Universität Basel

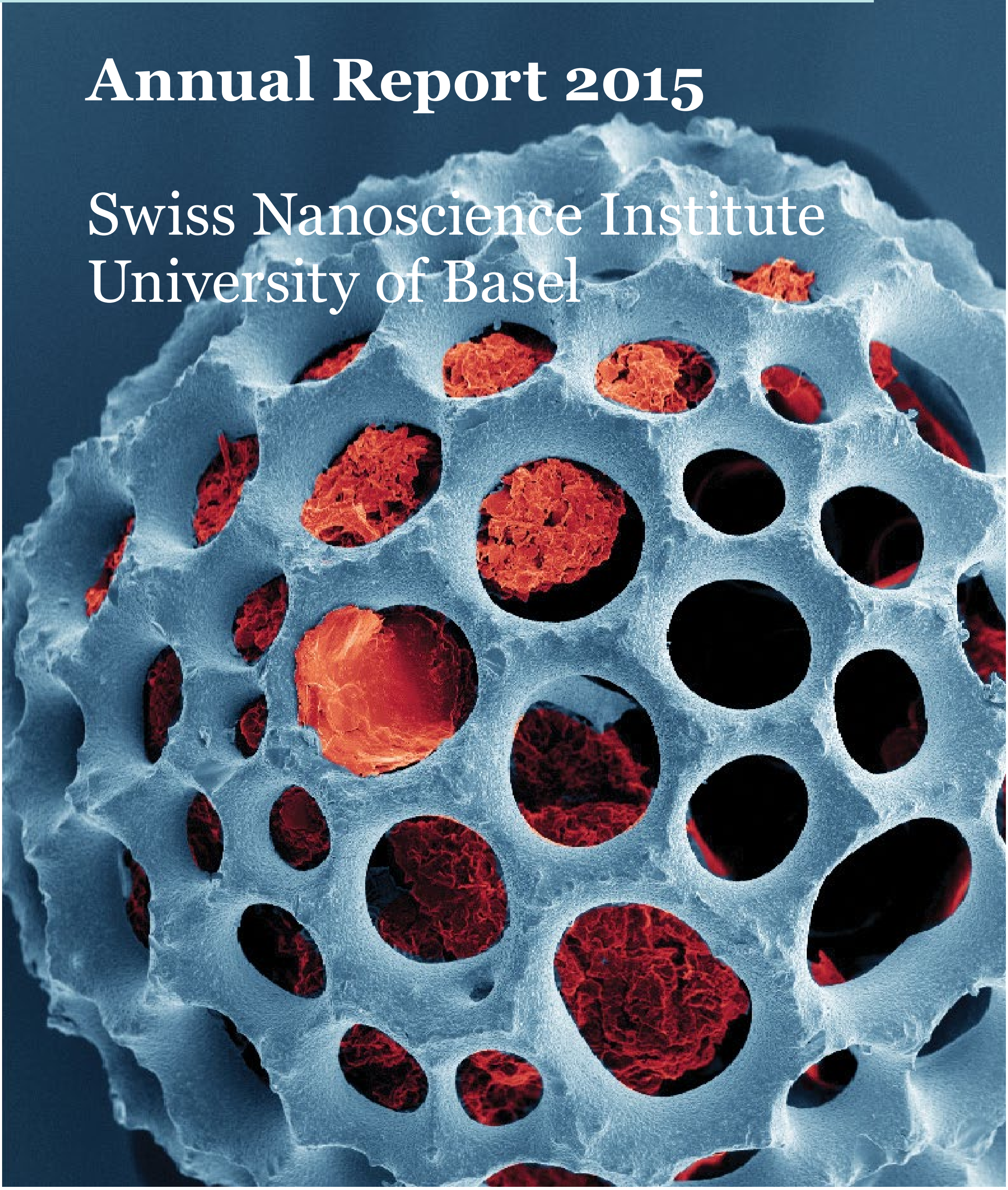
Swiss Nanoscience Institute

SNI SWISS NANOSCIENCE INSTITUTE

EINE INITIATIVE DER UNIVERSITÄT BASEL UND DES KANTONS AARGAU

Annual Report 2015

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 2015.

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Foreword

The annual report is written, and I have really enjoyed taking a look back at 2015. We have once again split the report into two parts, with a general section that presents some of the highlights of 2015 in a generally accessible format and an academic section describing all projects in the SNI PhD School and the Nano-Argovia program.

