University of Basel

Swiss Nanoscience Institute

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

Annual Report 2016

Swiss Nanoscience Institute University of Basel

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

This report summarizes work conducted at the Swiss Nanoscience Institute (SNI) in 2016.

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Content

Foreword

I am delighted by your interest in the Swiss Nanoscience Institute (SNI) and in our latest annual report on our activities throughout 2016. As in previous years, the report is divided into two parts – a general, non-technical section in which we present some of the year's highlights, and a scientific section in which we describe the results from all projects running within the Nano Argovia program and the SNI's PhD School.

2016 was a very busy year for the SNI. As well as being full of events, it was also the year of the atomic force microscope (AFM). Our vice-director Christoph Gerber developed the AFM with Gerd Binnig and Carl Quate in 1986. Thirty years later, in 2016, the three scientists received the Kavli Prize in Nanoscience in recognition of their work. They truly deserve this outstanding award, as the AFM is a fantastic instrument that allows us to view and analyze the nano world in detail. Thanks to the AFM, scientists today can observe biological, chemical, and physical processes at the atomic level and in real time. Numerous articles written by SNI members and published in renowned journals in 2016 show how scientists are using the AFM for an immense diversity of applications. It was wonderful to see how often the SNI's media releases about the AFM were picked up by scientific portals and journals.

In 2016, the SNI had the pleasure of organizing the Swiss NanoConvention in Basel – and we received a great deal of praise for this from our colleagues in Switzerland and abroad. We were all able to enjoy this excellent interdisciplinary conference with high-level experts from a variety of fields, and used the opportunity to make new contacts and refresh long-standing relationships. The numerous exhibitors from industry also showed that nanotechnology has arrived on the market.

2016 was also a special year for the SNI, as Jan Nowakowski became the first doctoral student to graduate from the SNI's PhD School. Many others will follow in the coming years. We hope that we will be able to stay in touch with the young scientists as they move forward in their careers. This is something we try to do with the students on our nanoscience programs, and we introduce three of them in this annual report. They each used SNI travel scholarships to further their education and expand their horizons beyond the interdisciplinary curriculum on offer in Basel.

We welcomed many alumni back to the SNI when we celebrated its tenth anniversary in October 2016. The event was a good opportunity to look back over the years, remind ourselves of the various milestones we have passed, and honor the work of the network as a whole. It is, after all, our network of different research groups at different institutions that makes the SNI so special and facilitates interdisciplinary collaborations in which one plus one equals much more than two.

This annual report also presents a new SNI service unit: the Nano Imaging Lab (NI Lab), which was founded at the start of 2016. It combines the Nanotech Service Lab with parts of the former Center for Microscopy Basel (ZMB), and offers members of the SNI network and other clients a comprehensive imaging service.

As you can already see from this handful of examples, 2016 was a truly eventful year. As for me personally, I suffered a serious cycling accident in early November that kept me bed-bound for weeks. I am now recovering slowly with the help of a great deal of training, and am very much looking forward to returning to research and teaching. I hope that our paths will cross again at one of the many nanoscience events coming up in 2017. In the meantime, please enjoy reading our latest annual report.

Best wishes,

Christian Schönenberger, SNI Director
March 2017

Swiss Nanoscience Institute

Interdisciplinary Network for Nanoscience

The Swiss Nanoscience Institute (SNI) at the University of Basel is a center of excellence for nanosciences and nanotechnology. In the SNI network, interdisciplinary teams of scientists conduct basic and applied research and actively support knowledge and technology transfer to industry. Within the study of nanoscience and the PhD School, the SNI trains young scientists and prepares them with different activities for careers in industry and academia. In addition to research and training, the SNI is also involved in public relations and outreach activities and specifically supports various initiatives, particularly those aiming to interest children, young people, and their teachers in the natural sciences.

Commitment from the Canton of Aargau
The SNI was founded in 2006 by the Canton of Aargau and the University of Basel to promote research and training in the nanosciences and nanotechnology in Northwestern Switzerland. Since then, numerous research projects have been successfully initiated and completed in which researchers from various disciplines and institutions work together in one network. The SNI has a total budget of 6.8 million Swiss francs, of which 4.5 million comes from the Canton of Aargau and 2.3 million from the University of Basel.

A diverse network
The success of the SNI is based on the interdisciplinary network that has been built up and consolidated over the years. This network includes various departments at the University of Basel, research groups at the University of Applied Sciences Northwestern Switzerland (FHNW) in Muttenz and Windisch, the Paul Scherrer Institute (PSI), the Department for Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel (D-BSSE), the CSEM (Centre Suisse d'Electronique et de Microtechnique) in Muttenz, the Swiss Tropical and Public Health Institute, and the University Hospital Basel. The wider network includes the Hightech Zentrum Aargau and BaselArea.swiss. Interdisciplinary academic conferences for members and active internal communication via a newsletter and the SNI website encourage and promote exchange within the network on an ongoing basis.

Excellent education for students
The University of Basel has offered Bachelor's and Master's programs in nanosciences since 2002. Today, this demanding degree program is firmly established. Around 40 students who begin the Bachelor's program each year receive a solid basic education in biology, chemistry, physics, and mathematics and can subsequently choose from a wide range of practical and theoretical courses that allow the students to focus on specific topics. Early on in their education, they have an opportunity to participate in various research groups, which is often highlighted as being particularly motivating and valuable. In addition, students are given the chance to participate in courses outside their field of specification. The courses on media competence for example prove popular. The degree program has also gained international recognition. For example, the SNI was invited to contribute a piece on education at the SNI to a book and to report on the success of the study of nanosciences in the renowned journal Nature Nanotechnology. Both contributions were published in 2016.

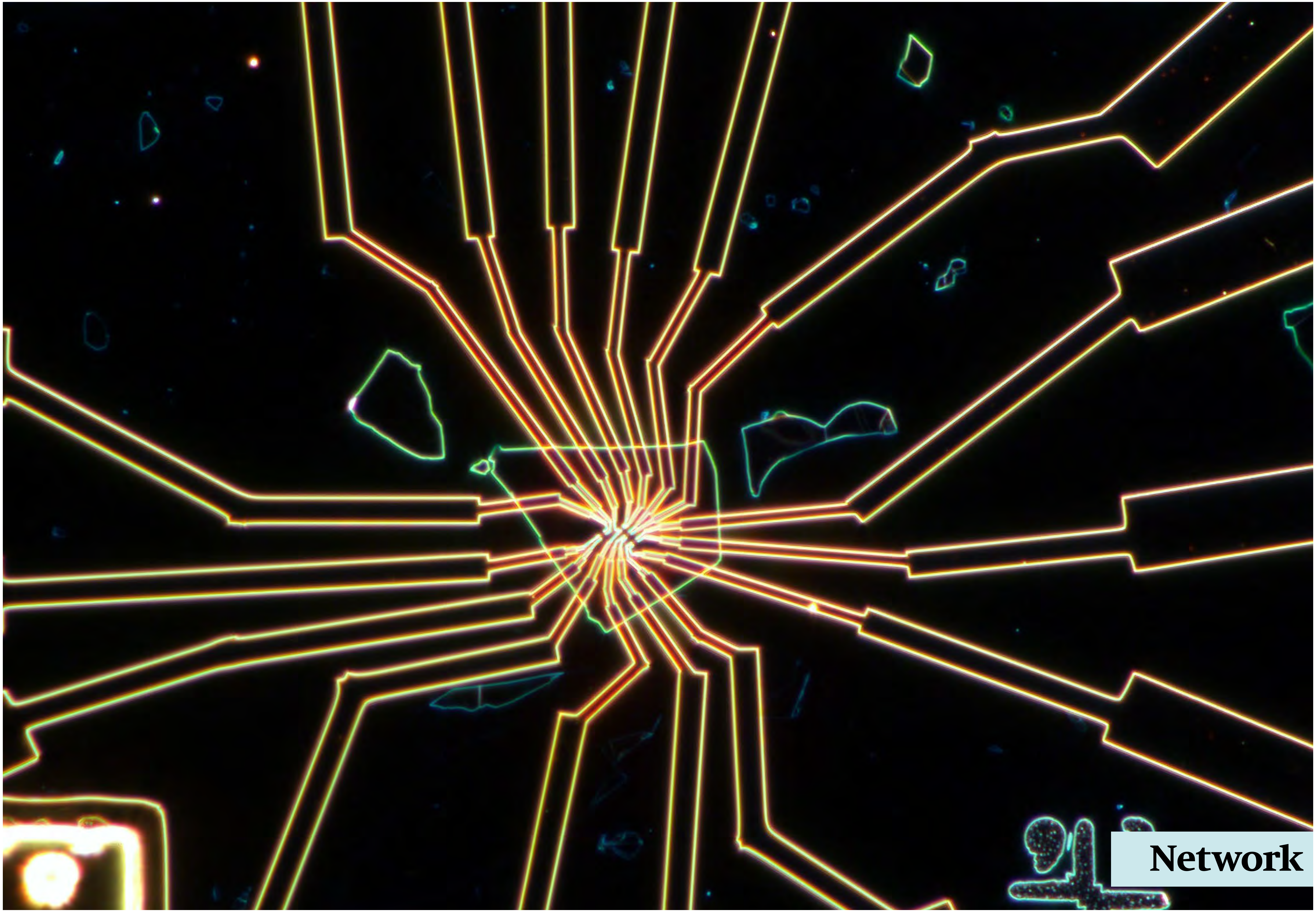
A variety of topics at the PhD School
To promote the further training of young scientists and a wide spectrum of basic scientific research, the SNI initiated a PhD School in 2013. At the end of 2016, 38 doctoral students were enrolled. Within the SNI PhD School, each doctoral student is supervised by two members of the SNI network. The principle investigators (PIs) and Co-PIs frequently belong to different departments at the University of Basel or institutions from the network. The interdisciplinary education is further enhanced by the participation of all doctoral students in internal scientific events such as the Winter School "Nanoscience in the Snow" and the Annual Meeting. Furthermore, the SNI offers a choice of courses to the doctoral students to provide insight into topics such as intellectual property, communication, rhetoric, and career strategies and to help them forge contacts with industry.

Leaders in their field
Basic sciences form the foundation of research work at the SNI. In addition to the various projects funded as part of the PhD School, the SNI also supports the basic scientific research performed by Argovia Professors Dr. Rodrick Lim and Dr. Martino Poggio. With their successful research in nanobiology and nanotechnology, both contribute to the SNI's outstanding international reputation. Further support is given to three titular professors: Professor Dr. Thomas Jung teaches and works in the Department of Physics at the University of Basel and leads a team at the PSI. Professors Dr. Frithjof Nolting and Dr. Michel Kenzelmann also lecture at the Department of Physics and are active with their research groups at the PSI.

Strong connections to practical application
Since it was founded, the SNI has placed great value on the transfer of academic findings to industry. To optimize this process, the SNI started an annual call for applied research projects. This program entitled Nano Argovia supports about ten projects each year from broad ranging areas of nanotechnology in close collaboration with industrial companies in Northwestern Switzerland and has a total budget of around 1.3 million Swiss francs. Through the Nano Argovia program, the SNI provides an important bridge between research and application. In several cases, this collaboration has led to Commission for Technology and Innovation (CTI) and other follow-on projects and to patent applications.

Services in demand
The SNI views itself not only as a pure research institution, but also as a wide-ranging service provider to academic institutions and industrial companies. For example, the SNI Nano Imaging Lab (NI Lab) was set up in 2016 to offer comprehensive imaging services. The NI Lab unites the Nanotech Service Lab previously run by the SNI with part of the former Center for Microscopy Basel (ZMB) and is affiliated with the SNI. The SNI also supports the excellently equipped workshops for technology, electronics, and mechanics in the Department of Physics. Research institutions and industrial companies can access both the expert knowledge of the staff as well as the outstanding technical resources of the SNI and affiliated departments.

Sharing the fascination with others
The SNI wishes to involve the public in its fascination with the natural sciences through active communication and participation in various events. For example, the SNI team is involved in science festivals, fairs, and exhibitions both at home and abroad, provides schools and groups of interested visitors with an insight into everyday laboratory life, and strives to produce materials for specific target groups as well as press releases about outstanding research results to make the SNI's scientific achievements accessible to a wide audience.



Network

A valuable SNI network partner

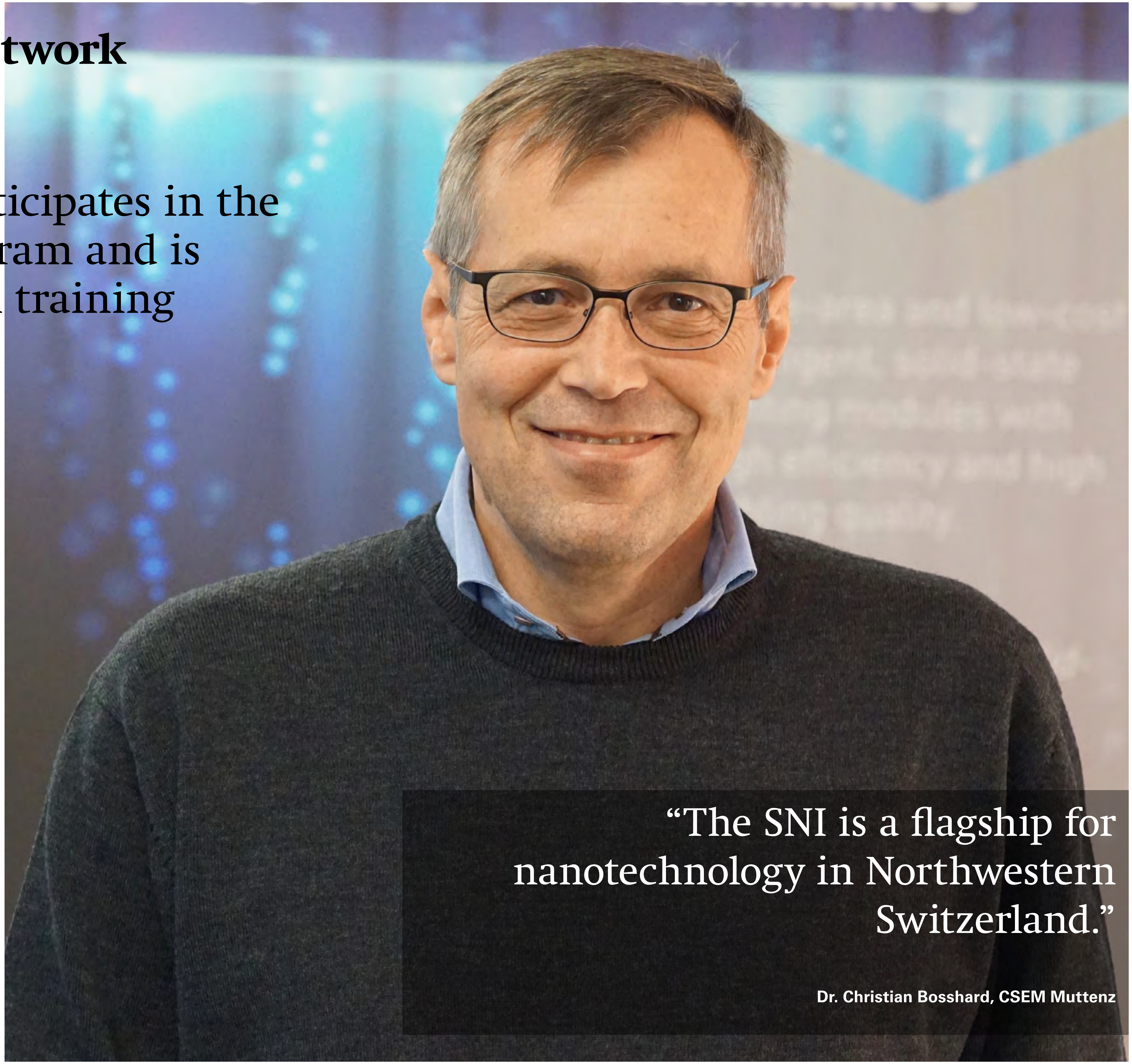
CSEM Muttenz participates in the Nano Argovia program and is actively involved in training

CSEM's regional center in Muttenz has been an important SNI network partner for a number of years. This partnership involves staff at CSEM Muttenz taking part in Argovia projects, supervising doctoral students and helping to train nanoscience students. Since the end of 2012, CSEM's regional center in Muttenz has been headed by the physicist Dr. Christian Bosshard. In conversation with us, he praises CSEM's collaboration with the SNI and highlights the valuable contribution that the SNI makes to training excellent young nanoscientists.

Innovative applied projects

CSEM is a private, non-profit-oriented research and technology organization that has been helping Swiss companies to develop new technologies and innovative products for more than 30 years. In 2009 it set up a business unit in Muttenz (in addition to its headquarters in Neuchâtel and existing sites in Alpnach, Landquart and Zurich) to improve its offer to partners in Northwestern Switzerland. The 38 staff currently based at the center are focused primarily on projects concerned with micro and nanostructuring of surfaces and printed electronics. At the same time, they are seeking solutions to problems relating to photovoltaics, lighting systems, security features for different products and sensor technology.

"For example, we have developed a printable glucose sensor, which is being used in production processes in the pharma industry. It is cheap to produce, so it is well-



"The SNI is a flagship for nanotechnology in Northwestern Switzerland."

Dr. Christian Bosshard, CSEM Muttenz

suited to the disposable fermenters that are now coming into use," Christian Bosshard explains, referring to an object in the research product showroom at CSEM Muttenz. Also on display there are printed photovoltaic films, which can be attached to windows and used to create all kinds of optical designs. Other exhibits have special nanostructures that – much like those on a butterfly's wing – produce color effects solely by virtue of their particular surface structure. These can be used as security features on bank notes, for example, or drugs packaging.

Participation in the Nano Argovia program and the PhD school

There are not yet any exhibits on display for the ongoing Argovia project NF-Optics, which is led by Dr. Martin Stalder of CSEM Muttenz. He is working alongside colleagues from CSEM, the University of Applied Sciences and Arts Northwestern Switzerland, and the firm BASF Schweiz AG to develop a brand-new method for producing optical coatings that does not require a vacuum. Normally, these optical coatings, which are only a few nanometers thick, are produced in cleanrooms using vacuum systems. This makes the process very resource-intensive. If a method of processing under normal pressure conditions could be found, it would bring down production costs, save energy and allow a wider range of materials to be used. For this reason, the Argovia project team is now looking at whether electrospinning is suited to producing precisely oriented nanofibers that can be applied to glass or thin films and then used as optical coatings.

"We welcome the opportunity to take part in the SNI's Nano Argovia program," Christian Bosshard explains. He himself spent years doing research into optical systems at ETH Zurich, before moving to CSEM in 2001. "Longer-term research projects, within the framework of doctoral dissertations, also complement our applied research activities very well," he adds, referring to the project at the SNI's PhD school in which CSEM Muttenz is involved. Nanoscience students from the University of Basel are also welcome as PhD researchers or interns. "So far, we have had really good experience working with nanoscience students from Basel. They are very well trained, with knowledge of both physics and the life sciences," Bosshard remarks. "We need more and more people with a broad knowledge base. The SNI is setting the standard for the training of these interdisciplinary young scientists."

A wide range of activities to establish new contacts

The wide range of activities at CSEM Muttenz includes a few basic research projects, but the focus is on supporting industry. "Our aim is to reduce the risk of innovation for our partner companies," Christian Bosshard explains. CSEM Muttenz serves as a point of contact for companies from Northwestern Switzerland – including for technologies deployed primarily at CSEM's other sites. To convince potential partners of the benefits of collaboration, Bosshard's team organizes a regular lecture series called "Innovation Talk", where new technological developments are discussed. Contacts can be established and developed over drinks afterwards. The center is also in dialogue with companies on a regular basis at CSEM's business days and various events run by BaselArea.swiss in which CSEM Muttenz takes part. "On the one hand, we have partners who approach us again and again. On the other, these different events result in new contacts that lead to exciting projects," Christian Bosshard confirms. This means that new opportunities are continually opening up for CSEM Muttenz to take part in SNI programs.

Minute structures produce remarkable effects

Micro- and nanostructured polymer surface expert Per Magnus Kristiansen plays a major role in the success of the Nano Argovia program

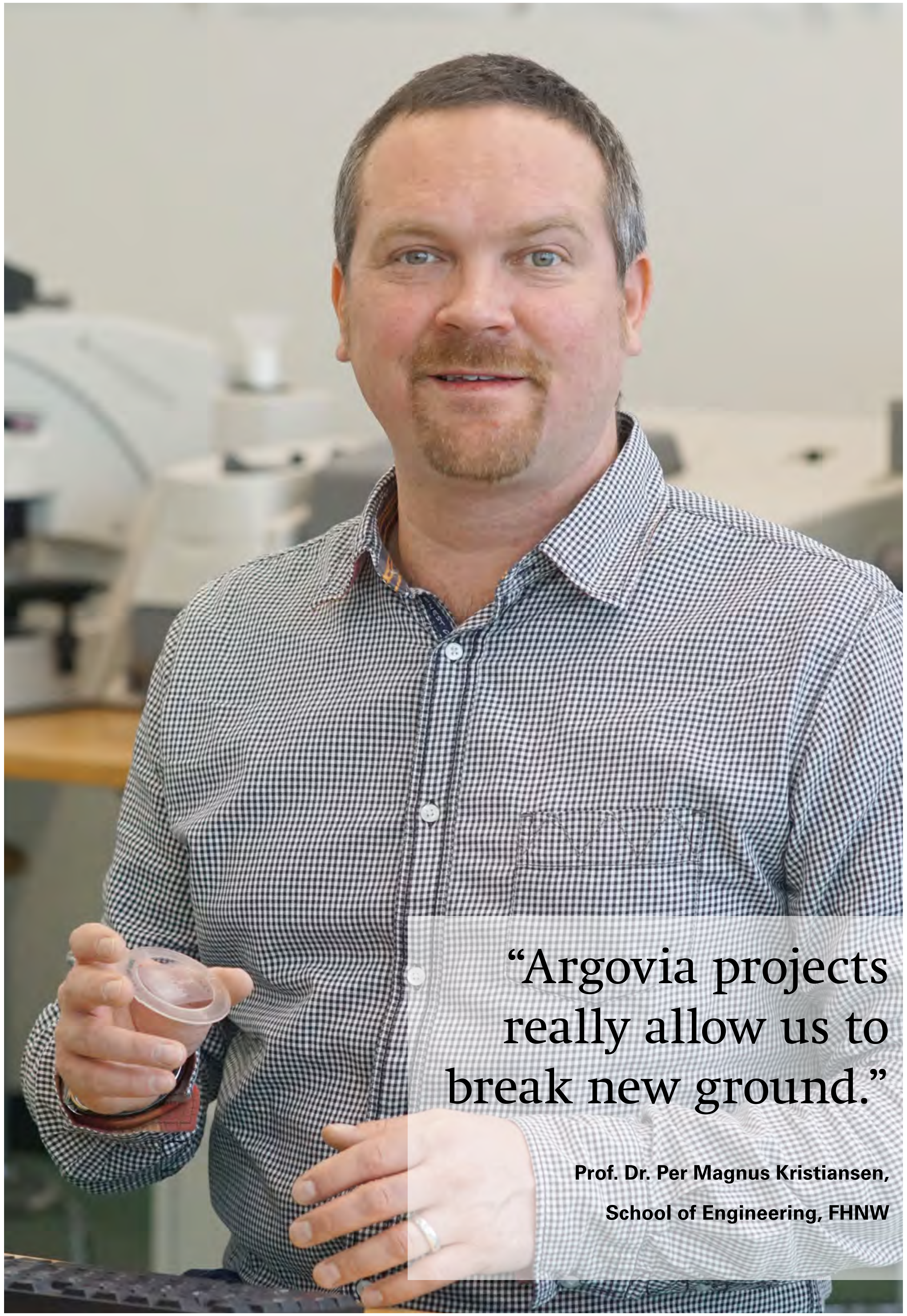
The School of Engineering at the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) is an important partner in the SNI Network. Since taking up a position at the school as professor of polymer nanotechnology in 2009, Dr. Per Magnus Kristiansen has contributed to the SNI's success with innovative Argovia projects in his specialist field – micro- and nanostructuring of polymer surfaces. Per Magnus Kristiansen, who studied materials engineering, took over from Professor Dr. Jens Gobrecht (Paul Scherrer Institute) as head of the Institute of Polymer Nanotechnology (INKA) in July 2016, and embraces the opportunity to work with the SNI.

