright green signal: endosomal escape, green signal: Galectin3-GFP, red signal: transgene RFP,-cyan signal: cell nuclei, blue signal: LNP
(Image: Claudio Alter, Department of Pharmaceutical Sciences, University of Basel)

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Scientific supplement