Excellent research
As the various articles will show, 2015 was a successful year for the SNI in a wide range of areas. SNI members have published many excellent papers and given high-profile presentations at international conferences. For example, we will present interesting news from the groups led by Argovia Professors Martino Poggio and Roderick Lim and the results of two applied Argovia projects. In addition to the Argovia professors and titular professors Thomas Jung, Michel Kenzelmann, and Frithjof Nolting – who work at the University of Basel and the Paul Scherrer Institute (PSI) – the SNI has been supporting Professor Jan Pieter Abrahams since May 2015. Professor Abrahams came to Basel from the University of Leiden and now runs research groups in the Biozentrum and the PSI, aiming to clarify the spatial structure of large molecules in their natural environment.

Recognition for good training
The SNI PhD School continued to grow in 2015 – not just in the number of doctoral students, but also with respect to the diversity of topics and continuing education courses on offer. In 2015, the SNI offered its first two-day course for SNI doctoral students on rhetoric and presentation skills. The participants used what they had learned at events such as the second Annual Meeting in fall 2015 and to win over audiences with interesting academic findings and good presentation techniques.

The majority of SNI doctoral students come to Basel from other universities. In this annual report, we also present two nanoscience students who studied outside of Switzerland before arriving in Basel. Sebastian Castilla, who comes from Barcelona, spent a research semester at the SNI as part of the ERASMUS program. Sara Freund, who received the award for the best nanoscience Master's thesis, left Strasbourg for a Master's degree at the University of Basel. The SNI's reputation for training excellent young nanoscientists has extended far beyond Switzerland's borders.

Continuing focus on communication
In addition to the excellent research in SNI member laboratories, the communications team also contributes to the SNI's good reputation. In 2015, we wrote several press releases about publications in renowned journals and took part in some major events with an interactive program that encouraged visitors to engage with the natural sciences. The SNI is open to school groups all year round, an offer that always receives an enthusiastic response.

Effective management team
Our main objective is to support training, research, and the application of nanosciences and nanotechnologies. However, this requires effective management and optimal interaction between processes. In 2015, we drew on past experience to anchor a number of processes within the SNI in a new set of regulations. However, these responsibilities have not just been committed to paper; they are already being put into effect. The SNI's management team plays a major role here. Each and every member enjoys shaping the respective area of responsibility and working as a team.

Positive outlook
I would like to thank everyone who has contributed to the SNI's successes for their great collaboration. We have another thrilling year ahead of us. Although we will have to deal with a budget reduction and bid farewell to some long-standing SNI members who will be retiring, 2016 will also bring some very rewarding projects for which intensive work has already begun. The SNI will once again be organizing the Swiss NanoConvention (SNC), which will take place in Basel in the summer, and will also be celebrating its 10th birthday in 2016.

I hope you enjoy reading our annual report and look forward to your feedback, suggestions and discussions.

Kind regards,

Christian Schönenberger

Christian Schönenberger, March 2016

Swiss Nanoscience Institute

Who Are We?

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 for careers in industry and academia through a range of activities.

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 in which researchers from various disciplines and institutions work together in one network. The SNI has a total budget of 7.3 million Swiss francs, of which 5 million comes from the Canton of Aargau and 2.3 million from the University of Basel. 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.

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, the University of Applied Sciences Northwestern Switzerland (FHNW), the Paul Scherrer Institute (PSI), the Department of Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel (D-BSSE), the CSEM (Centre Suisse d'Electronique et de Microtechnique) in Muttenz, the Swiss Tropical and Public Health Institute, and the University Hospital Basel. The wider network includes the Hightech Zentrum Aargau and i-net Nano. Exchange of information within the network is constantly stimulated and encouraged through membership of the SNI and regular academic conferences involving its members. One route to membership is by participating in SNI projects.

Excellent education for students
In 2002, the University of Basel – led by the SNI's predecessor institution – launched the Bachelor's and Master's degree programs in nanosciences. 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 courses that allow the students to focus on specific topics. Early on in their education, they have the opportunity to participate in various research groups, an activity that always proves particularly motivating. Additionally, students have the opportunity to participate in courses outside their field of specification. The courses on media competence, for example, prove popular.