Inspired by nature

The impact of minute structures on a surface can be considerable, as frequently demonstrated by the natural world. The lotus effect, for instance, which causes water and dirt to simply bead off the leaves of the lotus plant, is due to the special structure of the leaves' surface. Optical effects such as holograms or anti-reflective glasses also make use of special surface structures. Professor Dr. Per Magnus Kristiansen of the FHNW's School of Engineering and the Institute of Polymer Nanotechnology (INKA) specializes in this kind of micro- and nanostructures on polymer surfaces. He has contributed his expertise to eight Argovia projects so far, revealing some of the fascinating potential applications structured and functionalized polymer surfaces have to offer.

Broad range of applications

In the Argovia project "FiltrElec", researchers led by Per Magnus Kristiansen demonstrated how specially modified nano-additives can be used to impart a permanent electrostatic charge to the fibers of ventilation filters, enhancing their ability to filter out finer particles. The "NAPOHIC" project revealed how minute amounts of nanoscale carbon additives can make insulating plastics conductive. Kristiansen has also been involved in research into new lithographic methods for chip production (Versalith) and the use of electron beam emitters to chemically modify surfaces (RepAll). Reducing adhesion and improving the flow of liquids is not the only reason to optimize surface structures, however. Human cells also react differently to contact with different surface structures. In the Argovia project "PatCell", Kristiansen's team worked on structuring poly-



“Argovia projects really allow us to break new ground.”

Prof. Dr. Per Magnus Kristiansen, School of Engineering, FHNW

mer-based bone implants so as to promote the adhesion of certain body cells in order to enhance the implants’ biocompatibility.

All of these projects rely on ongoing cooperation among interdisciplinary teams. In each one, the team members are plunged into new and sometimes unfamiliar fields in pursuit of the project’s often ambitious goals. In the process they benefit enormously from cooperation with the industry partners and research institutions involved in the project, which, by their very nature, bring an extremely diverse mix of skills and expertise to the table. This makes the Argovia projects at once instructive and exciting. For example, it is important to understand that a bone implant affects a variety of cell types, each with a specific function inside the human body and a different reaction to the implant. The requirements for these surfaces therefore vary considerably from those in a project devoted to how a liquid flows out of a bottle, for example.

Ideal complement

For Per Magnus Kristiansen, it is precisely this variety that gives the job its charm. He is very enthusiastic about being involved in the SNI’s diverse Nano Argovia program: “The Nano Argovia program is a perfect supplement to industry-based, CTI and Aargau Research Fund projects as it has a strong research element and allows us to pursue genuinely new directions.” The projects give researchers an opportunity to explore new applied research ideas in interdisciplinary teams comprising an industry partner and a colleague from at least one other research institution. While Per Magnus Kristiansen is primarily occupied with structuring polymer surfaces, each project brings new applications in a vast range of fields. “There is always plenty to learn and discover, which is what makes the work so interesting,” he remarks.

Head of INKA

A new and exciting task lies ahead for Kristiansen as head of the Institute of Polymer Nanotechnology (INKA), a post he took over from Jens Gobrecht in July 2016. INKA is a joint venture of the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) and the Paul Scherrer Institute (PSI) drawing on the two institutions’ complementary strengths and expertise for research projects at the intersection between polymer engineering and nanotechnology. As deputy head of the Institute since 2011, Per Magnus Kristiansen has already devoted a considerable amount of time to raising INKA’s profile beyond Switzerland’s borders, boosting the institute’s reputation with successful applied projects in collaboration with industry partners and scientific publications in the field of structured molding. “The third International Conference on Polymer Replication on Nanoscale (PRN 2016), which we held in Windisch in May 2016, was a huge success, attracting 85 participants. This reassured us that we have been doing something right over the last few years,” he says with visible pride.

We can only hope that despite his numerous tasks at the FHNW and the PSI, Per Magnus Kristiansen will continue to participate actively in the Nano Argovia program and bring his expertise to bear on many more innovative SNI projects.

SNI network in brief

In the SNI network, interdisciplinary teams work closely together to conduct basic and applied research. The network includes various departments at the 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 Department for Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel (D-BSSE), the CSEM (Centre Suisse d’Electronique et de Microtechnique) in Muttenz, the Swiss Tropical and Public Health Institute, and University Hospital Basel. The wider network includes the Hightech Zentrum Aargau and BaselArea.swiss.

SNI membership is automatically given to all scientists involved in Argovia and SNI PhD School projects as principle investigators (PIs) or co-PIs and members of the SNI management team and the Nano Imaging Lab. This allows them to participate in SNI events free of charge granting them access to the SNI network and regular scientific exchange.

“The AFM helps us shed light on life processes.”

Prof. Dr. Christoph Gerber, SNI University of Basel

A success story spanning 30 years

Christoph Gerber receives the Kavli Prize for inventing the atomic force microscope

In September 2016, Professor Dr. Christoph Gerber, vice director of the SNI, was awarded the prestigious Kavli Prize in Nanoscience, along with Professor Dr. Carl Quate and Dr. Gerd Binnig, for their invention of the atomic force microscope. With the creation of this exceptional instrument, the three scientists ushered in a new era in the research and manipulation of minute structures, giving rise to a technology which has become an indispensable tool in the field of nanoscience. The invention 30 years ago was also a turning point for Christoph Gerber himself, marking the beginning of his exploration of the nanoworld.

It began in California
The story of the atomic force microscope (AFM) begins in 1985. At the time, Professor Dr. Christoph Gerber and Dr. Gerd Binnig of IBM’s Almaden research center were visiting Professor Dr. Carl Quate at Stanford University. All three were excited about the possibilities of the scanning tunneling microscope (STM) developed at IBM’s Rüschlikon research center in 1981. However, they dreamed of an instrument which, unlike the STM, was not limited to capturing conductive samples in atomic detail, but could also be used for detailed examination of non-conductive biological objects. This led them to work together on the idea of using atomic forces to scan samples, which in turn gave rise to the atomic force microscope.

To build the instrument, Gerber prepared a small movable cantilever using gold foil just a few microns thick, and glued the end of a record player needle to its tip. Moving this tip very close to a sample, the researchers observed that the attractive and repulsive forces between sample and tip caused a measurable displacement of the gold foil cantilever. Recording these forces point by point enabled them to capture a digital image of the sample. Over the course of just five months in 1986, Gerber, Binnig and Quate built, tested and described the AFM prototype in the journal “Physical Review Letters”. “At the time we never imagined that the paper would be referenced some 350,000 times, becoming one of the most cited papers in this prestigious journal,” recalls Christoph Gerber.

A variety of applications at the SNI and worldwide
The latest generation of atomic force microscopes still operates on the principle developed 30 years ago. Since then, besides capturing individual atoms and molecules at atomic resolution, scientists have also succeeded in observing natural nanomachines at work in short film sequences. Argovia Professor Dr. Roderick Lim, for example, has used the atomic force microscope to examine the behavior of pores in the cell nucleus. Other groups at the SNI are using the AFM to study chemical reactions. The team led by Professor Dr. Ernst Meyer, for instance, recently conducted step-by-step observation of the catalysis of various chemical reactions, demonstrating that chemical reactions on surfaces can lead to entirely new products. Using the AFM, SNI researchers were able to provide an experimental evidence for particles such as the exotic Majorana fermions. However, the

applications of the AFM are not limited to capturing a wide range of processes and samples – it can also be used to measure the magnitude and direction of various forces, or position individual atoms with very high precision.

Focus on the cantilever

While countless research groups worldwide work on optimizing the AFM, Christoph Gerber's research has focused on using the minute cantilevers for diagnostic purposes. To this end, Gerber's team coats the cantilever with different molecules according to the problem at hand. If compounds contained in a test solution bind to these molecules, a measurable displacement of the highly sensitive cantilever occurs. Applying this principle, Gerber's team was recently able to present a successful clinical trial in which genetic mutations present in fifty percent of all patients with malignant melanoma were detected.

A new direction

Even at the age of 74, Christoph Gerber remains a passionate scientist with a fascination for the unknown and a boundless enthusiasm for research. However, a career in academia was not always on the cards for Gerber. After attending school in Basel, he initially trained and worked as a precision engineer. It was not until his stimulating collaboration with future Nobel laureates Dr. Heinrich Rohrer and Dr. Gerd Binnig, along with other brilliant researchers at IBM's research centers in the seventies and eighties – and above all his involvement in the creation of the STM and AFM – that he came into contact with the fascinating world of atoms and molecules. Over the years he became a leading expert in the field of atomic force microscopy, convincing countless colleagues worldwide of the possibilities opened up by his new microscope, training them in its use and sharing the tips and tricks he acquired over the course of its development.

Dedication and perseverance

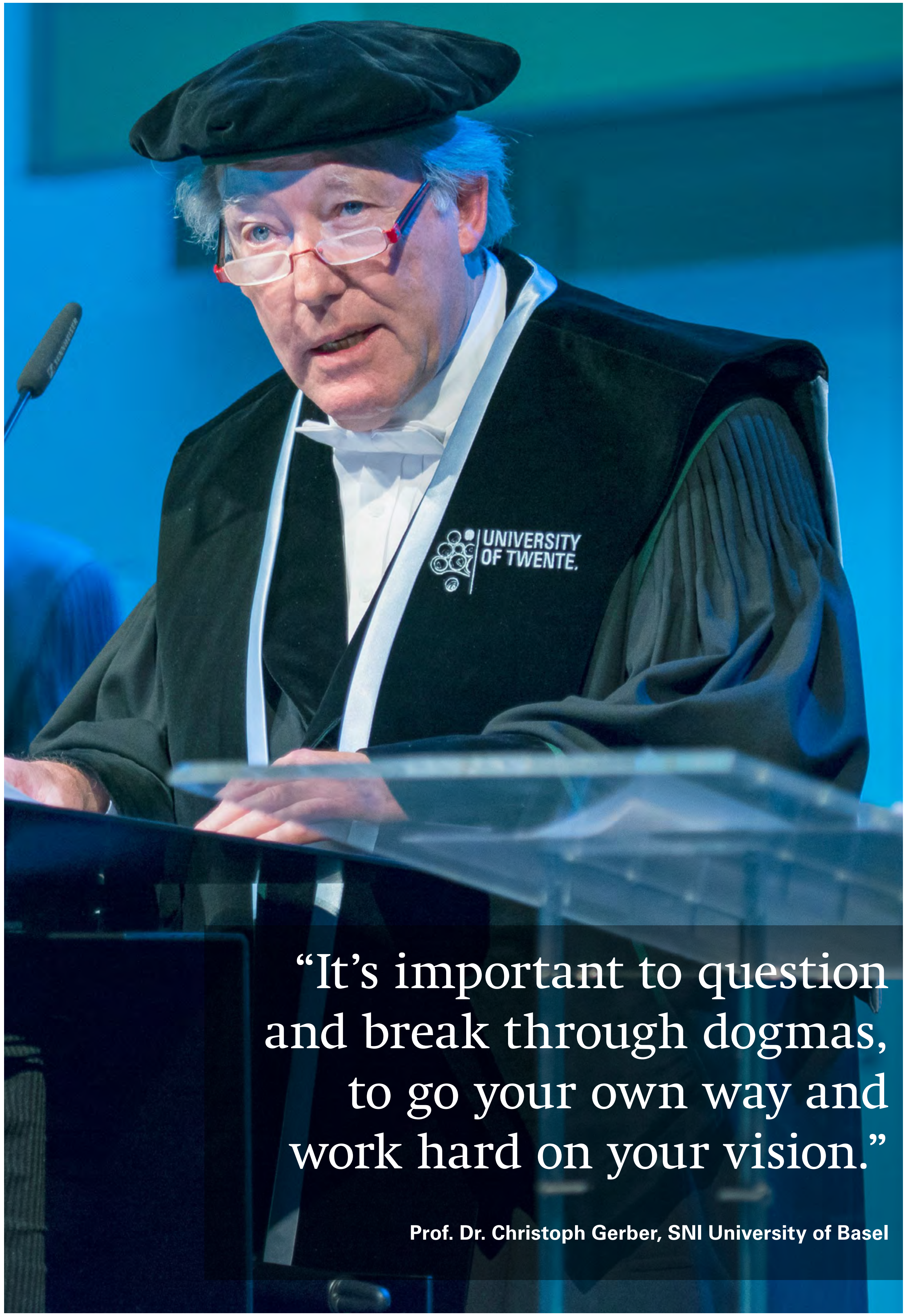
With these achievements and 35 years at the IBM lab under their belt, many other researchers would be content to rest on their laurels. Not Christoph Gerber – in 2001 he began a new chapter in his academic career, playing a key role in the foundation of a Nanocenter at the University of Basel. He accepted a post as Director of Scientific Communication and project leader for cantilever projects in the National Centre of Competence in Research Nanoscale Sciences (NCCR Nano), founded in 2001 and led by Professor Dr. Hans-Joachim Güntherodt. To this day, Gerber continues to devote his energy to the SNI in Basel, promoting nanoscience research in Northwestern Switzerland to an audience which extends far beyond the SNI network. Asked about the philosophy that drives his career, he replies "For success in science, dedication and perseverance are essential. Besides that, it is important to challenge dogmas, to find your own way, and to work hard on your vision."

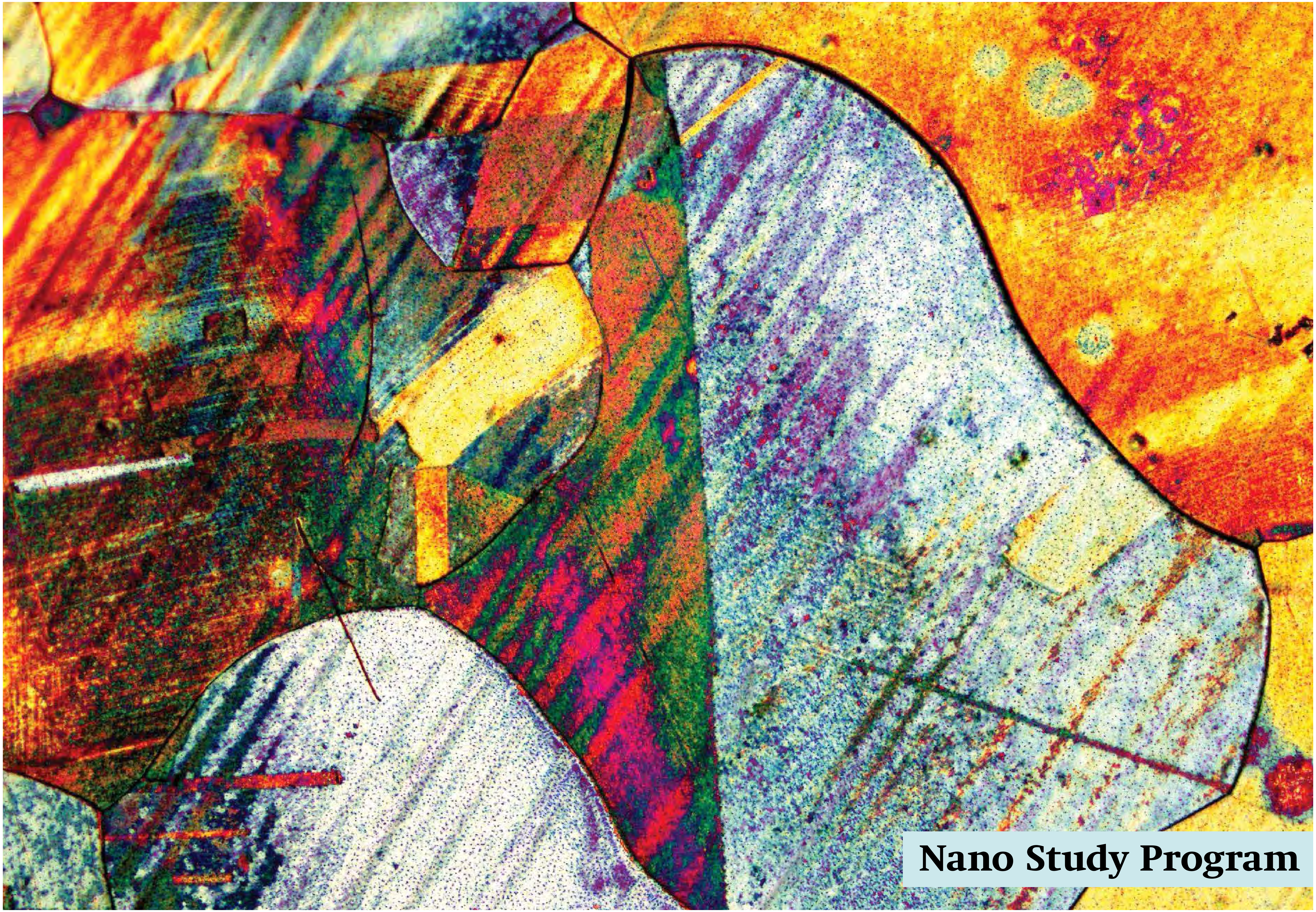
A remarkable award

Christoph Gerber has undeniably followed his own advice to great effect, accumulating numerous prizes and honors for his research over the years, among them honorary doctorates from the universities of Basel and Twente, a Lifetime Achievement Award from the scientific journal "Nature", and the City of Basel Science Award. As of this year, he can add the prestigious Kavli Prize for Nanoscience, sometimes compared to the Nobel Prize in the media, to this list. The distinction is a cause for celebration for the entire SNI network.

The Kavli Prize

The Kavli Prize has been awarded every two years since 2008 in recognition of outstanding research in the fields of astrophysics, neuroscience and nanoscience. It is endowed with one million dollars for each field of research, and recipients are selected on the basis of recommendations from internationally renowned scientists by the Kavli Foundation, the Norwegian Academy of Science and Letters and the Norwegian Ministry of Education and Research. The prize was sponsored by Norwegian-born entrepreneur and inventor Fred Kavli, who set up the Kavli Foundation in 2000 with the goals of advancing science for the benefit of humanity, promoting public understanding of science and supporting researchers in their work.




Nano Study Program

Best master's thesis in nanoscience 2015

Prize-winning thesis written at MIT

In 2015, the SNI once again awarded a prize to the best master's thesis in nanoscience at the University of Basel. The distinction was given to Andreas Reichmuth on the occasion of the Institute's 10^{th} anniversary in October 2016. For his award-winning thesis, Reichmuth examined nanoparticles with potential applications in gene therapy and immunotherapy for cancer treatment at the Massachusetts Institute of Technology (MIT) in Cambridge in the U.S.

High school hobby
Andreas Reichmuth's fascination for nanotechnology began in his school years, when he took an interest in the lotus effect. He went on to read extensively about nanotechnology, and ended up writing his Matura thesis on graphite under Professor Dr. Ernst Meyer at the Department of Physics. Reichmuth's enthusiasm for the nanoworld was such that in the fall semester of 2010 he signed up for a degree program in nanoscience at the University of Basel.

Clear connections
It is a decision he has never regretted. In the course of his studies, he suddenly became aware of connections between the different sciences that had not been obvious before: "I heard something in physics, then something similar in chemistry or biology, and suddenly the connection was clear," he recalls certain flashes of insight. Another thing he enjoyed about the course was the chance to experience a broad spectrum of fields within the nanosciences. Like many other students, he had the opportunity to familiarize himself with the various working groups of the SNI network, mainly by means of the block courses on offer. In this way, Reichmuth was able to gradually develop a feel for the direction he wanted to pursue. Although primarily interested in the life sciences, he initially devoted himself to physics in order to learn the basic principles he would later apply when dealing with issues in biology or medicine.

Perseverance pays
Speaking to other students who had completed a master's thesis abroad with the support of the SNI, Reichmuth soon decided that he too wanted to take this opportunity to travel. He sent off one application after another to countless professors – most of whom did not even bother to reply. He refused to give up, however. A former nanoscience student from Basel, Dr. Kaspar Renggli, put him in touch with the Massachusetts Institute of Technology (MIT) in Cambridge in the U.S. His perseverance finally paid off, and he was offered a project on nanoparticles in the lab of the highly-regarded Professor Dr. Robert Langer – one of the most prolific and frequently-cited researchers and entrepreneurs of our time, with over 1,100 patents to his name. "It was a huge stroke of luck to end up working under such a famous researcher," remarks Reichmuth. "And it was very satisfying to see that with my Basel academic background I was able to hold my own in a first-rate working group in such a renowned institute."