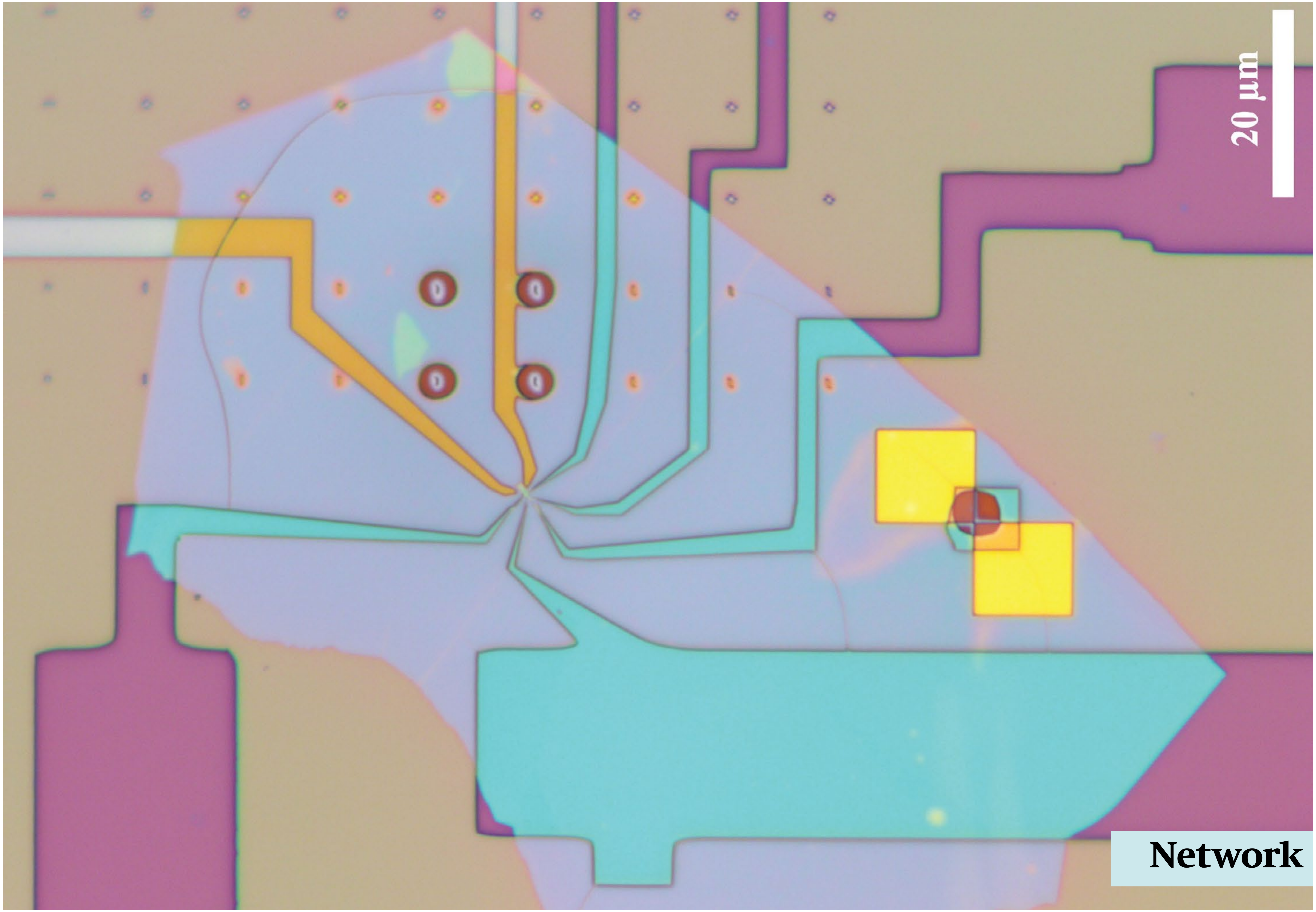
A variety of topics at the PhD School
To promote the further training of young scientists and a wide spectrum of basic scientific research, the SNI initiated a PhD School in 2013. At the end of 2015, 33 doctoral students were enrolled. Within the SNI PhD School, each doctoral student is supervised by two members of the SNI network. In more than half of the projects, these researchers belong to different departments of the University of Basel or institutions from the SNI network. The interdisciplinary education is further enhanced by the participation of all PhD students in internal scientific events such as the Winter School and the Annual Meeting. Additionally, the SNI offers a choice of courses to the doctoral students to provide insight into topics like intellectual property, communication rhetoric, and career planning.

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 Roderick Lim and Martino Poggio. With their successful research in nanobiology and nanotechnology, both contribute to the SNI's outstanding international reputation. Since 2015, the SNI has also supported Professor Jan Pieter Abrahams who studies the three-dimensional structure of proteins together with his teams at the Biozentrum and at the Paul Scherrer Institute (PSI). Furthermore, the SNI supports three titular professors: Professor Thomas Jung teaches and works in the Department of Physics at the University of Basel and leads a team at the PSI; Professors Frithjof Nolting and Michel Kenzelmann also lecture at the Department of Physics and are active in 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 1.5 million Swiss francs. With the Nano-Argovia program, the SNI is building 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.

Services in demand
The SNI views itself not only as a pure research institution, but also provides various services to academic institutions and industrial companies. In excellently equipped workshops for technology, electronics and mechanics, internal groups, research organizations, and industrial companies can harness the in-depth knowledge of the staff and the outstanding technical resources of the SNI and the affiliated departments. The Nanotech Service Lab (NSL) that is run by the SNI focuses on the analyses of technical surfaces.

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 actively involved in science festivals and fairs 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 to make scientific achievements accessible to a wide audience.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Network

Network Partner with Ideal Corporate Contacts

The Hightech Zentrum Aargau provides companies with straightforward, cross-sector support on innovation questions

The Hightech Zentrum Aargau (HTZ) is part of the Swiss Nanoscience Institute network. It was founded in December 2012 as a core element of the high-tech strategy of the Canton of Aargau to make it easier for Aargau-based companies to access new technologies and thus increase their performance and competitive edge. The HTZ actively approaches companies, supports them in various innovation-related matters, and enables them to access a wide-ranging network of Swiss research institutions.

Enabling access to innovation
Innovation is part of everyday life at universities and higher education institutions. Scientists are constantly tackling new questions and searching for innovative solutions. However, small- and medium-sized enterprises (SMEs) often have no direct access to this research and hear little about new technologies. To change this situation, inform SMEs about new technologies and opportunities, and make it easier for them to access innovative approaches, the Canton of Aargau founded the Hightech Zentrum Aargau (HTZ) in 2012. Since then, a team of practice-oriented experts has been advising Aargau companies on matters of innovation, nanotechnology, and energy technology. The HTZ is managed by Dr. Martin Bopp, who, with a PhD in physics, is familiar with both the Swiss university landscape and major research institutions and with the various funding options available for research projects. His many years as a development and production manager for a start-up company mean that he is also aware of the challenges companies must face in the market.

Proactive contact by the HTZ
“In many cases, projects are initiated by the specialists at the HTZ,” says Martin Bopp, explaining how the HTZ works. “Through our activities, we want to reduce the risk involved in an innovation by bringing additional expertise to the project, analyzing solutions, and then finding the best partners and funding options for the research and implementation,” he states. Since the HTZ was set up, he and his colleagues have responded to around 1,000 requests, visited almost 500 companies, and launched about 450 projects overall. The number of feasibility studies conducted and coordinated by the HTZ in collaboration with a higher education partner increased significantly in 2015. These studies aim to show whether an idea can be realized. The HTZ has its own means to do so, but also advises and supports corporate clients when the most sensible option would be to apply to the Commission for Technology and Innovation (CTI), the Aargau Research Fund, or the SNI’s Nano-Argovia program. “Rather than competing with one another, the various funding programs complement each other perfectly – depending on how close a process or product is to market launch. In the CTI projects, for example, we work very closely with the CTI’s innovation mentors,” explains Martin Bopp.

A range of questions
In some cases, the HTZ also helps with questions relating to the patentability of products. HTZ employees can work with the experts from the Swiss Federal Institute of Intellectual Property (IGE) to research the state of the art or the patentability of new developments. This support was required, among other things, in a collaboration with the Frick-based company TB-Safety, which produces protective suits. In a research project with the Zurich University of Applied Sciences (ZHAW), the company developed innovative, compact air purification filters from nano threads, for which a patent has since been filed. In other projects supported by the HTZ – such as a collaboration between the SNI's Nanotech Service Lab (NSL) and Jakob Müller AG in Frick – nanotechnology analysis methods were used. Here, the NSL team analyzed the cause of spring breakage in looms used to produce fabric tapes. Basel's scientists suggested altering the form of the springs, which eliminated the problem.