Focus on nanoparticles
His research, which was co-supervised from Basel by Professor Dr. Wolfgang Meier, focused on nanoparticles with potential applications in gene therapy and immunotherapy for cancer patients. The idea was to use the specific load of nanoparticles to teach the immune system to recognize a tumor and render it harmless. To this end, he began by producing lipid nanoparticles, which he filled with messenger RNA (mRNA) containing the

information required to produce particular tumor proteins. He then injected the loaded nanoparticles into mice. In the mouse model, he detected a strong cytotoxic immune response by T lymphocytes 6 to 8 days after the injection. This response was directed against the tumor cells and lasted several weeks. The project successfully demonstrated the viability of inducing an immune response against cancer cells in the mouse model. A rapid immune response to viruses in the body also seems theoretically possible using this method.

Back to Switzerland
Beyond his academic work, Andreas Reichmuth enjoyed life in Cambridge. He was struck by people's openness. At the same time, he noticed that things were much more competitive, and that quality of life in the U.S. was much more dependent on income than back home in Switzerland. Andreas Reichmuth has been back in Switzerland for some time now, and in January 2016 he began his doctoral studies in the Laboratory of Biosensors and Bioelectronics at the Federal Institute of Technology (ETH) Zurich. As he envisaged during his undergraduate studies, this will enable him to apply and combine his knowledge of physics, chemistry and biology. His current research is not aimed at developing new therapies, however. Instead, he is searching for markers which could enable early diagnosis of cancer. "I hope to detect metabolic products, contents or fragments of tumor cells in the bloodstream," he explains. As tumors require a blood supply in order to grow, he reasons that it must be possible to find traces of this sort in the bloodstream. The research is still in the early stages, but Reichmuth is optimistic that it will enjoy the same success as his award-winning master's thesis.

Nanoscience studies in brief

Beginning in 2002, the University of Basel was the first Swiss university to offer an interdisciplinary nanoscience program. Students receive a practice-oriented education and can graduate with both Bachelor's and Master's degree titles. In 2016, 104 students were enrolled on the Bachelor's degree program and 34 students took Master's courses. Eighteen students finished their Bachelor's degree and eleven completed their Master's degree. In 2016, we were able to welcome a total of six Erasmus students from Finland, Sweden, and Spain to the nanoscience program. Eight students from Basel used SNI scholarships to gain experience abroad.

In 2016, students were able to choose from more than 30 different block courses, some of which were offered for the first time. In these block courses, students work in various research groups at the University of Basel, the University of Applied Sciences and Arts Northwestern Switzerland, the Paul Scherrer Institute, and the Adolphe Merkle Institute. They gain practical experience and forge valuable contacts with working groups throughout the SNI network, which often lead to project work or Master's theses. In 2016, Dr. Katrein Spieler, the degree program coordinator, used software developed in-house for the first time to ensure optimal distribution of places on block courses.

Each year company visits are organized for the students to provide insights into applied research. In 2016, nanoscience students visited the companies ABB, BASF, Glas Trösch, Nanosurf, Rolic, and Sensirion as well as the research organizations CSEM and Empa.

In 2016, the SNI ran its second career workshop in collaboration with the Career Service Center at the University of Basel. Experts from the PSI, D-BSSE, and management consultants KPMG shared their experiences and raised the interest of numerous students and doctoral students.

The study of nanosciences in Basel is also gaining increasing international recognition. For example, the SNI was invited to contribute a chapter to the book "Global Perspectives of Nanoscience and Engineering Education", published in 2016 by Springer. The SNI was also asked to report on the study of nanosciences in Basel in 2016 by the editor of the renowned journal "Nature Nanotechnology".

Together through thick and thin

Two nanoscience students complete PhDs at McGill University in Montreal

Dr. Ann-Lauriene Haag and Dr. Zeno Schumacher studied nanosciences at the University of Basel from 2006 to 2011. In the course of their studies, both made use of scholarships from the Swiss Nanoscience Institute to complete project work for their course abroad. In this time, they established valuable contacts which subsequently led to positions as doctoral candidates for the two young researchers at McGill University in Montreal, Canada. With a nanoscience degree under their belts, Ann-Lauriene and Zeno were well equipped to work in a physics research group, and successfully completed their PhDs in July 2016.

A broad interest in the natural sciences
Dr. Ann-Lauriene Haag and Dr. Zeno Schumacher enrolled in the degree program in nanosciences in Basel in 2006. Ann-Lauriene Haag is from Kamp-Lintfort, a small town in the German state of North Rhine-Westphalia. An uncle had told her about a master's program in nanosciences in Saarbrücken. "Back then, I was interested in all the natural sciences, and was wavering mainly between physics and chemistry, so I was very interested in doing a course with a broad scope," she remembers in an interview. Looking for universities that offered nanosciences at bachelor level, she soon came across the University of Basel. "Since I also wanted to study abroad, the nanoscience course in Basel was a perfect fit," she adds. For Zeno Schumacher, it was attending the University of Basel's open day that made up his mind. A Swiss native from the Riehen area of Basel, he also had a general interest in the natural sciences, and was utterly convinced by the presentations at the open day that the nanosciences course was the one for him. "Besides the variety, I was also drawn to the course's innovative character – there weren't many universities offering degree programs in nanosciences at the time," he remarks.

Connections suddenly become clear
It was a decision neither of them has regretted since. Zeno has especially fond memories of Professor Dr. Christoph Bruder's lectures on quantum mechanics and electrodynamics, which had a lasting influence on him. Ann-Lauriene remembers how, particularly in the second and third years, connections between different subjects that had not previously been obvious suddenly became clear. Both enjoyed the cooperative atmosphere among students, the mutual support and the lasting friendships they made. They also highlight the practical experience afforded by the block courses. "The block courses gave us a taste of a whole range of different fields," says Ann-Lauriene. "We had the opportunity to discover what we enjoyed doing and find our own niche," adds Zeno.

Valuable experience abroad
Both Ann-Lauriene and Zeno soon realized that they wanted to gain experience outside of Switzerland and take advantage of the scholarships offered by the Swiss Nanoscience Institute to study abroad. They each completed one of the two projects required for the course in

"We encourage all students to maintain good relationships with their professors and to gain experience abroad while studying."

Dr. Zeno Schumacher and Dr. Ann-Lauriene Haag

the lab of Professor Dr. Peter Grütter at McGill University in Montreal. Ann-Lauriene then went on to work on her master's thesis at the California Institute of Technology in Pasadena, while Zeno moved to ETH Zurich. It was a valuable and memorable time for both of them, opening up doors and opportunities for doctoral projects. "We can wholeheartedly recommend going abroad for project work or research toward a master's," they both agree. "It's no big risk to go away for a few months. It's easy to get approval, as project work or research for a master's thesis do not involve any additional cost for the external professors, and you have the opportunity to start building a network."

Joint start in Montreal

In 2011, Ann-Lauriene and Zeno, who have since married, earned their master's degrees in nanoscience. Both had several potential doctoral positions to choose from, but the only option allowing them to embark upon this new chapter in their lives together was in Montreal, in the team led by Peter Grütter – who completed his own PhD under Professor Dr. Güntherodt in Basel. Ann-Lauriene's doctoral dissertation built on the topic of her earlier project work, exploring the basic principles for a cantilever sensor for DNA operating in solution. Zeno's doctoral research focused on organic solar cells which he excited using a laser beam and then examined with the help of an atomic force microscope. Neither had much difficulty making the transition from the nanosciences course to a physics research group. "At first we were wary about joining a physics group as nanoscience graduates, but it was reassuring to see that we knew a great deal and were in fact able to follow all the projects from the beginning." Peter Grütter, their doctoral supervisor, confirms that the couple's interdisciplinary training in Basel provided them with a solid foundation: "With their broad knowledge base and extensive practical experience, Ann-Lauriene and Zeno quickly became valuable members of my team."

Extensive experience

There can be no doubt that the likeable young couple enjoyed their four years in Montreal. The multicultural city, with its warm summers and cold winters, the ability to cycle everywhere and opportunities to travel throughout the country were just some of the highlights of their stay, as well as the excellent atmosphere in the research group. Nevertheless, in the long term Ann-Lauriene and Zeno would like to return to Switzerland. That said, settling down does not seem to be on the cards just yet. After completing their PhDs in July 2016, they went on a trip around the world. Zeno is currently applying for post-docs in Sweden and the US, while Ann-Lauriene has taken a break from research to found a startup company with her brother.

Whatever life holds in store for them, Ann-Lauriene Haag and Zeno Schumacher are glad that they studied nanosciences – not just because that is how they met, but also because it was the perfect way to quench their thirst for knowledge and sample so many different areas to find their ideal interests.

PhD School

“The winter school was a real boost for interdisciplinary learning.”

Tomaž Einfalt, Representative of the SNI doctoral students

Nanoscience in the Snow

Interdisciplinary SNI Winter School

Ever since the SNI founded its PhD School in 2012, the institute’s doctoral students have been gathering in the Swiss mountains at the height of winter. Yet instead of carving down the slopes, the young scientists use the time together to talk about their research. As coordinator of the SNI’s PhD School, Dr. Michel Calame set up the event and organized it in a different part of Switzerland every year. Michel Calame left the SNI at the start of 2017 to lead a department at Empa (Swiss Federal Laboratories for Materials Science and Technology), and handed over the reins of the PhD School to Dr. Andreas Baumgartner. Before he left, however, Michel Calame organized “Nanoscience in the Snow” one last time in January 2017 as coordinator.

Framework for interdisciplinary exchange

Doctoral students in the SNI’s PhD School met for the first “Nanoscience in the Snow” winter school in 2014. Dr. Michel Calame, the school’s former coordinator, had previously organized similar meetings for his working group and doctoral students at the National Centre of Competence in Research for Nanoscale Science. He felt that two days in the mountains offered the perfect setting for researchers to discuss their own work, learn from others, and make new contacts or extend existing ones. “I wanted to encourage this kind of intensive exchange between the SNI doctoral students, and also show them how beautiful Switzerland is,” says Michel Calame, recalling the beginnings of the winter gathering. “The idea was that the winter school would create a forum for interdisciplinary exchange – from biology to chemistry to physics. It would offer a colorful array of posters, tutorials by professors, and short presentations by the doctoral students.”

Contributions improving all the time

To date, the winter school has always been held in different locations: Kandersteg, Belalp, Zinal, and most recently in Zermatt. It has changed over the years, but the basic idea has remained the same. In the beginning, project managers and professors gave most of the talks. These days, however, the focus is on presentations by the doctoral students themselves. The SNI is currently funding 38 doctoral students, about a third of whom will complete their PhDs in 2017. This means there are plenty of fascinating research findings for the participants to present and discuss. “The quality of the presentations and posters has improved considerably over the years,” says Calame. “It’s wonderful to see the positive effects of the rhetoric and communication courses we run for the doctoral students, and of the previous winter schools and the Annual Event.” The winter school program still includes some talks by professors and project managers, who report on their research or their own experience. In Zermatt, for instance, Dr. Oren Knopfmacher gave a talk about his journey as the founder of a startup in Silicon Valley. He showed that, with a good idea, enough dedication, and a generous helping of luck, graduates of the PhD School could also have careers as entrepreneurs.

Relaxed and welcoming atmosphere

Another important aspect that has remained unchanged since the first winter school is the relaxed, casual atmosphere that makes it easy for even new doctoral students to enter the interdisciplinary group and make new contacts. Tomaž Einfalt, who was one of the SNI’s first PhD students and was elected as the doctoral students’ representative in 2015, summarizes it like this: “My time at the SNI’s PhD School was terrific. I learned a great deal – including things outside of my area of expertise – and

I connected with scientists from other disciplines, which might help me during my future career. The winter school was a real boost for interdisciplinary learning." Spending time together makes it much easier for the students to get to know each other. So every year, the winter school includes a group activity that is not directly linked to the students' research. In the early years, they went skiing, but other activities – such as attending an avalanche course or visiting an observatory – have been added since then.

Michel Calame, who coordinated the SNI's PhD School from 2012 until the end of 2016, moved to Empa at the start of 2017. He has handed over the running of the PhD School to the new coordinator, Dr. Andreas Baumgartner, a group leader in the Department of Physics at the University of Basel. Andreas Baumgartner is also planning to run a similar event that will encourage lively exchange between doctoral students from different departments and locations, and will promote interdisciplinary learning within the SNI's PhD School.

SNI PhD School in brief

In 2012, the Swiss Nanoscience Institute founded a PhD School to promote the education of young researchers in the nanosciences. The first doctoral students began their research activities in 2013. By the end of 2016, 38 doctoral students from 15 different countries were enrolled in the SNI PhD School. In 2016, seven further interdisciplinary projects were approved for doctoral dissertations; the application and selection process is currently underway.

All doctoral students at the SNI are supervised by two scientists from the SNI network. Currently, the Departments of Physics, Chemistry, Pharmaceutical Sciences, and the Biozentrum at the University of Basel as well as the partner institutions (University of Applied Sciences and Arts Northwestern Switzerland, Paul Scherrer Institute, University Hospital Basel, and the Department for Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel) are involved in the SNI PhD School. The SNI doctoral program was coordinated by Dr. Michel Calame until the end of 2016. Following his move to Empa at the start of 2017, the SNI PhD School is now coordinated by Dr. Andreas Baumgartner, a physicist.

At the Swiss NanoConvention 2016, the doctoral students in the SNI PhD School took the opportunity to present their work to an international audience. As in previous years, the SNI Winter School "Nanoscience in the Snow" and the annual event promoted interdisciplinary exchange within the PhD School. All doctoral students are encouraged to present their work through a poster or talk at both events.

The "Rhetoric and Communication" course, which took place for the second time in 2016, teaches SNI doctoral students to give good presentations. It looks at general presentation techniques as well as personal style and using clear examples to help audiences gain a better understanding of complex topics.

As the first doctoral students approach the end of their dissertations, the focus is increasing on the next stage of their careers. A career workshop organized by the SNI in 2016 offered valuable insights and a field trip to F. Hoffmann-La Roche AG in Basel showed the doctoral students how to gain entry to the pharmaceutical industry. A visit to CERN in Geneva organized by the doctoral students themselves also provided valuable information. In addition, a talk by and discussions with Dr. Oren Knopfmacher, the young founder of a start-up in Silicon Valley, had SNI doctoral students talking about the future during the Winter School.

First doctorate awarded to student at SNI's PhD school

Jan Nowakowski learned a great deal and enjoyed his time here

In 2013, the first doctoral students at the SNI's PhD school started work on their research projects. By the end of June 2016, Dr. Jan Nowakowski's studies were completed. He was the first of the 38 doctoral students currently at the SNI to be awarded his doctorate, passing his examination with flying colors.

Work at the PSI
Jan Nowakowski conducted his research at the Paul Scherrer Institute (PSI), in Professor Dr. Thomas Jung's group. He looked at how molecules containing metal ions behave on different substrates. This involved analyzing the magnetic properties of porphyrins on magnetic surfaces, for example. These organic pigments, which are present in the protein hemoglobin and whose functions include transporting oxygen in the blood, change both their configuration and their magnetic properties depending on their binding with gases. This makes porphyrins suitable for numerous applications, for example in sensitive gas sensors or for data storage.

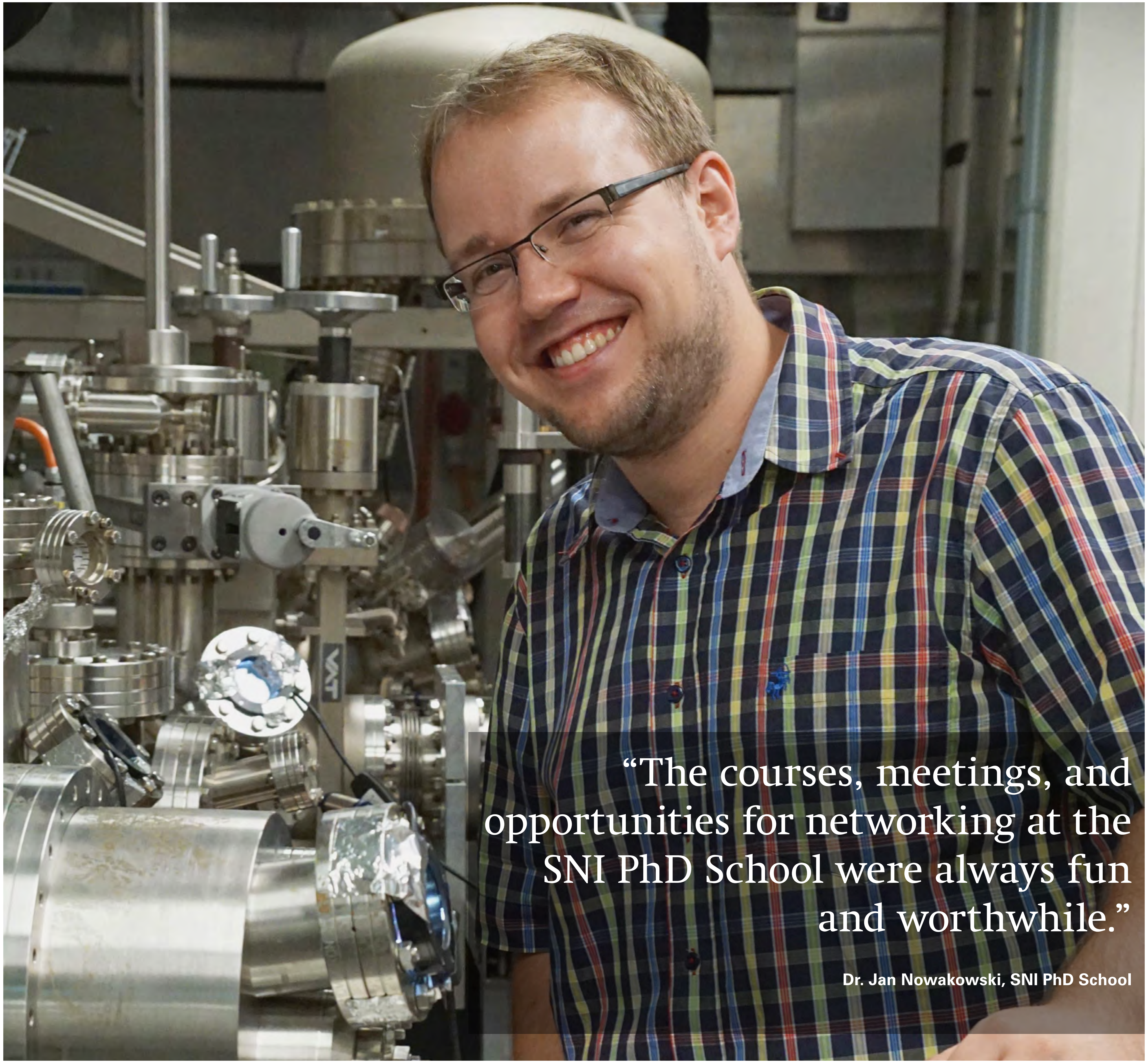
Reactions achievable even at room temperature – with oxygen
Porphyrins have the capacity to pick up metal ions from a surface at high temperatures. Scientists can make use of this so-called metalation reaction to produce modified porphyrins that cannot be synthesized in solution. While working on his doctoral dissertation, Jan Nowakowski discovered that porphyrins can react with metal ions even at room temperature. For that to happen, there need to be oxygen atoms on the surface, which catalyze the reaction. With this discovery, Jan Nowakowski has not only simplified the process of metal ion pick-up by porphyrins but also contributed to our general understanding of surface chemistry and showed how to modify the chemical properties of surfaces, which may lead to the development of new products.

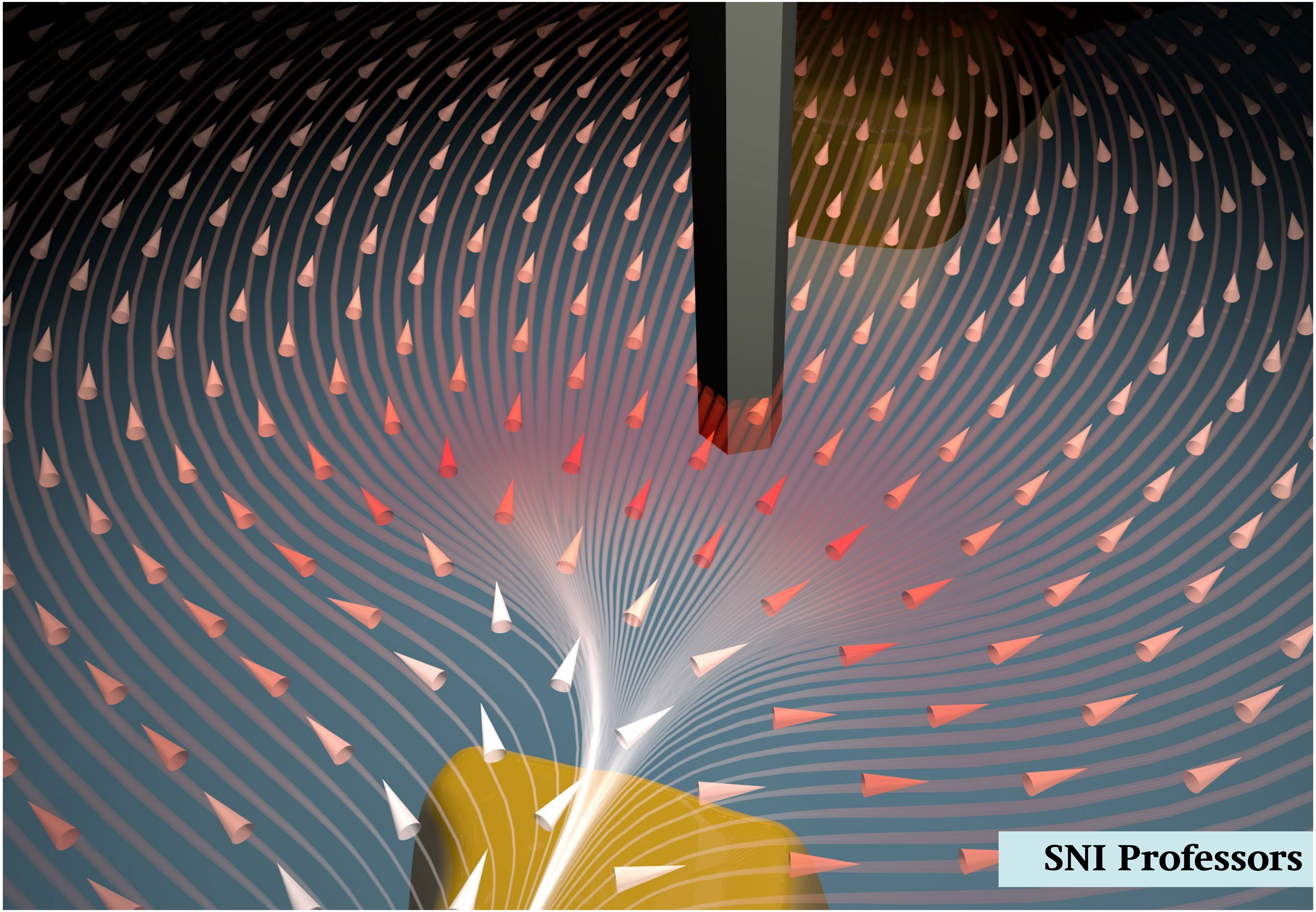
Special conditions
Studying the magnetic properties of individual porphyrins is a complex undertaking, as it is carried out in ultra-high vacuum conditions. They can be analyzed particularly well using the PSI's synchrotron light source. This extremely intense X-ray light allows to examine magnetic properties of a sample for each element separately. Jan Nowakowski had experience of working at ultra-high vacuum from his master's thesis, when he was already part of Thomas Jung's team. "I have learnt a great deal in the last few years," he observes. "When you are working with ultra-high vacuum, any mistake can cost you between one and several days, so it makes sense to learn from your mistakes," he adds with a broad smile.