All partners benefit from good networking
In 2015 alone, the HTZ initiated over 50 projects with higher education institutions – including SNI members – with more than CHF 2.5 million in project funding received by the institutions. One focal area was projects relating to energy and nanotechnology. "Naturally, the SNI is an important contact for nanotechnology topics," responds Martin Bopp when asked about the SNI's role for the HTZ. SNI Director Christian Schönenberger and SNI Vice Director Jens Gobrecht are both members of the HTZ Advisory Board. Martin Bopp sits on the selection committee for the SNI Nano-Argovia program. This ensures constant exchange about current research questions and collaborations. SNI members can contribute their scientific expertise, their experience, and their state-of-the-art technical equipment. Meanwhile, the HTZ provides key impetus for applied questions that are relevant for industry and acts as an intermediary between industry and higher education institutions.

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 University of Applied Sciences and Arts Northwestern Switzerland (FHNW), the Paul Scherrer Institute (PSI), the Department of Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel (D-BSSE), the CSEM (Centre Suisse d'Electronique et de Microtechnique) in Muttenz, the Swiss Tropical and Public Health Institute, and the University Hospital Basel. The wider network includes the Hightech Zentrum Aargau and i-net Nano.

In 2015, a new governance framework was established to regulate which committees and bodies are responsible for leadership of the SNI. The governance framework also stipulates the terms of the SNI network membership. SNI members are involved in the Nano Study program, the SNI PhD School, and in the Nano-Argovia Program. The exchange of information and ideas within the network is encouraged and supported through regular scientific conferences and meetings.

Always with Applications in Mind

Jens Gobrecht has been leading the way since the SNI was founded

Professor Jens Gobrecht of the Paul Scherrer Institute and the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) has been Vice Director of the SNI and a member of the SNI board since it was founded. He has played a decisive role in the positive relations between the University of Basel and the PSI, has always championed the interests of the SNI and is a straightforward, cooperative partner in all types of research project. The applied Nano-Argovia program is particularly close to his heart. Over the last few years, the 64-year-old physicist has managed or co-managed 15 different Argovia projects. Even in 2015, the year before his retirement, his enthusiasm for applied research has not waned in the slightest.

Interest in applied research
Jens Gobrecht has enjoyed a successful career in physics research. He gained both inside knowledge of industry and also experience of academic research from a range of perspectives. He originally wanted to become a physician after leaving school but was discouraged by the prospect of having to wait several semesters and so followed his father and brother into a career in physics. He studied in his hometown at the TU Berlin and remained in what was still a divided Berlin for his doctorate at the Fritz Haber Institute of the Max Planck Society. Even in the early stages of his career, he was interested in and motivated by applied topics. During his doctorate and a subsequent postdoc position with the Solar Energy

Research Institute in Colorado (USA), he developed electrochemical solar cells with an efficiency never before achieved. In 1981, he moved to ABB in Switzerland, where he concentrated on semiconductor research. He developed various electronic components that can withstand high currents and voltages and are therefore still extremely significant to this day.

New start at the Paul Scherrer Institute

Reorganization within ABB and grueling projects requiring extensive travel meant that, after 11 years at ABB, Jens Gobrecht was ready for something new. The opportunity to set up the new Laboratory of Micro and Nanotechnology (LMN) at the Paul Scherrer Institute came at just the right time, and he began this exciting and diverse role in 1993. “I came back to basic research,” Jens Gobrecht recalls. There were clean rooms to set up – not a problem for someone with his experience – and (a little more challenging and protracted) a research program to develop and suitable scientists to find. It was not always clear at first which direction the LMN’s research should take. Depending on the affiliation to different research groups, the focus fell more on basic science or on the applied field. After some time, however, it became clear that the research conducted at the PSI should have some connection with the major research facilities that make the PSI so unique. Even today, the LMN, which is managed by Gobrecht, pursues the same approach. Around one third of the work performed by the group, which now has about 60 employees, is basic research conducted using these research facilities (such as the synchrotron light source). Another third of its research activities concentrate on instrumentation to improve these facilities even further. The final third encompasses micro- and nanofabrication technologies, largely performed in close collaboration with the industry.

Jens Gobrecht also took a leading role in 2004, when Professor Ralph Eichler – then Director of the PSI – increased its collaboration with the University of Applied Sciences and Arts Northwestern Switzerland (FHNW). Gobrecht had been teaching at the FHNW since 2003 and enjoyed good relations with his colleagues, making him the ideal person to write a business plan for a joint institute. And the plan became a reality: At the start of 2005, the PSI and FHNW founded the Institute for Application of Polymers in Nanotechnology (INKA), and Professor Jens Gobrecht has presided over it ever since.