Night shifts as routine
Working with the synchrotron differs from normal lab work in another respect. As there are many other groups that also want to carry out measurements, users are allocated specific time slots, which must be kept to and cannot generally be moved around. Thomas Jung's group – and hence Jan Nowakowski – preferred to take the night shifts for these measurement phases, as it leaves time for sample preparation during the day and the fresh samples can be measured at night. That meant that, while working on his master's and his PhD, Jan Nowakowski spent about six months in total taking measurements with the synchrotron at night.

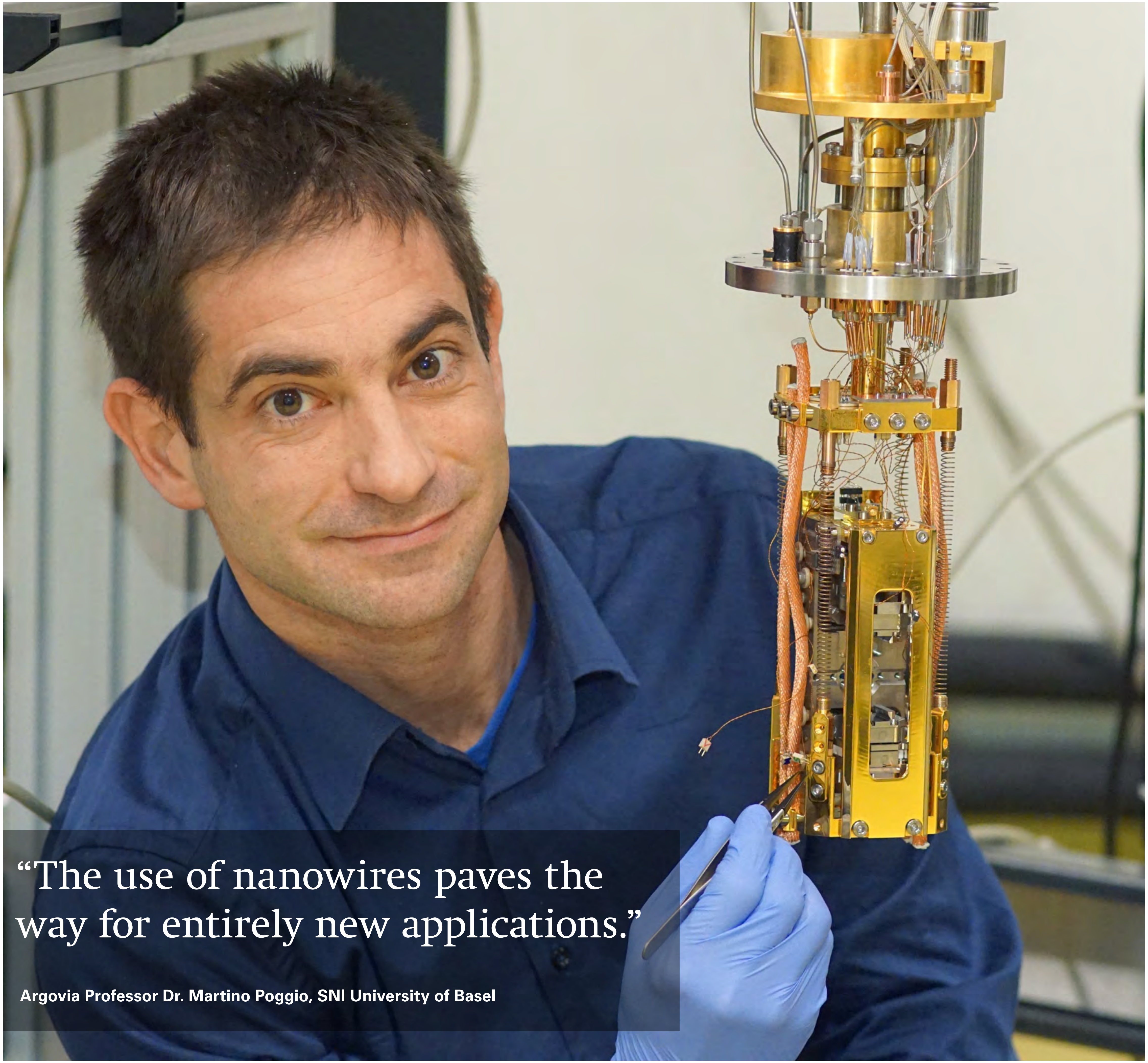
Abiding memories
Those nights will probably be what Jan Nowakowski remembers most in later life. He will also have lasting memories of the other activities within the SNI's PhD school – for example, the annual conferences in Lenzerheide, where he and his colleagues were able to present their initial findings and engage in discussion with scientists from other disciplines and other institutions in the SNI network, or the rhetoric and communication workshop, in which he was an enthusiastic participant in spring 2016. This called for completely different skills from those needed in day-to-day lab work. In one exercise, Jan Nowakowski gave a fairy-tale description of his laboratory so that anyone would want to work in such an enchanted place, with its magical atmosphere.

Next step beckons
The newly qualified doctor of nanoscience is now looking for a job. As his enthusiasm for research and for nanoscience is as strong as ever, he is keen to continue doing research in this area, though he would like to go into industry. His interdisciplinary training at the SNI's PhD school definitely provides a good foundation for this next step in his career. We wish Jan Nowakowski – the SNI PhD School's first doctor – the best of luck and every success in the future.





SNI Professors



“The use of nanowires paves the way for entirely new applications.”

Argovia Professor Dr. Martino Poggio, SNI University of Basel

Sensing size and direction

Nanowire sensors in atomic force microscopy

For the SNI, in addition to being a year of major events, 2016 was also a big year for atomic force microscopy. 30 years ago, SNI vice director Professor Dr. Christoph Gerber played a key part in developing the atomic force microscope (AFM), a highly versatile instrument for which he was awarded the prestigious Kavli Prize in September 2016 alongside his colleagues Professor Dr. Calvin Quate and Dr. Gerd Binnig. The distinction sparked a wave of local and international media interest in the AFM and its role in unlocking the secrets of the nanoworld. The technology’s ongoing success received another boost this year from the research being carried out by Argovia Professor Dr. Martino Poggio and his team. Using nanowires as sensors, they were able to measure both the size and direction of forces – a breakthrough in relation to standard AFM devices. They decribed the innovation in the journal “Nature Nanotechnology”* in October.

* Nicola Rossi, Floris R. Braakman, Davide Cadeddu, Denis Vasyukov, Gözde Tütüncüoglu, Anna Fontcuberta i Morral & Martino Poggio
Vectorial scanning force microcopy using a nanowire sensor
Nature Nanotechnology (2016), doi: 10.1038/nnano.2016.189

Nanowires as highly accurate sensors
Martino Poggio and his team have been exploring the possibility of using nanowires as highly accurate sensors for several years. Nanowires are extremely tiny filamentary crystals, which feature an almost defect-free crystal lattice structure. They are generally no thicker than 100 nanometers, making them around a thousand times thinner than a human hair. Their tiny dimensions mean they have an extremely large surface area in relation to their volume, and very low mass. These characteristics make nanowires excellently suited for use as minute sensors for biological and chemical samples, or as pressure or load sensors.

Charting size and direction
In their recent paper, Poggio's team demonstrated that nanowires can also be used as sensors in atomic force microscopes to measure forces. Whereas the sensor in standard AFMs consists of a needle mounted on the tip of a silicon cantilever that scans the surface of the sample, Poggio and his team used gallium arsenide nanowires created by their colleagues at EPF Lausanne. Due to their particular mechanical properties, these nanowires vibrate along two perpendicular axes at roughly the same frequency. When a nanowire is incorporated into an atomic force microscope to scan a sample, the vibrations change according to the size and direction of the forces acting on it. These changes can be measured, resulting in an image of the force field surrounding the sample. The nanowire behaves like the needle of a minute mechanical compass, indicating both the size and direction of the surrounding forces.

Technical challenge
For the researchers in Basel, the first technical hurdle was building a device able to simultaneously scan the tiny nanowire over the surface of a sample and measure the vibrations occurring in it along two perpendicular directions. Once they had successfully incorporated the nanowire into an AFM, they used minute electrodes to generate test force fields which they were able to accurately map on the basis of their measurements. The nanowire compass was then used to successfully map out the two-dimensional force field over an unknown structured sample surface, and the new AFM was complete.

The development of this new form of atomic force microscopy opens up new potential applications for the device, already an indispensable tool in fields such as solid-state physics, material sciences, biology and medicine. "Replacing the conventionally used crystalline silicon cantilever with substantially smaller nanowires will open the door to further improvements to this immensely successful technology," remarks Martino Poggio, adding that with the appropriate modifications, the potential uses of this new generation of AFM include examining the magnetic forces of a range of sample types. Furthermore, using nanowires with tapered tips could further boost the device's precision, giving rise to images in atomic or even sub-atomic resolution.

SNI professors in brief

The Swiss Nanoscience Institute has supported the two Argovia professors Dr. Roderick Lim and Dr. Martino Poggio since they began working at the SNI. Roderick Lim focuses on nuclear pore complexes in biological membranes in order to study how metabolic transport between the nucleus and the cytoplasma functions. Martino Poggio and his team conduct research into nanomagnetism and nanomechanics. Among others, he studies nanowires and their application as multifunctional sensors.

In 2016, Lim and Poggio presented their research results in ten papers in recognized scientific journals and in 29 lectures by themselves or members of their research group at various international and national conferences. In addition to the funding they received from the SNI, Lim and Poggio have together raised external funding of CHF 1.45 million for their research.

The SNI also supports the three titular professors Dr. Thomas Jung, Dr. Michel Kenzelmann, and Dr. Frithjof Nolting. All three teach in the Department of Physics at the University of Basel and lead research groups at the Paul Scherrer Institute. Thomas Jung is also responsible for the Nanolab in the Department of Physics at the University of Basel.

Fathoming natural nanomachine

SNI team looks inside nuclear pore complexes for the first time

The 2016 Nobel Prize in chemistry was awarded for the design and synthesis of a nanomachine. Argovia Professor Dr. Roderick Lim has also been investigating a nanomachine – the nuclear pore complex – for several years, and hopes to use his findings to build artificial nanomachines. In May 2016, Lim published the first ever video of the dynamic processes occurring in a natural nuclear pore complex in the journal "Nature Nanotechnology"*. Using a high-speed atomic force microscope, Yusuke Sakiyama – an SNI PhD student on Lim's team – was the first person on Earth to watch individual nuclear pore complexes at work, thereby confirming the hypothesis proposed by Lim on how nuclear pore complexes function.

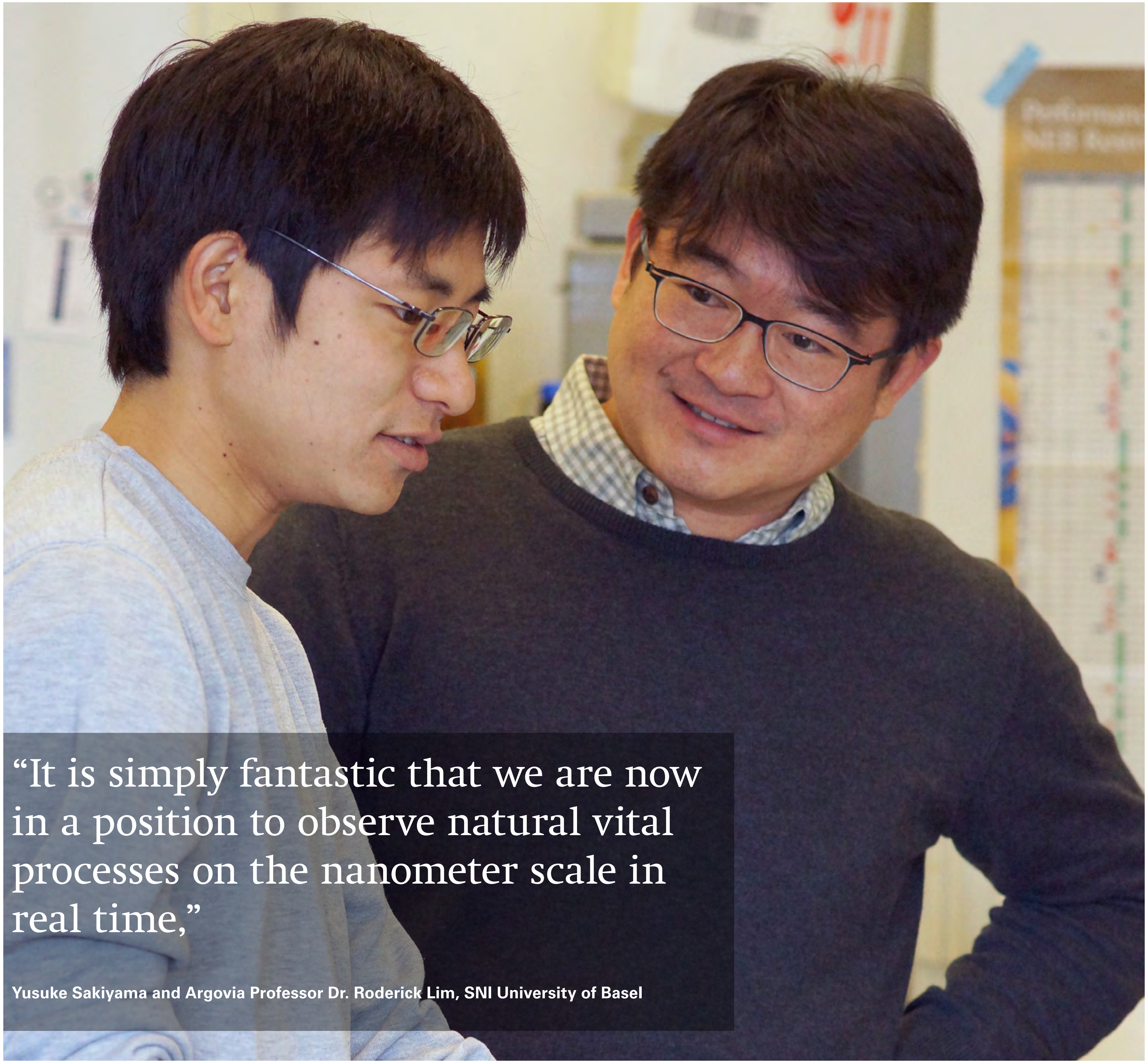
Natural nanomachines as molecular filters
Inside the cells of higher organisms, numerous perfectly functioning nanomachines are hard at work. There are small factories providing energy or forming a wide range of compounds. Alongside them are minute motors and complete transport systems which ensure that the right substances reach the various areas of the cell. One of these ingenious transport systems is the nuclear pore complex. Vast numbers of these remarkable pores, which act as highly effective molecular filters, regulate the exchange of compounds between the cell nucleus and the surrounding cytoplasm. Water and smaller molecules are able to pass through these barriers along a concentration gradient by diffusion. However, most larger molecules are prevented from entering the cell nucleus. Only those which perform certain functions in the cell nucleus are able to enter it by binding to transport proteins.

Transport and selection are regulated by specific proteins in the pore known as phenylalanine-glycine nucleoporins, or FG Nups. These proteins form the molecular barrier that only allows specific molecules to pass. The overall structure of nuclear pores has been known for a long time. However, it has so far remained unclear just how FG Nups operate, and how they prevent larger molecules from passing through the pore.

New findings obtained thanks to high-speed AFM
This year, Roderick Lim and his team gained new insights into how nuclear pore complexes work. Using a high-speed atomic force microscope (HS-AFM), Yusuke Sakiyama, a PhD student in Roderick Lim's laboratory, and Adam Mazur of the Biozentrum's Research IT group were able to observe the passage of molecules through the nuclear pores for the first time, and even capture the phenomenon in a short film.

To this end, the researchers examined the comparatively large nuclear pores of a frog. Even here, the diameter of the central pore channel measures just 40 nano-

* Yusuke Sakiyama, Adam Mazur, Larisa E. Kapinos and Roderick Y.H. Lim
Spatiotemporal dynamics of the nuclear pore complex transport barrier resolved by high-speed atomic force microscopy
Nature Nanotechnology (2016), doi: 10.1038/nnano.2016.62



Yusuke Sakiyama and Argovia Professor Dr. Roderick Lim, SNI University of Basel

meters. “It is simply fantastic that we are now in a position to observe natural vital processes on the nanometer scale in real time, and finally gain insights we have been working toward for years,” said Roderick Lim of the innovation.

A barrier of undulating tentacles

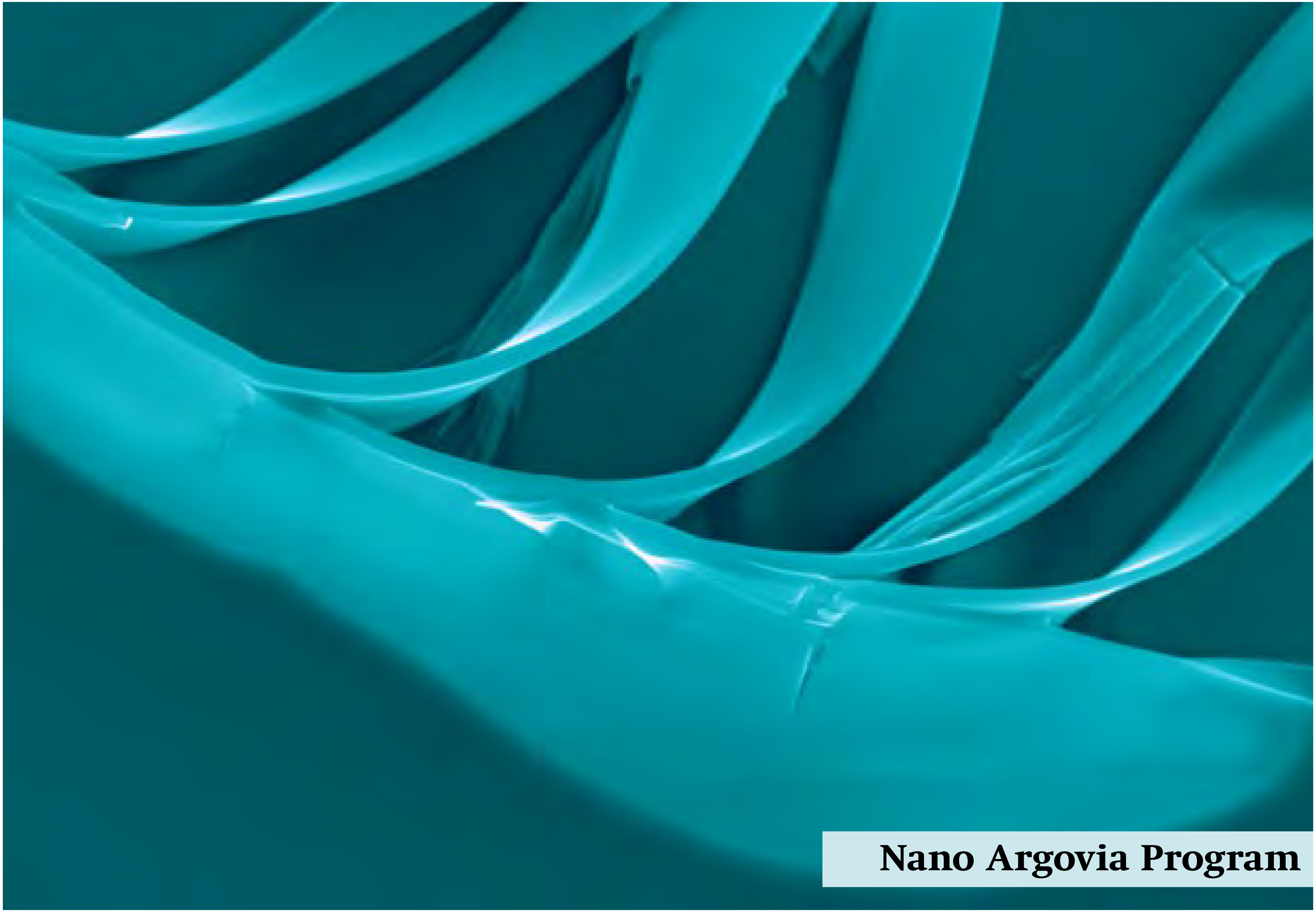
Watching the first recordings, the researchers soon noticed that some pores became “blocked” by molecules passing through them. In order to conduct a more detailed examination, Lim’s team then observed “open” pores with no molecules lodged in the central pore channel. To obtain the film sequences, the researchers recorded still images of the pore under examination at intervals of around 100 milliseconds, which they then edited together. The resulting films revealed that the arrangement and structure of the FG Nups changed constantly. The FG Nups behaved like tentacles, extending into the pore, elongating and momentarily interlinking to form short-lived “condensates” inside the central pore channel. At no point in the observations did the arrangement of the FG Nups stay the same, even though their individual tethering points on the pore walls remained constant. The FG Nups also occasionally formed sieve-like structures, although these were not static states as sometimes described in the literature.