Involvement in numerous Argovia projects

The application of polymers in nanotechnology has also formed the basis for some projects in the Nano-Argovia program, which was initiated in 2006 when the SNI was founded. Jens Gobrecht has been highly involved ever since. “The Nano-Argovia program is enormously important for projects with the industry that are still far removed from an actual product,” he comments. “The SNI network has the major advantage that all partners at the various institutions know each other well. Knowing each other’s potential and skills means that we can easily initiate joint projects.”

When asked which of his 15 Argovia projects have been most successful, he mentions “Flashcard”, “Dicans”, and the ongoing “NanoSiCTrenchFet” in particular. In “Flashcard”, the scientists developed new security features on plastic cards. “Dicans” led to the successful construction of a cantilever array made from synthetic material and to numerous high-quality publications. The research team in the “NanoSiCTrenchFet” project is examining a novel type of transistor using silicon carbide that will meet the requirements of increased energy needs. Outside of the research supported by the SNI, “extreme UV lithography” (EUV-L) is currently proving particularly exciting. Using the lithography beam from the PSI’s synchrotron light source, Gobrecht and his team can employ interference effects to expose photoresists with minute structures. The semiconductor industry requires such surfaces structured in the single-digit nanometer range to develop future chips, and is therefore working closely with the PSI in this area.

For the SNI, Jens Gobrecht has always been a builder of bridges between the University of Basel and the PSI. He has supported the involvement of PSI colleagues at the university and remains an experienced and approachable partner for research projects of all types, allowing university staff to benefit from the LMN’s equipment, for example. “Jens is always very reliable and cooperative in executive board meetings. He always champions the interests of the SNI and is dedicated to achieving a consensus,” says Professor Christian Schönenberger of Jens Gobrecht’s role on the SNI executive board.

New challenges await

Although Jens Gobrecht will be retiring next year, there is no indication that he is tiring of research. Quite the opposite. Upon retiring, he will continue to intensively pursue his “hobby”, Eulitha, the nanolithography company he co-founded. He will presumably also have more time for other activities that have taken a back seat in the last few years, such as singing, carpentry, golf, and travelling with his wife, Barbara. Jens Gobrecht can also look forward to a very different, and no less exciting, role in the future – his first grandchild is due in February 2016.

Responsibilities Delineated

SNI fixes procedures in new governance framework

The Swiss Nanoscience Institute was established in 2006 and has been fully autonomous since the National Center of Competence for Nanosciences was discontinued as planned in 2013. Since 2013, the SNI has taken steps to optimize its organizational structures, procedures, and business processes. In 2015, these were enshrined in a new governance framework, which was adopted by the Argovia Board and the SNI Board of Directors midway through the year. The new framework also sanctions the introduction of an SNI membership scheme, which clearly defines who qualifies for membership of the SNI network.

Strategic body: the Argovia Board
There are a number of bodies and committees in place to ensure that the Swiss Nanoscience Institute is well run and achieves its targets. The ultimate governing body of the SNI is the Argovia Board, which consists of the institute's financial sponsors. Generally, the Committee meets at least once a year to discuss strategic realignments and organizational changes affecting knowledge and technology transfer. Its membership comprises Alex Hürzeler, Minister for Education, Culture, and Sport in Aargau, Professor Edwin Constable, representing the rectorate of Basel University, and Professor Christian Schönenberger, Director of the SNI. Also invited to the committee's meetings in an advisory capacity are Professor Crispino Bergamaschi, President of the University of Applied Sciences Northwestern Switzerland, and Professor Joël Mesot, Director of the Paul Scherrer Institute, from 2016 along with Professor Gian-Luca Bona of Empa and Dr Walter Riess of IBM, as independent representatives of science and industry.

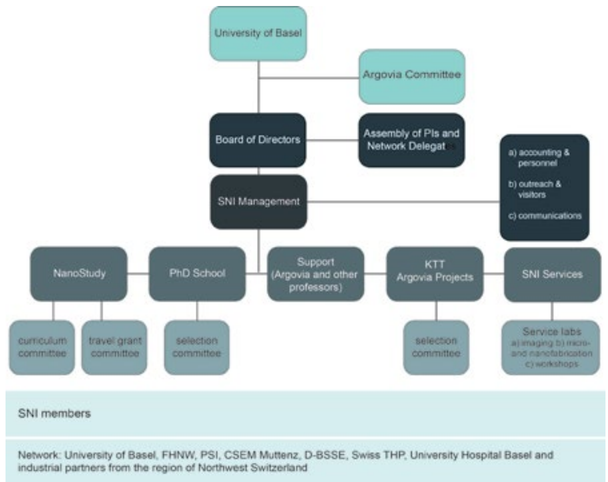
Executive body: the SNI Board of Directors
The key decision-making body within the SNI is the Board of Directors. In his capacity as Vice-Rector for Research at Basel University, Professor Edwin Constable is a member of the SNI board. The Biozentrum and the Departments of Chemistry and Physics at Basel University are represented by Professors Erich Nigg, Ernst Meyer, Daniel Loss, and Wolfgang Meier, who also represents the nanoscience study program. Professor Jens Gobrecht attends on behalf of the SNI network, while Professor Christoph Gerber represents scientific exchange with external partners. Director of the SNI, Christian Schönenberger, and the institute's general manager, Claudia Wirth, are also board members.