“The speed of these dynamic movements determines which molecules are allowed to pass through the pore,” explains Lim. “The FG Nups move at a faster rate than large proteins, denying them access to the nuclear pore complex. Small molecules, meanwhile, are more agile, enabling them to pass through the FG Nups barrier.”

Further questions remain

The footage supports the hypothesis proposed by Roderick Lim that transport is not determined by the static arrangement of FG Nups, but rather by their dynamic shape-changing behavior. While a number of questions have been answered by these first striking recordings of the nuclear pore complex, it still remains unclear how large molecules are able to overcome the FG Nups barrier. “We are nevertheless confident that further investigation will resolve this issue, too,” claims Lim.

Understanding how these selective transport systems work would pave the way for synthetic creation of similar nanomachines, for instance as components in tiny molecular factories.



Nano Argovia Program

Working as a team to track down single cells

Researchers from the Nano Argovia program develop a system for analyzing single cells

In the Argovia project SCeNA (Single Cell NanoAnalytics), an interdisciplinary team of scientists led by Dr. Thomas Braun (C-CINA, Biozentrum, University of Basel) has developed a system that can be used to analyze a variety of parameters associated with single cells. The researchers focus on analyzing single cells as there can be considerable differences between the cells found in a tissue or cell culture. If a mixture containing thousands of cells is analyzed, as in a standard analysis, the researchers obtain only mean values and no information on individual differences. It is also impossible to observe interactions between cells in the measurement results. The analysis of single cells, however, yields a clear picture that permits a different set of statistical analyses and conclusions regarding different populations within the culture.

Means are not always meaningful
There are differences between the individual cells in a tissue or in a cell culture. For example, there are variations in the proteins that are formed, and individual cells can also vary widely in the level of low molecular weight compounds they contain. If all the cells in a cell culture are processed and analyzed together, these individual differences disappear and the researchers obtain nothing more than an overview of the mean values. Still, to understand how diseases develop, spread, and can be treated, it is essential to know how the individual cells behave and what metabolic processes are taking place inside them. It also important to examine the interactions between the cells, for example to improve our understanding of how neurodegenerative diseases such as Parkinson's and Alzheimer's spread.

Therefore, the team of scientists involved in the SCeNA project set themselves the aim of constructing a system for the automated analysis of a range of variables relating to single cells. Obtaining meaningful answers to a specific problem requires the observation of a large number of cells, so effective sample preparation and smooth transfer to the various analyzers is key.

A compact system for selecting and processing single cells
Stefan Arnold, who has been a PhD student at the Swiss Nanoscience Institute's PhD School since 2013, laid the foundations for this approach in his doctoral dissertation. He developed a compact system that allows him to grow cells in a cell culture, examine them under an optical microscope, and select single cells in a highly targeted manner. Subsequently, he uses an electrical field to make the cell membrane permeable before sucking out the entire cell contents, a few nanoliters in all, into a microcapillary in a matter of seconds. Depending on the planned analysis, this lysate is then applied to specific microscope slides or grids. "Unlike in the preparation of an entire cell culture, our approach allows us to obtain a precise overview of the contents of single cells. Our cells are also exposed to less stress, as they are living in their adherent cell culture and are interacting

"Our system allows us to investigate specific cells in an adherent cell culture and improve our understanding of their biology."

Dr. Thomas Braun, Dr. Gregor Dernick, Dr. Christian Berchtold and Stefan Arnold
Partner in the Argovia project SCeNA

with one another until a few seconds before processing," Stefan Arnold explains.

Sample preparation is followed, for example, by examination on an electron or scanning force microscope, allowing the proteins contained in the cells to be visualized and identified. This analysis does not require labelling, but the samples must be desalted and partially treated with heavy metal salts to increase the contrast.

Viscosity indicates RNA binding
The researchers are interested not only in the proteins that the sample already contains but also in the nucleic acids (RNA) involved in the production of proteins. With this in mind, the scientists first measure the viscosity of the sample using a high-throughput microfluidic system that was developed in-house. Their plan is then to take complementary RNA sequences for the RNA fragments they want to detect and add these to the sample. If this results in binding and hence the formation of double strands, the resulting change in the sample's viscosity can be measured precisely even in the case of small sample volumes.

Further analyses by the partners
Further analyses are conducted by the project partners. For example, Dr. Gregor Dernick of the Roche pRED Innovation Center Basel investigated how antibodies can be used to detect specific proteins in the cells. The system was adapted so that, within a period of 90 minutes, 192 single cells could be selected, lysed, and placed on a single coated slide for analysis. "With heat shock proteins, we showed that antibodies can be used to detect specific proteins reliably and in a short period of time," Gregor Dernick reports.

Partners from the FHNW School of Life Sciences in Muttenz expand the range of investigations even further with mass spectrometric analyses. Professor Dr. Götz Schlotterbeck and Dr. Christian Berchtold face the problem of achieving the necessary sensitivity to detect various low molecular weight compounds in single cells. So far, they are able to search for specific substances in a targeted manner in a lysate mixture of about ten cells. It will therefore be necessary to further optimize the system's sensitivity before information can be obtained on the low molecular weight metabolites of a single cell.

A successful conclusion
"We succeeded in developing an effective selection, preparation, and hand-over system for a wide range of single cell analyses. This system is largely automated, allowing a large number of single cells from an adherent cell culture to be processed in a short time," concludes project leader Thomas Braun with regard to the results of the Argovia project SCeNa. Braun's research group is working to further optimize various aspects of this single cell analysis, so refinements can be expected over the next few years and will most likely be followed by applications that are tailored to concrete scientific questions.

Argovia program in brief

The Argovia program bridges the gap between the basic scientific research conducted at the SNI and its industrial applications. Each Argovia project pairs two academic partners from the SNI network with an industrial company from Northwestern Switzerland. The team first spends one year examining the feasibility of various nanotechnology approaches which mostly originated from the research conducted at the SNI. In 2016, eleven Argovia projects received total funding of approximately CHF 1.4 million. Six of the collaborations (55%) involved companies from the Canton of Aargau. Three Argovia projects continued in 2016 without additional costs.

Industrial companies that participated in Argovia projects finalized in 2015 were surveyed again in 2016 regarding their satisfaction with the projects. The seven companies surveyed stated an average satisfaction level of 92% and confirmed that they would participate in another Argovia project.

In 2016, the Nano Argovia program resulted in a total of 26 publications and the filing of three patents.

Structure is everything

How different surfaces affect properties

Nature is filled with examples of surfaces that have particular properties due to their structure. A special nano- and microstructure, for instance, allows butterfly wings to shimmer in different colors without any pigments at all. Some leaf surfaces cause water and dirt to simply roll off them, and cicada wings have a certain surface structure that stops microorganisms taking up residence. Research teams around the world are investigating these types of phenomena and attempting to simulate them for a vast range of applications. Some of the interdisciplinary teams in current Argovia projects are also working on producing special surfaces to suit their specific needs. The RepAll and Nano Cicada Wing projects are aiming to develop a fairly rough, structured surface that prevents water and bacteria from sticking to it. Researchers in the SurfFlow project, by contrast, are trying to produce the smoothest surfaces possible for the small polymer lenses they are developing for optical applications.

Nothing should stick
The team in the RepAll Argovia project is laying the groundwork for producing surfaces that make water and other liquids roll off them – very similar to what happens with lotuses and duck feathers. Researchers working under project leader Dr. Sonja Neuhaus from the FHNW School of Engineering in Windisch are using nature as their model. They are testing out various ways of producing structured and chemically modified surfaces that repel various liquids.

The researchers began by using electron beam lithography to make stamps that then allowed them to transfer structures onto polymer films via roller and hot stamping. This results in synthetic surfaces with patterns of tiny hollow and solid pillars that are much less wettable than solid surfaces are. To measure the wettability, the team recorded the contact angle between the drops of liquid and the surface. The lower the interaction between the liquid and the surface, the bigger the contact angle (also known as the wetting angle). The researchers also used wire mesh as a stamp to make surfaces more repellent to various liquids and thus achieve their aim of significantly reducing wettability.

Improvements through chemical modification
For a variety of applications, it is not only important to increase the contact angle, but also to reduce the roll-off angle (which indicates how much a surface needs to be tilted before droplets roll off it). Initially, structuring the surfaces increased the roll-off angle. Chemically modifying the surfaces, however, reduces the incline needed to make the droplets roll off. To this end, the researchers produced fluid-like surfaces which improved the roll-off of both water and oil.

The interdisciplinary team of researchers from FHNW, PSI, and the company Cellpack Packaging AG have produced structured synthetic surfaces that cause a variety of liquids to run off well. However, achieving the desired effects is a complex process and difficult to transfer to an industrial scale. Nonetheless, researchers will continue down the path they are currently on and will intensify their research into combining structuring methods with chemical functionalization.

As antibacterial as cicada wings
Within the Nano Cicada Wing Argovia project, researchers from the University of Basel, the FHNW School of Life Sciences in Muttenz, and the company DSM in Kaiseraugst want to equip surfaces with bactericidal properties without using antimicrobial active substances. They are basing their work on cicada wings, which have a special surface structure that inhibits bacterial growth. The wings are peppered with nano-sized, pillar-like structures that make the wings highly hydrophobic but allow bacteria to stick to them well – so well, in fact, that when the tiny pillars move, the bacteria die because their cell membranes stretch and ultimately rip. This bactericidal effect is based on a purely mechanical principle, not on bactericidal or antibiotic substances. The hope is that bacteria will be slower to develop resistances to this mechanical mechanism.

Structuring prevents adhesion
Other groups have successfully simulated this principle on silicon and titanium surfaces, and now the Nano Cicada Wing researchers want to apply the findings to synthetic surfaces, as they offer a wide spectrum of possible applications. To do this, the team working under project leader Professor Dr. Ernst Meyer started by using low-energy plasma etching to produce polymer surfaces with nanometer-sized columns arranged with varying degrees of compactness. Unlike the surface's natural prototype – the cicada's wings – bacteria in liquids survived contact with the structured polycarbonate surface to the same extent as bacteria that came into contact with a non-structured control surface. However, the number of bacteria that adhered to the surface fell significantly – by 60% in the case of the intestinal bacterium *E. coli*.

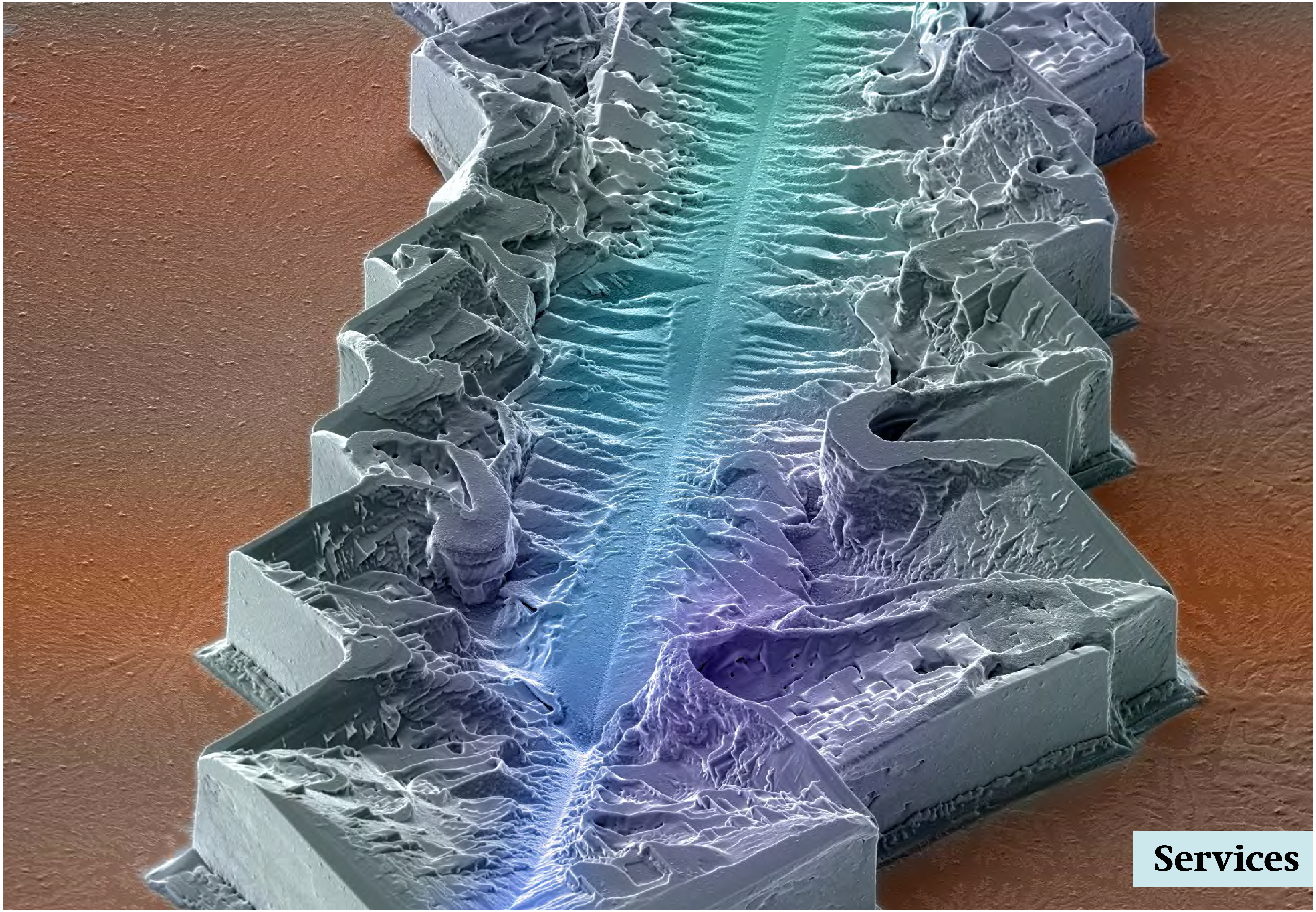
In situ studies using an atomic force microscope showed that only a small number of the bacteria died on the structured surface. Some of the bacterial membranes were destroyed. However, as the process takes many hours, the researchers suspect that the bacteria were more likely to have died from starvation than from the membrane rupturing when the columns moved. Experiments conducted so far suggest that the structured polymer surfaces have a relatively minor antibacterial effect. Experiments with materials such as titanium and tungsten, however, show a larger effect. In future, researchers will investigate applications in the field of dental implants in collaboration with the University Center for Dental Medicine Basel (UZB).

As smooth as possible
While the RepAll and Nano Cicada Wing projects are aiming for structured surfaces, researchers in the SurfFlow Argovia project want to make polymers with very smooth surfaces. The team working under project leader Dr. Helmut Schift of the Paul Scherrer Institute (PSI) are working with the kind of optical polymer microlenses that are found in devices such as smartphones. To produce larger quantities of these small lenses, the researchers begin by using 3D lithography to make master structures out of thin layers. However, the master structures and the resulting lenses have rough surfaces that are problematic for optical applications. The SurfFlow researchers from PSI, the FHNW School of Engineering in Windisch, and the company Heptagon are investigating how they can subsequently smooth out the surface without changing the underlying layers or affecting the shape of the lenses.

Just the surface, not the shape
In working toward their goal, the researchers applied the TASTE method that was developed at PSI. This involves selectively changing the material properties of the sample section that is due to be changed at a later stage. The researchers illuminated the master structure with short-wave UV light to modify the polymers. This also alters the temperature at which these polymers change from a solid state into a thick molten mass (glass transition temperature). The researchers have now succeeded in lowering the glass transition temperature of a thin surface layer. When the sample is then warmed to a specific temperature on a hotplate, only the treated surface starts to melt a little. It becomes smoother, while the shape and the underlying layers remain practically unchanged. This method allowed the SurfFlow researchers to reduce the roughness of their polymer lenses in the nanometer scale, while retaining structural details of a few micrometers in size.

"The Nano Argovia Program is very valuable, as it allows us to pursue innovative ideas."

Dr. Sonja Neuhaus, School of Engineering, FHNW



Services

A broader range of services

The SNI now offers an even more comprehensive package of services covering every aspect of electron and atomic force microscopy

"We offer a comprehensive service for everything related to imaging."

Dr. Markus Dürrenberger, Dr. Monica Schönenberger, Evi Bieler, Daniel Mathys and Susanne Erpel, SNI University of Basel

In early 2016, the SNI gave a major boost to its portfolio of imaging services with the creation of the Nano Imaging Lab (NI Lab). The NI Lab team is made up of Evi Bieler, Susanne Erpel, Daniel Mathys and Dr. Markus Dürrenberger – all from the former Center for Microscopy Basel (ZMB) – and Dr. Monica Schönenberger, previously at the helm of the SNI's Nanotech Service Lab (NSL). The Nano Imaging Lab now offers clients in the SNI network and external bodies alike a comprehensive range of services devoted to imaging minute structures.

Decades of experience at the service of clients

The SNI had already been providing detailed surface imaging services to internal and external clients for several years with its Nanotech Service Lab (NSL). The creation of the Nano Imaging Lab (NI Lab) at the start of 2016 was accompanied by a considerable expansion of the range of services on offer. The new service unit is staffed by Evi Bieler, Susanne Erpel, Daniel Mathys and group leader Dr. Markus Dürrenberger of the former Center for Microscopy Basel (ZMB) along with Dr. Monica Schönenberger (previously of the NSL), and conducts an extensive range of microscopic analyses to internal and external clients alike. The five specialists benefit from decades of combined experience in the field of atomic force and electron microscopy, and are equipped to handle the most varied research issues. Depending on the nature of the sample and the client's needs, the NI Lab has a range of microscopes at its disposal.

Surface analyses

For instance, Monica Schönenberger is involved in the Argovia project NanoSilkTex. The project's goal is to combine the useful properties of silk with those of synthetic textiles, an endeavor requiring highly detailed information on changes in surface structure obtained with the help of an atomic force microscope (AFM). The need for detailed surface analyses at nanometer resolution was also what led Basel-based company Rolic Technologies Ltd. (Allschwil, Switzerland) to turn to the experts at the NI Lab for help. Last year, the company commissioned the NI Lab to perform numerous roughness analyses on thin polymer films for quality control using atomic force microscopy.

Many other research problems call for the NI Lab's electron microscopes. Last year, for instance, Evi Bieler used the scanning electron microscope (SEM) to examine how different bone replacement materials are colonized by cells. The project, led by Professor Dr. Ivan Martin of University Hospital Basel, has a twofold objective: to assess how well body cells respond to the implants, and to determine how certain materials affect unwanted bacterial growth. The detailed images provided by the NI Lab help the researchers choose the most appropriate surface structures and materials.

Special treatment for sensitive samples

The NI Lab examines particularly sensitive samples, such as the mirrors for use in the planned ITER fusion reactor, with a cold-field-emission microscope. Dr. Laurent Marot of the University of Basel's Department of Physics, who is involved in the ITER project, has developed a method for cleaning the light-conducting mirror surfaces inside the ITER fusion reactor. To test the method, it is important to examine the highly sensitive mirrors at an extremely high resolution without subjecting them to damaging radiation.

Just as sensitive are the samples examined by the NI Lab for the State Viticultural Institute in Freiburg, Germany. Here, the aim is to find out how the micro- and nanostructure of different vine varieties affects the susceptibility of leaves and grapes to pests. To this end, the samples were first flash-frozen and then analyzed in a deep-frozen state at an examination temperature of -150° Celsius, ensuring largely artifact-free specimens.

Modifications also an option

Besides conducting detailed analyses, the NI Lab team is also able to make precisely targeted alterations to samples. Using a scanning electron microscope equipped with a focused ion beam (FIB), samples can be cut and manipulated with very high precision. Daniel Mathys has familiarized himself with this technology in recent years, and is now able to use the ion beam to modify samples with a very high degree of accuracy. In two of his latest projects he examined the layer structure of solar cells and produced special silicon cantilevers which can be used to closely study and influence the mechanics of cell division.

Analyzing elements and inner structures

Images are not the only way in which the lab's fleet of microscopes help solve research problems, however. Spectroscopic analysis can also be used to obtain a qualitative and quantitative description of most of the elements contained in a sample. For example, the NI Lab recently analyzed passively collected air samples on newly developed boron substrates for Particle Vision GmbH, supporting the analysis and services offered by the company.

The lab also investigates a wide range of nanoparticles. Using a transmission electron microscope, which allows researchers to image a sample's internal structure, a group led by Professor Dr. Wolfgang Meier of the Department of Chemistry is exploring the possibilities offered by nanocontainers. The focus of the research is on the size distribution of the vesicles, which can be filled with a variety of substances, as well as the contents themselves.

An attentive ear

Numerous other projects have been tackled by the Nano Imaging Lab's accomplished team in the past year. In addition, Christian Schönenberger and Markus Dürrenberger have drafted a business plan more suited to the Lab's new requirements as a part of the SNI Network. Susanne Erpel, who only joined the NI Lab in March 2016, has settled in very well, and the five-strong team now eagerly awaits the diverse challenges that lie ahead. They invariably have an attentive ear for clients' needs, and can undertake as many project stages as desired, from sample preparation to documentation. They are also on hand to train clients in the use of the various devices should they prefer to conduct analyses themselves in the course of longer-term projects.

As well as providing tailored services to clients, the NI Lab also has a teaching role, and is involved in the outreach activities of the Biozentrum and SNI. Students at the Biozentrum and on the nanoscience study program alike have been benefiting from the NI Lab's expertise for years. Again and again, bachelor students have praised the block courses offered by the lab as a highlight of their studies – to say nothing of the younger visitors who were enthralled by the NI Lab's fantastic images at the Future Day held in November 2016.

A helping hand enables innovative ideas

Workshops play a valuable role

Since its formation, the SNI has supported the workshops at the University of Basel's Department of Physics. In return, the workshops offer services to the researchers of the SNI network which are often crucial to the execution of novel ideas. In 2016, for instance, the electronics and mechanics workshops were instrumental in refining an electronic nose which the team led by Kavli Laureate Professor Dr. Christoph Gerber has been working on for several years. A research alliance has now been formed to manufacture the device for the first time in small batches for external research groups.