The SNI board is responsible for managing the SNI. It ensures that there is good communication with network partners, determines funding allocations, and is accountable to the Argovia Board for expenditure. The board is also responsible for ensuring that university guidelines and contractual agreements with the Government of Aargau are adhered to. In addition, it nominates the SNI's director and deputy director and selects the general manager, who is employed by the University of Basel.

In charge of business operations
Besides these two bodies, the SNI has a number of committees with different tasks and responsibilities.

The SNI management team deals with day-to-day business. The institute's director, Christian Schönenberger, its general manager, Claudia Wirth, and the heads of the different business areas meet once a week to discuss and coordinate their work. Dr Katrein Spieler is coordinator of the nanoscience degree program, Dr Michel Calame is in charge of the SNI's PhD school, Dr Kerstin Beyer-Hans and Dr Christel Möller oversee outreach and PR activities, while Dr Monica Schönenberger is responsible for the Nanotech Service Lab operated by the SNI.

One of the management team's tasks is to plan the annual conference, where all members of the SNI meet to exchange scientific ideas. In 2015, as in the previous year, this annual meeting was held in Lenzerheide. The event provides all of the SNI's members with an opportunity to present their research in the form of lectures and posters, to renew existing contacts, and to make new ones. All project heads and delegates from the network partners get together at least once a year, either during the annual event or at a specially convened meeting. The purpose of this meeting is to stimulate discussion within the SNI and to monitor scientific progress.



Promoting continuous improvement in education
Issues relating to the nanoscience programs at Bachelor and Master level are dealt with by the Curriculum Committee, which draws up course regulations and scrutinizes and refreshes the curriculum. The Curriculum Committee is also tasked with approving learning agreements and recognizing equivalent qualifications. It includes members from the Biozentrum and the Departments of Chemistry, Physics, Mathematics and Computer Science, together with a representative of the "Fachgruppe Nanowissenschaften".

There is also a forum for doctoral students from the SNI's PhD school. All PhD candidates in receipt of SNI funding attend this committee and elect a representative. In 2015, this position was held by Tomaz Einfalt. The PhD students also get together regularly at a winter school, "Nanoscience in the Snow", and at the SNI's annual event.

Independent selection of Argovia projects
Members of the Argovia Project Selection Committee evaluate projects submitted to the Nano-Argovia program once a year and make funding recommendations to the SNI Board. The Selection Committee's members are appointed by the SNI Board, based on suggestions from participating parties. To ensure maximum co-ordination with other local and national funding programs, the Committee includes at least one expert assessor from each of the following bodies: the Forschungsfond Aargau, the Hightech Zentrum Aargau, and the CTI.