Distortion alters resistance

For some years now, the team led by Christoph Gerber has been developing electronic noses employing minute mechanical sensors that react to trace small amounts of gaseous substances. Each of these microfabricated silicon sensors consists of a round membrane measuring around 1 mm in diameter, held in place within a frame by four tiny beams. The electronic nose developed in Basel combines eight such sensors, with each membrane coated in a different polymer. When a gaseous sample is pumped over the sensors, the molecules in the sample are absorbed into the polymer networks. These networks then swell at different rates and to different degrees depending on the substances present in the sample, resulting in a distortion of the membrane that causes the silicon beams to bend. The beams are fitted with piezoelectric resistors connected to form measurement bridges which convert the distortion into an electrical signal that can be accurately measured by the device's electronic components.

Electronic noses for end users

The team behind the device has already used it to identify specific trace compounds in the exhaled breath of cancer patients which provide clear evidence of the disease with no need for biopsies. In fact, the technology has now matured to the extent that other research groups are interested in acquiring an electronic nose for their own applications. A project funded mainly by the Nano-Tera program and led by Dr. Hans Peter Lang of Gerber's team now plans to build five of the electronic noses for end users. "However, without the professional support of the workshops at the Department of Physics, this is not possible," remarks Lang. "We need a compact device that unites all the components of the electronic nose. It must meet the requirements of different end user applications without further modifications, be robust, and provide automated data analysis."

Electronics workshop supports development

Andreas Tonin, an engineer in the electronics workshop at the Department of Physics in Basel, was tasked with creating all of the electronics for the new, more compact artificial nose prototype. He designed a circuit board measuring roughly 19 x 9 cm, on which the pumps for the gaseous sample and the purging gas nitrogen, as well as the measurement chamber housing the eight mini-sensors, are arranged. The system electronics designed by Tonin rely on software to reset the measurement bridges before measurement, control the gas pumps and carry out multiple consecutive measurements with each sensor. For each measurement, the electronics amplify the tiny signals emitted by the measurement bridges and use the connected data acquisition card to output the results to the computer, which doubles as a power supply for the system in addition to automatically processing and evaluating the data. The resulting curves are analyzed using multivariate statistical methods, and the data is benchmarked against control compounds. As a result of this procedure, the researchers are able to accurately identify a wide range of gaseous samples.

Wide-ranging cooperation
Besides Andreas Tonin of the electronics workshop, the project also relies on the work of Sascha Martin, head of the mechanics workshop at the Department of Physics. Martin and his team are responsible for supplying the small precision-made measurement chamber housing the sensors, into which the gaseous samples are injected. Another vital contribution is that of Dr. Alexander Bubendorf of Professor Ernst Meyer's group at the Department of Physics, who wrote the software for the project. The project's industry partner is the company Nanoworld AG in Neuchâtel, which supplies the membrane sensors and has a strong interest in optimizing and marketing the electronic nose.

The project is not yet completely finished. For instance, a handbook providing guidance to lay users operating the device and troubleshooting in the event of problems is still missing. "However, our part in the development work is for the most part over, and we are turning our attention to new challenges," reports Andreas Tonin. Christoph Gerber, whose research in recent years has focused entirely on the development of nanomechanical sensors of this sort for medical diagnoses, highlights the excellent cooperation between his team and the workshops: "We are truly fortunate to enjoy such competent and professional support from our workshop technicians. Without their help, many of the successes we have enjoyed in our research would not have been possible."

SNI services in brief

The SNI offers various technology services for internal and external partners from science and industry. In particular, the technology department and the electronics and mechanics workshops in the Department of Physics and the Nano Imaging Lab (NI Lab), which is run by the SNI itself, consistently develop innovative solutions to a wide range of problems and tasks with their excellent equipment and highly qualified employees.

The NI Lab was set up in 2016 and unites the Nanotech Service Lab with part of the former Center for Microscopy Basel (ZMB), which was disbanded when the NI Lab was founded. The NI Lab now offers comprehensive imaging services. Its five employees have decades of experience in electron microscopy, scanning electron microscopy, scanning probe microscopy, and light microscopy, allowing them to accommodate a wide range of customer needs. Various analyses and sample modifications can also be combined with imaging services. In 2016, the NI Lab's excellent services were used by various working groups from the SNI network, particularly those at the University of Basel, as well as external institutes such as the Staatliches Weinbauinstitut (State Viticulture Institute) in Freiburg (Germany) and companies such as Particle Vision.

Communication & Outreach

“I was very impressed by the consistently high quality of the presentations and the opportunities to interact with a wide range of disciplines in nanosciences and nanotechnology.”

Prof. Dr. Vinothan N. Manoharan, Harvard University

Basel as nanoscience central

SNI organizes highly lauded Swiss NanoConvention

One of the key events on the 2016 calendar was the Swiss NanoConvention (SNC), organized for the second time by the Swiss Nanoscience Institute in Basel (first organized in 2013). From June 30 to July 1, nearly 650 nano researchers from all over the world came together at the Congress Center Basel for the SNC's sixth edition. The organizers had compiled a varied program of first-rate presentations on the latest research in the field, mounted an exhibition of over 160 posters, and convinced 30 exhibitors of the SNC's value as an ideal showcase for their products and services.

Networking opportunity

For a number of years, the Swiss NanoConvention (SNC) has provided researchers in Switzerland and abroad with a unique platform for sharing information on research projects and breakthroughs in the nanosciences. This year's conference was opened by Professor Dr. Andrea Schenker-Wicki (President of the University of Basel) and Dr. Ralf Dümpelmann (representing the event's primary sponsor BaselArea.swiss), kicking off two days of focus on science. Eight renowned nano researchers from elite international universities delivered plenary lectures, sharing insights into their groundbreaking research with the audience. Meanwhile, in eight science sessions consisting of four presentations each, 32 invited speakers presented their latest research findings under the topics “30 Years of Atomic Force Microscopy”, “Nanobiology”, “Nano for Energy”, “Production Processes”, “Materials”, “Sensors and Quantum Technology”, “Quantum Optics”, and “Functional Surfaces”. In addition, on day 1 the Commission for Technology and Innovation (CTI) hosted a satellite symposium presenting applied topics. Lively discussions ensued during the breaks, at the 160 posters, and with the 30 exhibitors offering proof that nanotechnology has made the market breakthrough.

Impressive range

In particular, the SNC's 2016 edition was praised by participants for the organization, variety and quality of the presentations. “The meeting was one of the best I have attended this year. It was well organized. The talks were very interesting, and dealt with a wide range of fields within the nanosciences,” remarked Professor Dr. Omar M. Yaghi of the University of California, Berkeley (USA). This diversity was clearly apparent in the plenary sessions alone. The first and last lectures focused on phenomena from the quantum world: in the QSIT talk, Professor Dr. Michelle Simmons of Sydney (Australia) discussed her approach to creating a quantum computer using silicon, while Professor Dr. Thomas Ebbesen (University of Strasbourg, France) showed how certain properties of vacuum can be used to create products with altered characteristics, such as improved electrical conductivity. In the Güntherodt lecture, Professor Dr. Daniel Müller (ETH Department of Biosystems Science and Engineering in Basel, Switzerland) explained how he and his team are investigating cell division in animals with the long-term goal of finding ways to suppress the division of cancerous cells. Also relevant to the treatment of disease was the nanotechnological method for quick and reliable deciphering of genetic information presented by Dr. Steven Henck (Genia Technologies, Santa Clara, California, USA). Henck's team uses a biological nanomachine able to quickly analyze a patient's genetic information on the basis of very small sample amounts, enabling predictions about a drug's effectiveness.

Practical applications also on the program

The highly topical issues of energy supply and fixation of the greenhouse gas carbon dioxide are among the research interests of Professor Dr. Peidong Yang (University of California, Berkeley, USA), whose talk on artificial photosynthesis concluded the scientific part of the first day. Yang's work uses semiconducting nanowires that act as tiny solar cells and provide charge carriers for bacteria. Day 2 began with further approaches to binding carbon dioxide, presented by Professor Dr. Omar Yaghi (University of California, Berkeley, USA). Yaghi uses porous crystalline materials made from metallic components and organic molecules forming one, two or three-dimensional networks known as metal-organic frameworks (MOF) which can be used to fix carbon dioxide. The focus on practical applications continued with demonstrations by Professor Dr. Joanna Aizenberg (Harvard University, Cambridge, USA), who develops surfaces, inspired by pitcher plants, which are impervious to adhesion by microorganisms, ice or liquids even under extreme conditions. Aizenberg's colleague Professor Dr. Vinothan Manoharan, also of Harvard University, presented his research into self-organization in viruses, which is expected to lead to crucial breakthroughs in the fields of medicine and nanotechnology.

Relaxed atmosphere

The mood of the entire conference was informal and relaxed, offering fertile ground for the exchange of ideas and development of contacts. In the words of Professor Daniel Müller of the ETH Department of Biosystems Science and Engineering in Basel, "the cordial and cooperative atmosphere greatly encouraged the formation of new partnerships." For those unable to attend in person, comprehensive reports and interviews were broadcast by Kanal K's Science Radio (http://www.scienceradio.ch) throughout the event.

Although organizing the SNC 2016 involved a great deal of work for the SNI, judging from the amount of positive feedback it was undoubtedly well worth the effort.

Communication and outreach in brief

In the first part of the year, the SNI communications team focused on preparing for the Swiss NanoConvention 2016. Following the success of the SNC, the group turned its attention to various science events. For example, the SNI was involved in the first KidsCamp at the University of Basel in the summer. The SNI stand at the "Festival of Molecules" drew the attention of many children, young people, and adults. As in previous years, the outreach team took part in the 2016 Science Days at Europa-Park Rust (Germany). Presentations at various TecDays and TecNights raised interest among school pupils, as did the laboratory tours that provided groups of visitors with an insight into everyday laboratory life at the SNI. Around 800 people also visited the "Quantum and Nano Worlds" exhibition organized by the Department of Physics and the SNI in Gelterkinden. In addition to the Annual Event, the communications team also organized a party to celebrate 10 years of the SNI, the perfect occasion to thank honorary SNI members Professor Dr. Andreas Engel and Dr. Alexander Hofmann and several SNI members for their longstanding support.

In 2016, the SNI network published numerous scientific papers in renowned journals. This research was reported on in a range of interesting press releases that created considerable media resonance.

A busy year

The SNI's communication and outreach team informs and inspires

2016 was an eventful year for the SNI's communication and outreach team. In the first half of the year, the main focus was on organizing the highly successful Swiss NanoConvention. At other times, the SNI team was busy planning internal events such as the Annual Event or the 10th anniversary celebration, which play a crucial role in helping the members of the network to get to know each other better and in promoting the exchange of research ideas and findings within the SNI. The SNI team was also involved in a number of external events designed to arouse interest in the diverse and exciting disciplines which make up the nanosciences, and tap into the enthusiasm of children and young people in particular with experiments and interactive activities. Meanwhile, numerous press releases throughout the year detailing the groundbreaking research results achieved by SNI members sparked extensive coverage in both print and online media.

A healthy exchange of information

As in previous years, the Annual Event was held at Lenzerheide. Around 80 participants were once again treated to an overview of the diverse research being done at the PhD School and in the Nano Argovia program. "At an interdisciplinary conference like the Annual Event it is not always easy for speakers to pitch their lecture at the right level, making the basic principles accessible to everyone while also going into the scientific details," explains SNI Director Christian Schönenberger. Of the doctoral students speaking at the 2016 Annual Event, Arne Barfuss tackled the problem particularly well, winning the prize for best presentation. A more amenable task from this perspective were the explanations and discussions during the poster sessions, which can be tailored to individual listeners' needs. Accordingly, many participants were reluctant to leave the posters behind and move on to dinner, where current research remained a popular topic of conversation. Christian Schönenberger concluded the event, which comprised a total of 18 lectures and 30 poster presentations, by awarding prizes to Arne Barfuss, Jan Overbeck (best poster) and Tomaž Einfalt for his exceptional contribution to the SNI's outreach activities in 2016.

Anecdotes and awards

A little lighter on the science compared to the Annual Meeting was the SNI's 10th anniversary celebration in November. Christian Schönenberger took the opportunity to share some amusing anecdotes from the SNI's short history and pay tribute to a number of SNI members who have contributed to the Institute's success, awarding honorary memberships to Dr. Alexander Hofmann and Professor Dr. Andreas Engel.

Packed popular events

Besides internal communication, one of the goals of the SNI's communication and outreach team is to promote public awareness of and interest in the natural sciences, in particular among children and young people. In May, in collaboration with the University of Basel's Department of Physics, the SNI mounted an exhibition in Gelterkinden with 16 stands offering the roughly 800 visitors a chance to explore the nano- and quantum worlds. The outreach team was also involved in a number of events held by the University of Basel in 2016. At the "Festival of Molecules" in August, the SNI and the Department of Physics shared a stand devoted to the subject of color, where 80 school classes and more than

4,000 visitors attending the event had the opportunity to build a spectrometer and use it to split white light into its component colors, produce white light by combining red, green and blue light with a gyroscope, or observe how nanostructures such as those on a butterfly's wing give rise to striking color effects. The spectrometer project was also a major hit with young researchers who decided to spend their first week of holidays in the University of Basel's laboratories instead of heading to the swimming pool as part of the university's first ever KidsCamp.

The extent of children and young people's fascination with scientific research was also apparent at the Future Day held in November, where the activities organized by the SNI were fully booked up after just a few hours. Six children were taken on a tour of the micro- and nanoworlds with the help of the Nano Imaging Lab's fleet of microscopes, while twenty other young researchers took part in the varied joint program prepared by the SNI and the Department of Physics, finding out about different forms of energy, building solar flowers and wind turbines, soldering an electronic game and hazarding a visit to the physics laboratories.

Spooky Science Days

For some years now, a special place on the SNI calendar has been reserved for the Science Days at the Europa-Park in Rust (Germany), where hundreds of children and youngsters have the opportunity to interactively explore the world of science and research. The topic for the 2016 edition was electricity. The SNI team, ably assisted by PhD candidates and students, spent three days with visitors of all ages building batteries from copper coins and acid to power LEDs which the children then diligently attached to polystyrene balls with great creative flair to make small ghosts with glowing red eyes, perfectly suited to the approaching Halloween season.

Catering to young people

In contrast to the activities described above, which were designed primarily with younger children in mind, the program for the 2016 TecDays and TecNights was geared toward young people between the ages of 14 and 18. As in previous years, the presentations and discussions organized by the SNI were very well received by the teenagers. The SNI team enjoyed yet more contact with enthusiastic youngsters in the form of school visits to the Institute. In all, some 160 schoolchildren and their teachers – including a 70-strong group from China – paid a visit to Klingelbergstrasse in Basel for a taste of nanoresearch at the SNI in the form of lab tours and short presentations by SNI doctoral students. The pupils' interest in this topic is clearly shared by their teachers as seen from the 2016 Teachers' Event jointly organized by the SNI and the Departments of Chemistry and Physics.

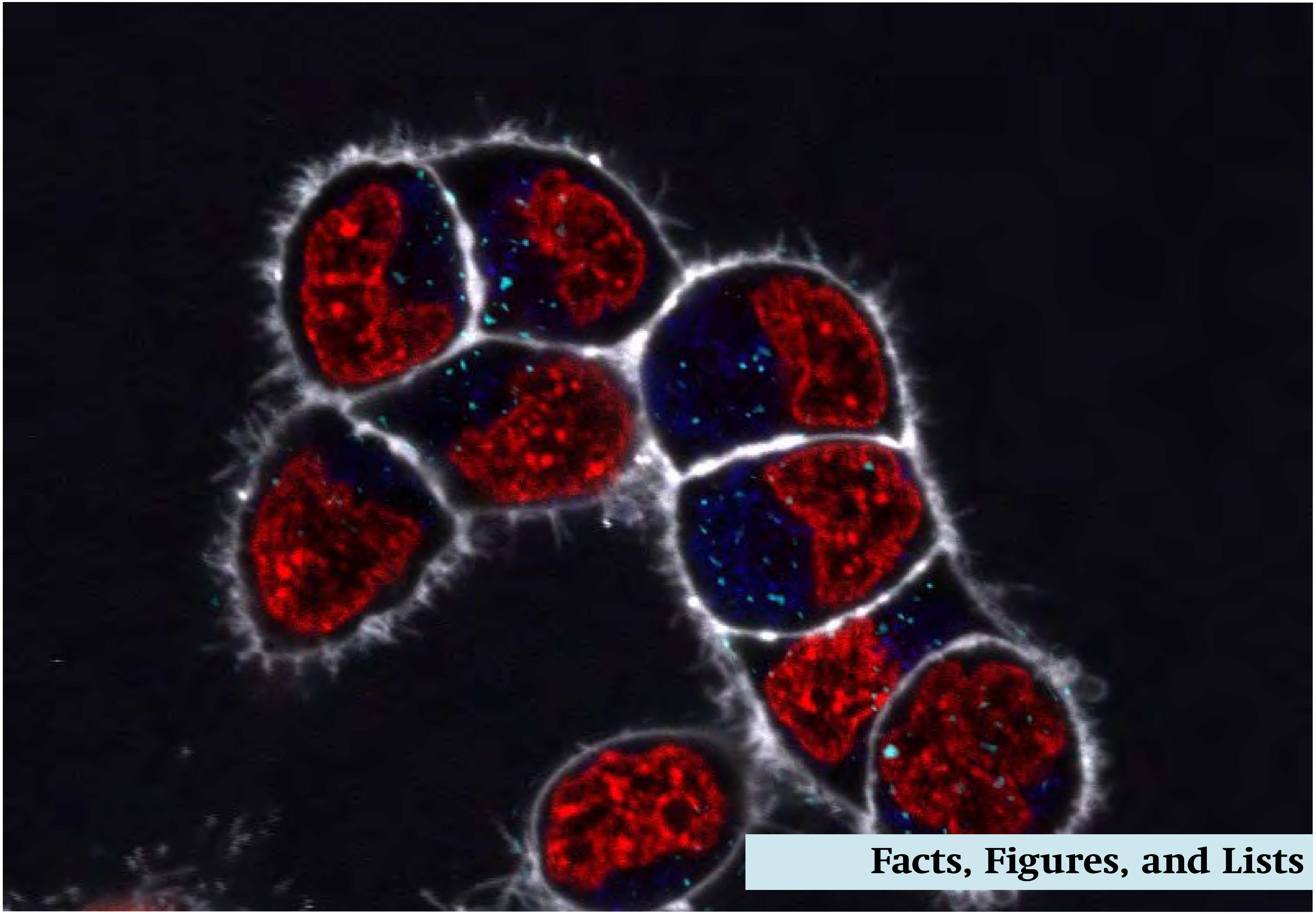
Extensive coverage

In addition to these events, 2016 brought numerous opportunities for the SNI to share its latest research findings with the public in the form of press releases. The frequent publication of papers by SNI members in prestigious scientific journals such as "Nature" gave the SNI occasion to draft press releases in collaboration with the university's communication department on average around once a month, generating a substantial media response. Again and again, online science portals and sometimes local print media reported on findings published by researchers in the SNI Network over the course of the year. A particular highlight for the Institute was the request by the editor of "Nature Nanotechnology", one of the leading nanoscience journals, for a piece on the University of Basel's nanoscience study program.* "This is clear evidence that the SNI is held in increasingly high regard, that our research is internationally recognized, and that our efforts in terms of public relations are bearing fruit," remarked SNI Director Christian Schönenberger.

* Nature Nanotechnology, October 2016 Vol. 11 No. 10
In the classroom – A success story
C. Möller and C. Schönenberger

"We want to capture young people's imagination for science by using experiments based on everyday materials."

Dr. Michèle Wegmann and Dr. Kerstin Beyer-Hans, SNI University of Basel



Facts, Figures, and Lists

Financial report

The Swiss Nanoscience Institute (SNI) was founded at the University of Basel exactly ten years ago in 2006. It was initiated by the Canton of Aargau to maintain existing competences in nanoscience and nanotechnology in Northwestern Switzerland in the long term and to further pursue these competences in a center of excellence.

The last ten years have been a great success. Today, the SNI is an established research institution respected both within Switzerland and around the world – a transregional beacon with a network that incorporates all the research institutions in Northwestern Switzerland with nanotechnology expertise. In addition to our two most important partners, the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) and the Paul Scherrer Institute (PSI), these include the Basel locations of CSEM and of the Federal Institute of Technology Zurich (ETHZ), the Hightech Zentrum Aargau, and BaselArea.swiss (formerly i-net Basel). Our task is to educate and encourage talented young people, to gain new insights through scientific research, and to engage in knowledge and technology transfer that benefits industry in Northwestern Switzerland.

The three core aspects of teaching, research, and knowledge and technology transfer (KTT) are also reflected in the SNI's finances, as research and KTT have the largest volume. Research is primarily conducted by doctoral students who are enrolled in the SNI PhD School. They all earn their doctorates from the Faculty of Science at the University of Basel. They work on individual and joint projects that can be run at any of the institutions in the SNI network. Some doctoral researchers mainly work at the University of Basel, at the PSI, CSEM or ETHZ, while others collaborate with several institutions at once. Knowledge and technology transfer primarily happens within the highly successful Nano Argovia program – another significant item in the SNI budget. With its Argovia projects, the SNI has succeeded in creating a platform that fulfils the needs of researchers and, in particular, of the FHNW and industry. This is clearly reflected in the extremely positive feedback consistently received from industry partners regarding completed applied Argovia projects.

Spending within the SNI is divided into the following items: Management & Overheads, Infrastructure (investments in premises and apparatus), KTT & PR (knowledge and technology transfer), Outreach (conferences, brochures, public events, and making contact with future students, particularly teenagers and children), Support (funding at the professorial level), Nano Study (Bachelor's and Master's programs), and the SNI PhD School. As was the case last year, the SNI PhD School, which supports young researchers, is the largest item in the 2016 budget at CHF 2.3 million. Support is the next largest item, with CHF 1.6 million. These funds are used to support various professors, particularly the two Argovia professors Dr. Roderick Lim and Dr. Martino Poggio, and to a lesser extent three PSI titular professors. This year, a new professor, Dr. Ilaria Zardo, benefited from a significant contribution from the SNI when she was appointed. PSI professor Dr. Thomas Jung also received funding for equipment. KTT & PR takes up a very similar proportion with costs of CHF 1.5 million. This item covers knowledge and technology transfer projects such as the highly successful Argovia projects, which receive roughly CHF 1.3 million each year.

In addition to the contributions that the SNI receives from the Canton of Aargau and the University of Basel, the project partners – via public research funding instruments and their own funds – and industry contribute a total of CHF 2.4 million to the applied research projects (Argovia projects). The share of third-party funding here amounts to more than 62% of total spending. In 2016, 11 Argovia projects were supported. Six of these projects (55%) have an Aargau-based company as their industry partner. A total of 38 doctoral students were enrolled in the SNI PhD School and 144 students were registered for the Nano Study Program. The SNI-funded Argovia professorships are both proving extremely successful: In 2016 alone, they raised a combined total of CHF 1.45 million in third-party funding, and have had papers published in world-leading scientific journals.

SNI assets decreased from CHF 8.05 million as of January 1, 2016, to CHF 7.5 million on December 31, 2016. To be deducted from this are grants (excluding those for the SNI PhD School) totaling CHF 1.2 million that were made in 2016 but will only become effective in 2017. The actual balance thus stands at approximately CHF 6.3 million. According to the forecast for 2017, the balance will drop by a further CHF 1 million at the end of 2017.

At this point, we would like to point out that the Canton of Aargau has temporarily reduced its financial commitment for the years 2016–2019 by CHF 0.5 million from CHF 5 million to CHF 4.5 million. The SNI has made adjustments to compensate for this. The number of new doctoral students who may be accepted into the SNI PhD School each year has been reduced to a maximum of seven. In the long term, this will cap the number of doctoral students at 28 (compared to the current figure of 38), saving around CHF 0.5 million per year. Further savings are planned to balance the budget in the medium term. The current negative balance can only be offset gradually over the coming years because doctoral students are employed for four years and we currently have a large pool of doctoral students.

We would like to thank the Office of Finance and Controlling at the University of Basel for the report. Even greater thanks are due to the Cantons of Aargau, Basel-Stadt, and Baselland for the goodwill they have shown toward the SNI.

The following table lists 2016 outgoings by item as per the University of Basel's financial report dated February 6, 2017:

Expenditure 2016 in CHF

		Univ. Basel	Kanton AG	Total
Management	Personnel and operational costs	286,209	209,191	495,400
	Overhead		585,000	585,000
Infrastructure	Infrastructure building	—	—	—
	Infrastructure equipment	50,025	503,411	553,437
KTT & PR	Personnel and operational costs	24,618	125,831	150,449
	Argovia projects		1,378,481	1,378,481
Outreach	Personnel and operational costs	54,140	82,647	136,787
Support	Argovia professors	548,592	893,116	1'441,708
	PSI professorships		148,491	148,491
Nano Study	Bachelor and master program	315,106	207,508	522,614
PhD School	Research projects	681,284	1,589,664	2,270,948
Total expenditure for 2016 in CHF		**1,959,976**	**5,723,339**	**7,683,315**

The following table shows the balance sheet for SNI funds as at December 31, 2016.

Balance sheet 2016 in CHF

	Univ. Basel	Kanton AG	Total
Grants	2,310,606	4,500,000	6,810,606
Investment income -	39,853	258,791	298,644
Income	**2,350,459**	**4,758,791**	**7,109,250**
Expenditure	**1,959,976**	**5,723,339**	**7,683,315**
Balance year 2016	**390,483**	**-964,548**	**-574,065**
SNI assets per 01/01/2016	**1,296,409**	**6,751,639**	**8,048,049**
Annual balance	390,483	-964,548	-574,066
SNI assets per per 31/12/2016 in CHF	**1,686,892**	**5,787,091**	**7,473,983**

SNI members

SNI Board

Prof. C. Schönenberger, Director SNI
Prof. E. Constable, Vice-Director (Rectorate)
Prof. C. Gerber, Vice-Director (Scientific Outreach)
Prof. J. Gobrecht, Vice-Director (Network)
Prof. D. Loss, Vice-Director (Theoretical Physics)
Prof. W. Meier, Vice-Director (Chemistry & Nanocurriculum)
Prof. E. Meyer, Vice-Director (Experimental Physics)
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Argovia Board

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Prof. C. Schönenberger, Director SNI
Prof. G.-L. Bona, Director Empa
Dr. W. Riess, IBM Department Head & Coordinator Binnig & Rohrer Nanotechnology Center

SNI Management

C. Wirth, HR & Finance (General Manager)
PD Dr. M. Calame (PhD School, until 31.12.2016)
Dr. A. Baumgartner (PhD School, since 01.01.2017)
Dr. K. Spieler (Coordination Nanocurriculum)
J. Isenburg (Coordination Nanocurriculum)
Dr. K. Beyer-Hans (Communication & Events)
O. Diener (SNC Organization, until 31.08.2016)
S. Hüni (Communication & Events)
Dr. C. Möller (Communication & Events)
Dr. M. Wegmann (Communication & Events)

Nano Imaging Lab

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Dr. M. Dürrenberger
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Dr. M. Schönenberger-Schwarzenbach

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Prof. Dr. S. Willitsch, Chemistry Department, University of Basel
Prof. Dr. T. Wintgens, School of Life Sciences, FHNW
Prof. Dr. D. Zumbühl, Physics Department, University of Basel

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P. Thakkar, Nano-Diffraction, Paul Scherrer Institute
L. Wang, Physics Department, University of Basel
D. Yildiz, Physics Department, University of Basel
C. Zelmer, Biozentrum, University of Basel

Projects of the SNI PhD School

Started in 2013

Project	Principle Investigator (PI) and Co-PI	PhD Student
P1201 Microfluidics to study nano-crystallization of proteins	T. Braun (Univ. Basel), H. Stahlberg (Univ. Basel)	S. Arnold
P1202 Nanofluidic devices for biomolecules (Electrostatic nanotrapping)	Y. Ekinci (PSI), T. Pfohl (Univ. Basel)	M. Gerspach
P1203 On surface covalent assembly of coordination polymers with integrated read and write functions	C. Housecroft (Univ. Basel), T. Jung (PSI)	T. Nijs
P1204 Site-specific magnetic studies and control of large self-assembled spin systems	T. Jung (PSI), A. Kleibert (PSI)	J. Nowakowski
P1205 Watching the nanomachinery of the nuclear pore complex at work by high speed-AFM	R. Y. H. Lim (Univ. Basel), C. Gerber (Univ.Basel, NanoMotion)	Y. Sakiyama
P1206 Nanomechanical oscillators for diamond spin-optomechanics	P. Maletinsky (Univ. Basel), R. Warburton (Univ. Basel)	A. Barfuss
P1207 Design of a polymer membrane-based molecular «hoover»	W. Meier (Univ. Basel), D. Müller (D-BSSE)	R. Goers
P1208 Ultra-sensitive force detection and molecular manipulation	E. Meyer (Univ. Basel), M. Poggio (Univ. Basel)	M. Schulzendorf
P1209 Design of polymer nanoreactors with triggered activity	C. Palivan (Univ. Basel), J. Huwyler (Univ. Basel)	T. Einfalt
P1210 Bottom-up nanowires as ultra-sensitive force transducers	M. Poggio (Univ. Basel), R. Warburton (Univ. Basel)	D. Cadeddu
P1211 Ultraclean suspended graphene	C. Schönenberger (Univ. Basel), D. Zumbühl (Univ. Basel)	C. Handschin
P1212 Nano-photonics with diamond	R. Warburton (Univ. Basel), P. Maletinsky (Univ. Basel)	D. Riedel
P1213 Artificial metalloenzymes for molecular nanofactories	T. Ward (Univ. Basel), S. Panke (D-BSSE)	S. Keller
P1214 An ion-atom hybrid trap on a chip: synthesis and control of nanosystems on the single-molecule level	S. Willitsch (Univ. Basel), P. Treutlein (Univ. Basel)	I. Rouse
P1215 Nanostructure quantum transport at microkelvin temperatures	D. Zumbühl (Univ. Basel), D. Loss (Univ. Basel)	M. Palma

Started in 2014

Project	Principle Investigator (PI) and Co-PI	PhD Student
P1301 Energy dissipation over structural and electronic phase transitions	E. Meyer (Univ. Basel), M. Poggio (Univ. Basel)	D. Yildiz
P1302 Probing the initial steps of bacterial biofilm formation: dynamic and molecular principles of surface-based cell motility and mechanosensation	T. Pfohl (Univ. Basel), U. Jenal (Univ. Basel)	N. Sauter
P1303 Assembly and investigation of electrochemically triggered molecular muscles	M. Mayor (Univ. Basel), M. Calame (Univ. Basel)	Y. Aeschi
P1304 Folding mechanisms of beta-barrel outer membrane proteins and their catalysis by natural holdases and foldases	S. Hiller (Univ. Basel), D. Müller (D-BSSE)	N. Ritzmann
P1305 Towards X-FEL based dynamic studies on 2D and 3D nanocrystals of membrane proteins on solid supports	C. Padeste (PSI), H. Stahlberg (Univ. Basel)	N. Opara
P1306 Slow-release nano-pills for mosquitoes for interrupting malaria transmission	P. Hunziker (Univ.-Spital Basel), R. Brun (Tropeninstitut, Univ. Basel)	D. Gonçalves
P1307 Optoelectronic nanojunctions	M. Calame (Univ. Basel), M. Mayor (Univ. Basel)	J. Overbeck
P1308 Supramolecular charge and spin architectures produced by chemical clipping	P. Shahgaldian (FHNW), T. Jung (PSI)	M. Moradi
P 1309 Cooling and control of a nanomechanical membrane with cold atoms	P. Treutlein (Univ. Basel), P. Maletinsky (Univ. Basel)	T. Karg
P1310 Plasmonic sensing in biomimetic nanopores	Y. Ekinci (PSI), R. Y. H. Lim (Univ. Basel)	D. Sharma

Projects of the SNI PhD School

Started in 2015

Project	Principle Investigator (PI) and Co-PI	PhD Student
P 1401 Targeted single cell proteomics using magnetic nanoparticles to study prion-like spreading of amyloid nanoparticles	T. Braun (Univ. Basel), H. Stahlberg (Univ. Basel)	C. Schmidli
P 1402 Lightweight structures based on hierarchical composites	C. Dransfeld (FHNW), C. Schönenberger (Univ. Basel)	W. Szmyt
P 1403 Tailor-made proteins and peptides for quantum interference experiments	V. Köhler (Univ. Basel), M. Mayor (Univ. Basel)	J. Schätti
P 1404 Selective transport of functionalized nanocarriers into biomimetic and natural nuclear pore complexes	R. Y. H. Lim (Univ. Basel), C. Palivan (Univ. Basel)	C. Zelmer
P 1405 Surface-functionalization of diamond nano-magnetometers for applications in nano- and life sciences	U. Pieles (FHNW), P. Maletinsky (Univ. Basel)	M. Batzer
P 1406 Charge transfer versus charge transport in molecular systems	O. Wenger (Univ. Basel), M. Calame (Univ. Basel)	S. Neumann
P 1407 Coupling a single ion to a nanomechanical oscillator	S. Willitsch (Univ. Basel), M. Poggio (Univ. Basel)	P. Fountas
P 1408 Clean zigzag and armchair graphene nanoribbons	D. Zumbühl (Univ. Basel), D. Loss (Univ. Basel)	M. Rehmann

Started in 2016

Project	Principle Investigator (PI) and Co-PI	PhD Student
P 1501 Nanomechanical mass and viscosity measurement-platform for cell imaging	T. Braun (Univ. Basel), E. Meyer (Univ. Basel)	P. Oliva
P 1502 Investigating individual multiferroic and oxidic nanoparticles	A. Kleibert (PSI), M. Poggio (Univ. Basel)	D. M. Bracher
P 1503 Watching giant multienzymes at work using high-speed AFM	T. Maier (Univ. Basel), R. Y. H. Lim (Univ. Basel)	S. Singh
P 1504 Valleytronics in strain-engineered graphene	C. Schönenberger (Univ. Basel), M. Calame (Univ. Basel)	L. Wang
P 1505 A programmable e-beam shaper for diffractive imaging of biological structures at Å resolution	S. Tsujino (PSI), J. P. Abrahams (Univ. Basel)	P. Thakkar

Argovia projects

Prolonged projects

(with and without financial support)

Project	Project leader	Project partner
A9.6 NANOFIL: Functionalized nanofiber-enhanced filter media for fine particle and heavy metal removal in flue gas and sewage water	C. Ludwig (PSI)	T. Griffin (FHNW), U. Pieles (FHNW), I.-V. Thanou (Alstom AG, Bir)
A9.9 NANOzyme: Novel nanobiocatalysts based on confined and concerted artificial and natural enzymes	P. Shahgaldian (FHNW)	P. Corvini (FHNW), T. Ward (Univ. Basel), A. Cumbo (INOFEA GmbH, Basel)
A9.10 PATCELL: Surface-patterning of PLGA for improved cell interaction and tissue integration of resorbable fixation implants	M. Kristiansen (FHNW)	V. Guzenko (PSI), J. Lungershausen (FHNW), J. Köser (FHNW), S. Beck (Synthes, Oberdorf)
A9.12 SCeNA: Single cell nanoanalytics	T. Braun (Univ. Basel)	H. P. Lang (Univ. Basel), G. Schlotterbeck (FHNW), G. Dernick (Roche, Basel)
A9.15 SINAPSIS: Niederdruck Wasserstrahl injizierte Nanopartikel zur Verbesserung von Implantaten	R. Schumacher (FHNW)	M. de Wild (FHNW), O. Braissant (Univ. Basel), M. Straubhaar (WATERjet Robotics AG, Oftringen)
A10.07 RepAll: Omniphobe Oberflächen nach Vorbild der Natur mittels Strukturierung und e-beam unterstütztem Grafting	S. Neuhaus (FHNW)	P. M. Kristiansen (FHNW), R. Kirchner (PSI), C. Padeste (PSI), L. Lötscher (Cellpack AG Packaging, Villmergen), G. Moissonnier (Cellpack AG Packaging, Villmergen)
A10.8 Atolys: Atomic-scale analysis of SiC-Oxide interface for improved high-power MOSFETs	S. Goedecker (Univ. Basel)	T. Jung (PSI), J. Lehmann (ABB Switzerland Ltd, Baden-Dättwil), H. Bartolf (ABB Switzerland Ltd, Baden-Dättwil)
A10.10 Nano-Cicada-Wing: Bactericidal nanostructures mimicking cicada wings for consumer products	E. Meyer (Univ. Basel)	M. Kisiel (Univ. Basel), T. Glatzel (Univ. Basel), J. Köser (FHNW), H. Hug (DMS Nutritional Products Ltd, Kaiseraugst)
A10.13 SurfFlow: A localized surface equilibration process for the generation of optically super-smooth surfaces for micro-optical lens systems using selective thermal reflow	H. Schift (PSI)	S. Neuhaus (FHNW), M. Altana (Heptagon Advanced Micro Optics, Rüschlikon)

Projects started in 2016

Project	Project leader	Project partner
A11.01 CerInk: Biomimetic ceramic scaffolds with density gradient and improved mechanical stability fabricated by Binder-into-Bed 3D-printing and ceramic NanoInk	P. Chavanne (FHNW)	R. Schumacher (FHNW), A. Testino (PSI), C. Ludwig (PSI), P. Gruner (Medicoat AG, Mägenwil)
A11.04 HPD4FED: Hybrid pixel detectors for electron diffraction of nano-samples	J. P. Abrahams (Univ. Basel)	T. Grüne (PSI), H. Stahlberg (Univ. Basel), B. Schmitt (PSI), C. Schulze-Briese (Dectris Ltd., Baden)
A11.05 IgG AptaNP: IgG Aptamer-Nanopartikel für die Entwicklung von Zelllinien für die Antikörperproduktion	G. Lipps (FHNW)	M. Held (D-BSSE ETHZ Basel), R. Pellaux (FGen GmbH, Basel)
A11.10 NanoSilkTex: Development of nanostructured silk fibroin-synthetic textile composites	O. Germershaus (FHNW)	U. Pieles (FHNW), M. Schönenberger (Univ. Basel), M. Height (HeiQ Materials AG, Bad Zurzach), W. Bender (HeiQ Materials AG, Bad Zurzach)
A.11.12 NF-Optics: Uniaxilly Oriented Anisotropic Electrospun Nano-Fibrous Layers for Optical Applications	M. Stalder (CSEM Muttenz)	U. Pieles (FHNW), A. Hafner (BASF Schweiz AG, Basel)

SNI Impact

Peer-reviewed articles

C. Adler, M. Schönenberger, A. Telekid, M. Kuentz, Molecularly designed lipid microdomains for solid dispersions using a polymer/inorganic carrier matrix produced by hot-melt extrusion, Int. J. Pharm. 499, 90-100 (2016)

P. Appel, E. Neu, M. Ganzhorn, A. Barfuss, M. Batzer, M. Gratz, A. Tschoepe, P. Maletinsky, Fabrication of all diamond scanning probes for nanoscale magnetometry, Rev. Sci. Instrum. 87, 063703 (2016)

C. Arend, P. Appel, J.N. Becker, M. Schmidt, M. Fischer, S. Gsell, M. Schreck, C. Becher, P. Maletinsky, and E. Neu, Site selective growth of heteroepitaxial diamond nanoislands containing single SiV centers, Appl. Phys. Lett. 108, 063111 (2016)

S. A. Arnold, S. Albiez, N. Opara, M. Chami, C. Schmidli, A. Bieri, C. Padeste, H. Stahlberg, and T. Braun, Total Sample Conditioning and Preparation of Nanoliter Volumes for Electron Microscopy, ACS Nano, vol. 10, no. 5, pp. 4981– 4988, (2016)

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Book chapter

D. Asgeirsson, P. Oertle, M. Loparic and M. Plodinec. The Nanomechanical Signature of Tissues in Health and Disease. Nanoscience and Nanotechnology for Human Health, First Edition. Edited by Bert Müller and Marcel Van de Voorde (2017) ISBN: 978-3-527-33860-3

R. Maier, P.M. Kristiansen, Nukleierungsmittel und Transparenzverstärker, chapter in: Handbuch Kunststoff Additive, 4th Ed.: Eds. R. Maier, C. Schiller, Carl Hanser Verlag: München (2016), ISBN Nr. 978-3-446-22352-3;

C. Möller, K. Spieler, M. Calame, E. Meyer, From Bachelor to PhD: The Swiss Nanoscience Institute at the University of Basel Offers Excellent Interdisciplinary Education at All Levels, chapter in: Global Perspectives of Nanoscience and Engineering Education, Eds. K. Winkelmann, B. Bhushan, Springer-Verlag (2016)

H.P. Lang, M. Hegner, Ch. Gerber, Nanomechanical cantilever array sensors, chapter in: Springer Handbook of Nanotechnology, 4th edition (2017)

Invited talks

J. P. Abrahams, Electron nanodiffraction for structural biology, ECM30: European Crystallography Meeting, Basel (Switzerland), August 28 – September 1, 2016

F. Braakman, Vectorial scanning force microscopy using a nanowire mechanical resonator, Department of Physics, University of Konstanz (Germany), May 25, 2016

V. Cadarso, Photonic Nanofences: Fabrication challenges of high aspect ratio polymeric nanostructures, PRN2016 3rd International Conference on Polymer Replication on Nanoscale, Windisch (Switzerland), May 19 - 20, 2016

M. Calame, Can we beat stochasticity in molecular devices?, Quantum Effects in Electronic Nanodevices (QuEEN) European workshop, Oxford (UK), December 18 - 20, 2016

M. Calame, Transistors à nanofils de silicium pour la détection de ions et protéines, Trends in Micro Nano, Swiss MNT Network, Bienne (Switzerland), October 25, 2016

M. Calame, On-chip biochemical sensing using Si nanoribbon field-effect transistors, European & Global Summit for Cutting-Edge Medicine - Clinical Nanomedicine and Targeted Medicine, Basel (Switzerland), June 26 - 29, 2016

M. Calame, Chemical & biochemical sensing with Si-based transistors, From Solid State to Biophysics VIII: From Basic to Life Sciences, Dubrovnik (Croatia), June 4 - 11, 2016

M. Calame, Molecular electronics, Workshop «Beyond CMOS», NEREID (NanoElectronics Roadmap for Europe: Identification and Dissemination), Helsinki (Finland), May 16 - 17, 2016

M. Calame, Si nanoribbon transistors for chemical and biochemical sensing, E-MRS Spring meeting - Symposium O: Group IV semiconductors at the nanoscale - towards applications in photonics, electronics and life sciences, Lille (France), May 2 - 6, 2016

M. Calame, From ions to proteins sensing using Si-Nanoribbons transistors, Kista Science Seminar, Royal Institute of Technology (KTH), Stockholm (Sweden), September 28, 2016

Ch. Gerber, Pushing the boundaries in personalized healthcare with AFM technology, nanoPortugal 2016, Braga (Portugal), February 16 - 19, 2016

Ch. Gerber, Pushing the boundaries in personalized healthcare with AFM technology, FNANO16 13th Annual Conference Foundations of Nanoscience, International Society for Nanoscale Science, Computation and Engineering (ISNSCE) Award Lecture, Snowbird (USA), April 11 - 14, 2016

Ch. Gerber, AFM technologies applied in personalized healthcare, ISPM International Scanning Probe Microscopy Conference, Grindelwald (Switzerland), June 12 - 15, 2016

Ch. Gerber, AFM technologies applied in personalized healthcare, Clinical nanomedicine and Targeted Medicine, Basel (Switzerland), June 26 - 29, 2016

Ch. Gerber, AFM technologies applied in personalized Healthcare, Kavli Prize Lecture 2016 in Nanoscience, University of Oslo, Blindern Campus, Oslo (Norway), September 5, 2016

Ch. Gerber, AFM technologies - A world of opportunities, Kavli Prize Lecture 2016 in Nanoscience, NTNU Norwegian University of Science and Technology, Trondheim (Norway), September 8, 2016

Ch. Gerber, AFM technologies applied in personalized healthcare, SNI Annual Meeting, Lenzerheide (Switzerland), September 15 - 16, 2016

Ch. Gerber, Atomic Force Microscopy (AFM), the ultimate toolkit for Nanoscience and technology, Dies natalis 2016, Honorary Doctor Degree Reception Lecture, University of Twente, Twente (Netherlands), November 24, 2016

O. Germershaus, New Silk: Coating of Synthetic Texiles using Regenerated Silk Fibroin, SNI Annual Meeting, Lenzerheide (Switzerland), September 15 - 16, 2016

J. Gobrecht, 20 years of surface nanoreplication: from science to applications, PRN2016 – 3rd International Conference on Polymer Replication on Nanoscale, Windisch (Switzerland), May, 19 – 20, 2016

T. Gruene, Structural Chemistry and Structural Biology with Electrons, Institutskolloquium Anorganische Chemie, Georg-August-Universität, Göttingen (Germany), December 12, 2016

R. Holtz, Ultrafast lasers for manufacturing of biomedical devices, 9th International Conference on Photonic Technologies LANE 2016, Fürth (Germany), September 19-22, 2016

P. Hunziker, Nanomedicine – need for excellence in material characterization and toxicity assessment, Labor Spiez, Spiez (Switzerland), March 3, 2016

P. Hunziker, Personalized medicine: knowledge-based medicine enabled by Nano-Medicine, NPTE Conference, Kyoto (Japan), July 18, 2016

P. Hunziker, Contributing to a future for African Healthcare, Swiss-Ethiopian Healthcare Association, Foundational meeting, Zurich (Switzerland), June 18, 2016

P. Hunziker, The principles of Translation in Nanomedicine for Personalized Medicine, International CLINAM Summit, Basel (Switzerland), June 27, 2016

P. Hunziker, Structure-Function Relationships of Nano-Bio-Interaction, International CLINAM Summit, Basel (Switzerland), June 28, 2016

P. Hunziker, Introduction to the State of the Art and Point of Start for Nanomedicine in Atherosclerosis, International CLINAM Summit, Basel (Switzerland), June 29, 2016

P. Hunziker, Nano in Medicine, SNI Annual Meeting, Lenzerheide (Switzerland), September 15 - 16, 2016

P. Hunziker, What is Nanomedicine and where are we today? Autumn meeting of the European Materials Research Society EMRS, Warshaw (Poland), September 18, 2016

P. Hunziker, Principles of Nanomedicine, Summer school of the International Society of Nanomedicine, Seoul (South Korea), September 26, 2016

P. Hunziker, Structure-Function Relationship of Polymeric Nanosystems in Medicine, International Conference of the International and the Korean Society of Nanomedicine, Seoul (South Korea), September 30, 2016

P. Hunziker, Structure-Function Relationship of Polymeric Nanosystems, Annual Meeting of the Chinese Society for Nanomedicine. Wuhan (China), October 24, 2016

L. E. Kapinos, Mechanism of Cargo Release by RanGTP at the Nuclear Pore Complex, Telluride Workshop on Nuclear Pore Complexes and Smart Polymers, Telluride (USA), July 25 - 29, 2016

P. M. Kristiansen, Funktionalisierung von Kunststoffoberflächen: Stand der Technik und ein Ausblick in die Zukunft, Fachtagung Mehrwert durch Funktion, Windisch (Switzerland), September 22, 2016

P. M. Kristiansen, Zwischen Magie und Alchemie – Funktionelle Beschichtungen mittels Elektronenstrahl-Grafting , Winterthurer Oberflächentag – Funktionale Dünnschichten, Winterthur (Switzerland), June 9, 2016

R. Y. H. Lim, The Nuclear Pore Complex: Paradoxes and Possibilities, Rockefeller University, New York (USA). July 8, 2016

R. Y. H. Lim, Watching Native Nuclear Pore Complexes at Work, 4th Bio-AFM Workshop, Kanazawa (Japan), October 3 - 6, 2016.

P. Makk, Electron optics in ballistic graphene, GM2016 (Graphene and related Materials: properties and applications), Paestum (Italy), May 23 - 27, 2016

P. Makk, Electron-Optics in ballistic graphene, 2D materials conference at Empa, Dübendorf (Switzerland), March 23, 2016

P. Makk, Spin pumping into graphene, Seminar talk at the University of Budapest (Hungary), April 6, 2016

P. Maletinsky, «Spin-based quantum sensing using all-diamond nanostructures», SBDD XX, Hasselt (Belgium) , February 26, 2015

P. Maletinsky, International conference on quantum condensed matter, Engelberg, 2nd October 2016

P. Maletinsky, Swiss Nanoconvention, Basel, 30th June 2016

P. Maletinsky, Swiss Workshop on Materials with Novel Electronic Properties, Les Diablerets, 6th July 2016

P. Maletinsky, Trends in Nanotechnology, Fribourg, 5th September 2016

P. Maletinsky, CeNS workshop, Venice, 19th September 2016

P. Maletinsky, Magnetism and magnetic materials, New Orleans, 2nd November 2016

“I’m delighted to have been invited to the SNI’s Annual Event and to have the opportunity to engage with the entire network.”

Prof. Dr. Patrick Maletinsky, University of Basel

D. J. Müller, Liposomes, Exosomes, and Virosomes: From Modeling Complex Membrane Processes to Medical Diagnostics and Drug Delivery, Mte Verita (Switzerland), September 30, 2016

D. J. Müller, Imaging of G-protein Coupled Receptors while Quantifying their Ligand-binding Free Energy Landscape to Mutiple Ligands, NovAliX Conference Biophysics in Drug Discovery 2016, Strasbourg (France), June 7-10, 2016

D. J. Müller, Güntherodt Lecture: Atomic Force Microscopy to Study Processes of Life from the Cellular to Molecular Scale, Swiss NanoConvention, Basel (Switzerland), June 30, 2016

D. J. Müller, Cut-and-paste of single integral membrane proteins, Biomembrane Days, Berlin (Germany), September 4-7, 2016

C. G. Palivan, Polymer membranes decorated with biomolecules:Novel systems with medical potential, Biointerfaces International, Zurich (Switzerland), August 23 -25, 2016

C. G. Palivan, «Smart» self-assembled functional nanosystems based on polymer membranes decorated with proteins, International Conference in Physics of Advanced Materials, Cluj-Napoca (Romania), September 8 - 14, 2016

T. Pfohl, Utilizing anisotropy in microfluidics: From interacting filaments to load-sorting bacteria, Workshop on Anisotropy and Shape in Biological Materials: From Structure to Functionality, Lorentz Center, University of Leiden (Netherlands), May 23 - 27, 2016

M. Plodinec, The nanomechanics of living epithelia in vitro and in situ with implications for cancer progression and clinical practice, Aspen Winter Conference: Physics of Development and Disease, Aspen (USA), March 27 - April 2, 2016

M. Plodinec, An *in vitro* engineered epithelia that bears the hallmarks of living tissue, 8th Cytoskeleton and Tissue Mechanics Course, Paris (France), April 13- 20, 2016

M. Plodinec, Mechanobiology of epithelia on native basement membranes and relevance for cancer cell invasion, AACR Special Conference on Engineering and Physical Sciences in Oncology, Boston (USA), June 25 - 28, 2016

M. Plodinec, An *in vitro* engineered epithelia that bears the hallmarks of living tissue, Biophotonic approaches: From molecules to living systems, Dundee (Scotland), August 22 - 23, 2016

M. Plodinec, Physics of Cancer, Houston Methodist Research Center Annual Student Symposium, Houston (USA), December 5, 2016

M. Plodinec, Mechanobiology of epithelia on native basement membranes and relevance for cancer cell invasion, American Society for Cell Biology Annual Meeting; Minisymposium Cell Migration and Invasion, San Francisco (USA), December 3 - 7, 2016

M. Poggio, Vectorial scanning force microscopy using a nanowire sensor, German-Japanese Workshop on Hybrid Quantum Systems, Berlin (Germany), November 10, 2016

M. Poggio, Vectorial scanning force microscopy using a nanowire sensor, Swiss NanoConvention, Basel (Switzerland), June 30, 2016

C. Rytka, Filling simulation of micro- and nanostructures in comparison to iso- and variothermal injection moulding trials, Technologietagung der Kunststofftechnik, Fribourg (Switzerland), Mai 12, 2016

H. Schift, Nanoimprint lithography: the (planar) world is not enough, 4M Conference, Copenhagen (Denmark), September 13 - 15, 2016

H. Schift, Additives Manufacturing für optische 3D-Mikrostrukturen, swiss mnt network, Trends in Micro Nano, INNOCAMPUS Biel/Bienne (Switzerland), October 25, 2016

H. Schift, Nanoimprint lithography: the (planar) world is not enough, 4M/IWMF2016 conference, Int. Conference on ‹Multi-Material Micro Manufacture›, Danish Technical University (DTU), Kongens Lyngby (Denmark), September 13 – 15, 2016

H. Schift, As smooth as possible – selective surface equilibration of polymer topographies, Swiss NanoConvention, Basel (Switzerland), June 30 – July 1, 2016

H. Schift, Nanoimprint lithography: the (planar) world is not enough, nanoPT, International Iberian Nanotechnology Laboratory (INL), Braga (Portugal), February 16 – 19, 2016

C. Schönenberger, Electron optics in suspended graphene, Colloquium at the University of Ulm (Germany), invited by Prof. Ankerhold, January 18, 2016

C. Schönenberger, Die vielen Facetten von Kohlenstoff als Nanomaterial, Vortrag im Rahmen des Studiums generale der Johannes Gutenberg Universität Mainz zum Semesterthema Nanokosmos: Die Welt im Kleinsten, Mainz (Germany), January 26, 2016

C. Schönenberger, Electron optics in suspended graphene, Colloquium at University of Maryland (Prof. Jimmy Williams, host), Maryland (USA), February 22, 2016

C. Schönenberger, Electron optics in suspended graphene, Seminar at NIST (Dr. Garnett Bryant, host), Washington DC North/Gaithersburg (USA), February 23, 2016

C. Schönenberger, Electron optics in suspended graphene, Seminar at MIT (Prof. Pablo Jarillo-Herrero, host), Boston (USA), February 24, 2016

C. Schönenberger, Electron optics in suspended graphene, Seminar at Harvard (Prof. Amir Yacoby, host) Boston (USA), February 25, 2016

C. Schönenberger, PN-Junction-Based Devices in Ultra-Clean Graphene, ICPS 2016, Beijing (China), July 31 – August 5, 2016

C. Schönenberger, PN-Junction-Based Devices in Ultra-Clean Graphene, TNT-2016, Fribourg (Switzerland), September 5 - 9, 2016

C. Schönenberger, PN-Junction Based Devices in Ultra-Clean Graphene, Seminar at ICFO, Barcelona (Spain), November 2, 2016

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B. Shields, Frontiers In Quantum Materials, Riken, 13rd June 2016

H. Stahlberg, A Prokaryotic Potassium Channel in Lipid Membranes Studied by Electron Crystallography: MloK1, GRC on Ligand Recognition and Molecular Gating, Il Ciocco (Italy), January 31 - February 5, 2016

H. Stahlberg, Nano-Scale Structural Characterization of Parkinson’s Disease,UC Davis, Davis (USA), Invited Seminar, March 29, 2016

H. Stahlberg, «Cafe Scientifique», Podium Discussion with Journalist about «Seeing is Believing», Basel (Switzerland), April 10, 2016

H. Stahlberg, Structural analysis of lipid membrane reconstituted membrane proteins by cryo-EM, Kuo Symposium, Beijing (China), June 26 - 30, 2016

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L. Thiel, Nano confined superconductors and their applications, Garmisch Partenkirchen, 4th September 2016

G. Tinti, Hybrid pixel detector developments for synchotrons and free electron lasers at the Paul Scherrer Institute, SSOM Interdisciplinary Symposium on 3D Microscopy 2016, Le Diablerets (Switzerland), October 18 - 21, 2016

P. Treutlein, Hybrid atom-membrane optomechanics, Gordon Research Conference «Mechanical Systems In The Quantum Regime», Ventura (USA), March 8, 2016

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P. Treutlein, Quantum interfaces of atoms and solid-state systems, Physics Colloquium, Université de Fribourg (Switzerland), November 16, 2016

R. J. Warburton, Towards Quantum Hardware with a Semiconductor Quantum Dot, Swiss NanoConvention, Basel (Switzerland), June 26 - July 1, 2016

T. R. Ward, Artificial metalloenzymes: versatile nano-catalysts inspired by nature, SNI in the snow, Zinal (Switzerland), January 28, 2016

T. R. Ward, Artificial metalloenzymes: challenges and opportunities, CECAM Workshop 2016, Pisa (Italy), May 23, 2016

T. R. Ward, Artificial metalloenzymes for xenobiological applications, XB2, Berlin (Germany), May 25, 2016

T. R. Ward, Artificial metalloenzymes bearing precious metal cofactors, GRC Metallocofactors, Easton MA (USA), June 15, 2016

T. R. Ward, Artificial metalloenzymes: challenges and opportunities, 42nd ICCC, Brest (France), July 6, 2016

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T. R. Ward, Artificial metalloenzymes for synthetic biology applications, Basel Life Sciences, Basel (Switzerland), September 22, 2016

T. R. Ward, Artificial metalloenzymes: challenges and opportunities, ICCAS, Frontiers in Asymmetric Catalysis, Beijing (China), September 18, 2016

T. R. Ward, Artificial metalloenzymes: challenges and opportunities, Departmental talk, Princeton University, Princeton NJ (USA), September 19, 2016

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T. R. Ward, Second coordination sphere interactions in catalysis: artificial metalloenzymes based on biotin-streptavidin, Departmental talk, Peking University, Beijing (China), September 20, 2016

T. R. Ward, Artificial metalloenzymes for in vivo catalysis: challenges and opportunities, Departmental talk, Barcelona University, Barcelona (Spain), October 4, 2016

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O. S. Wenger, Photoinduced long-range electron transfer across molecular bridges, Swiss Nanoconvention, Basel (Switzerland), June 30, 2016

S. Willitsch, Cold molecular ions, methods and applications, University of Aarhus PhD School on Cold Molecules, Aarhus (Denmark), December 7, 2016

S. Willitsch, AMO methods for precise studies of chemical reactions, 252. National Meeting of the American, Philadelphia (USA), August 21 - 23, 2016

S. Willitsch, Ion-atom and ion-molecule hybrid systems, 2. Conference on Cold and Controlled Molecules, Rehovot (Israel), March 13 - 17, 2016

S. Willitsch, Ion-atom and ion-molecule hybrid systems, NNV AMO Meeting, Lunteren (Netherlands), October 11 - 12, 2016

S. Willitsch, Cold and controlled ion chemistry, 20. Symposium on Atomic, Surface and Cluster Physics (SASP), Davos (Switzerland), February 7 - 12, 2016

S. Willitsch, Nanoscience meets AMOC Physics, SNI Annual Meeting, Lenzerheide (Switzerland), September 15 - 16, 2016

S. Willitsch, Cold Molecular Ions in Traps, Swiss Snow Symposium, Saas-Fee (Switzerland), January 22, 2016

M. de Wild, SINAPIS - Slurry Injection of Nano-scale Particles into Implant Surfaces, SNI Annual Meeting, Lenzerheide (Switzerland), September 15 - 16, 2016

L. Zweifel, Towards Artificial Nuclear Pore Complexes built from Glass Nanocapillaries, Workshop on Nuclear Pore Complexes and Smart Polymers, Telluride (USA), July 25 - 29, 2016

Contributed talks

Y. Aeschi, Assembly of Molecular Daisy Chains in Water, 36th Regio Symposium, Mittelwihr (F), September 29 - 31, 2016

S. A. Arnold, Nanoliter sample preparation for life science applications, Nanoscience in the Snow, Zinal (Switzerland), January 27 - 29, 2016

A. Barfuss, Coherent dynamics of a strain-coupled, hybrid spin-oscillator system, DIADEMS summer school, Cargeze (Greece), May 3, 2016

F. Braakman, Vectorial scanning force microscopy using a nanowire mechanical resonator, 15èmes Journées de la Matière Condensée (JMC15), Bordeaux (France), August 23, 2016

D. Cadeddu, A fiber-coupled quantum-dot on a photonic tip, 6th NCCR QSIT General Meeting, Arosa (Switzerland), February 4, 2016

M. Calame, Noise and Limit of Detection in Organic Electrochemical Transistors for Biosensing Applications, MRS Fall Meeting, Boston (USA), November 28 - December 2, 2016

N. Chidambaram, Surface Confined equilibration for super-smooth surfaces, PRN2016 – 3rd International Conference on Polymer Replication on Nanoscale, Windisch (Switzerland), May 19 - 20, 2016

N. Chidambaram, Tailored surface smoothening of the inherent roughness of micro-lenses fabricated with 2-photon-lithography, MNE2016 - 42th International Conference on Micro and Nano Engineering, Vienna (Austria), September 19 - 23, 2016

T. Einfalt, Biomimetic Engineering of Stimuli Responsive Artificial Cell Organelles, Swiss Soft Days, Zürich (Switzerland), Talk, May, 2016

T. Einfalt, Towards stimuli responsive artificial cell organelles by biomimetic engineering of complex membrane processes, 80th PMM conference Self-assembly in the World of Polymers, Prague (Czech Republic), Talk, July, 2016.

T. Einfalt, Towards stimuli responsive artificial cell organelles by biomimetic engineering of complex membrane processes, SNI Annual Meeting, Lenzerheide (Switzerland), Talk, September, 2016

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M. Ganzhorn, Nanoscale magnetic imaging with a single electron spin in diamond, Hasselt Diamond Workshop, Hasselt (Belgium), March 9-11, 2016

M. Gerspach, Nanofluidic trapping devices for detecting critical reaction concentrations of reactants on single nano-objects, Micro and Nano Engineering 2016, Vienna (Austria), September 19 - 23, 2016

R. Goers, Using proteorhodopsin fusion proteins to direct proton transport across synthetic membranes, SNI Annual Meeting, Lenzerheide (Switzerland), September 16, 2016

B. Gross, Dynamic cantilever magnetometry on individual magnetic nanoparticles, 8th Joint European Magnetic Symposia (JEMS), Glasgow (UK), August 26, 2016

B. Gross, Magnetic states of individual ferromagnetic nanotubes, International Conference on Magnetism and Spintronics (Sol-SkyMag 2016), San Sebastian (Spain), June 28, 2016

R. Hoekstra, Characterization of Spatially Confined Polymer Softening for Ultra-Smooth Surfaces, MNE2016 - 42th International Conference on Micro and Nano Engineering, Vienna (Austria), September 19 - 23, 2016

F. Huber, Study of BRAF mutations in biopsies of malignant melanoma, 13th International Conference on Nanomechanical Sensing, Delft (Netherlands), June 24, 2016

M. Kisiel, Elasticity Study of Polymer and Biological Surfaces by Oscillating Contact AFM, The Second European Workshop on Understanding and Controlling Nano and Mesoscale Friction, Riga (Latvia), July 4 - 7, 2016

A. Mehlin, X-PEEM imaging of global vortex states in ferromagnetic nanotubes, Annual Meeting of the Swiss Physical Society (SPS), Lugano (Switzerland), August 25, 2016

A. Mehlin, The use of dynamical cantilever magnetometry for the detection of the skyrmion phase, International Conference on Magnetism and Spintronics (Sol-SkyMag 2016), San Sebastian (Spain), June 26, 2016

S. Neuhaus, Mit Elektronen zu funktionalen Polymeroberflächen, Transfer Transparent, FHNW Windisch (Switzerland), May 24, 2016

J. Nowakowski, Probing reactive metal atoms and weak intermolecular magnetic interactions on a surface, Laboratory for Micro- and Nanotechnology Meeting, Villigen (Switzerland), February 25, 2016

J. Nowakowski, 2D-ferrimagnetic ordering in a chessboard-like molecular layer on Au(111), Magnetism 2016 conference, Sheffield (UK), April 4 - 5, 2016

P. Oertle, *In vitro* epithelia bearing the hallmarks of living tissue can recapitulate cancer invasion, 12th International Congress of Cell Biology (ICCB), Prague (Czech Republic), July 21 - 25, 2016

P. Oertle, *In vitro* epithelia bearing the hallmarks of living tissue can recapitulate cancer invasion, 9th European and Global Conference for Clinical Nanomedicine (CLINAM), Basel (Switzerland), June, 26 - 29, 2016

N. Opara, Fixed target approach to time-resolved measurements on protein crystals at Free Electron Lasers, SLS-PSI, Villigen (Switzerland), April 19, 2016

M. Rehmann, Helical Modes in Armchair Graphene Nanoribbons, SNI Nano in the Snow, Zinal (Switzerland), January 27 - 29, 2016

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M. Rehmann, Anisotropic H-Plasma Etching of Graphene Nanoribbons, Graphene Workshop, Basel (Switzerland), October 17 - 18, 2016

D. Riedel, A Fully Tunable Fabry-Perot Microcavity for Diamond-Based Photonics, DPG Tagung, Regensburg (Germany), March 6 - 11, 2016

D. Riedel, Efficient readout of a coherent single spin in diamond, Single Photons Single Spins Meeting, Oxford (England) September 12 - 13, 2016

D. Rohner, Quantitative nanoscale vortex-imaging using a cryogenic quantum magneto- meter, DIADEMS summer school, Cargeze (Greece), May 5,2016

N. Rossi, Vectorial scanning force microscopy using a nanowire mechanical resonator, 13th International Workshop on Nanomechanical Sensing (NMC), Delft (Netherlands), June 22, 2016

Y. Sakiyama, Spatiotemporal dynamics of the nuclear pore complex transport barrier resolved by high-speed actomic force microscopy, International Congress of Cell Biology, Prague (Czech Republic), July 21 - 25, 2016

N. Sauter, The birth of a cell: Flagellum dynamics in the release of daughter cells, Biocenter PhD Club, Basel (Switzerland), November 1, 2016

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C. Schmidli, Single-cell visual proteomics and supporting technologies, Lab Retreat, Membrane Protein Friends, Porquerolles (France), May 4 - 8, 2016

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D. Sharma, A Functionalized Nanofluidic System for Trapping Nano-Objects, 42nd Micro and Nano Engineering, Vienna (Austria), September 19 - 23, 2016

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S. Starosielec, Towards high-cooperativity strong coupling of a quantum-dot in a tunable microcavity: the role of emitter broadening, CLEO, San Jose (USA), May 14 - 19, 2016

W. Szmyt, Carbon fibre with and without a protective ultrathin alumina film grafted with carbon nanotubes for hierarchical composites observed by ptychographic X-ray computed tomography, ECCM17 - 17th European Conference on Composite Materials, Munich (Germany), June 26 - 30, 2016

W. Szmyt, To grow CNTs on carbon fibre not damaging it? 3D nano-examination, SNI Annual Meeting, Lenzerheide (Switzerland), September 15 - 16, 2016

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