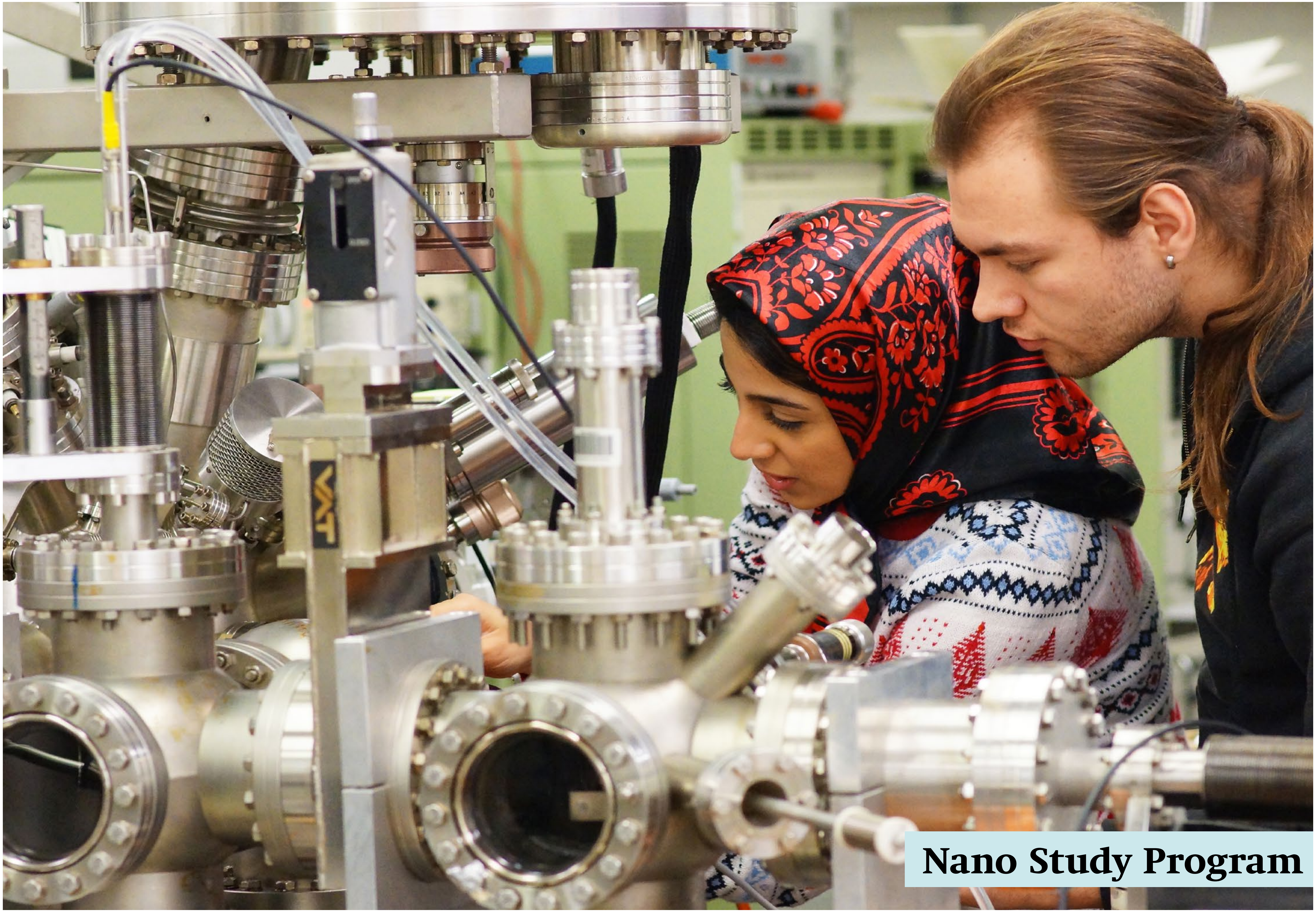
There are also committees in place for every SNI scientific project to ensure that it is run as efficiently as possible and contributes to the advancement of science.

Membership scheme proves a success
As well as describing these bodies and committees, the governance framework requires the SNI to submit an annual report each year, setting out the scientific results that have been achieved and incorporating a financial report.

In 2014, the SNI introduced a membership scheme to define clearly who is included in the SNI research network. Under this scheme, all principle investigators (PIs) and co-PIs of Argovia projects and projects within the SNI's PhD school are automatically members of the SNI. All SNI PhD students and members of SNI management are also part of the SNI. Scientists active in the field of nanoscience may apply for membership, even if they are not working on an SNI project. All members may participate free of charge in SNI events such as the annual conference, avail of SNI services, and benefit more generally from being part of this diverse network. At the end of 2015, a membership fee of 300 Swiss francs was successfully levied on all PIs and co-PIs for the first time, so the scheme has proved its worth.

An honorary member was also elected for the first time in 2015. Honorary membership was bestowed on Professor Andreas Engel for his contribution to the study of nanoscience and ongoing commitment to the field.

The governance framework and SNI membership rules are available on the SNI's website at www.nanoscience/About us.



Nano Study Program

Popular All Round

The nanostudies block courses offer a wide range of practical training

When asked about their best nanostudies experiences, nanoscience students always mention the block courses that take place in the third year of their Bachelor's degree programs – to follow on from the solid basic education in biology, chemistry, physics, and mathematics. These courses give students an opportunity to become actively involved in current research projects in various laboratories within the SNI network. They attend eight courses of their choice from a diverse range and gain initial experience as "real" researchers.

Third year focus on practical training
Shortly after the nanoscience study program was introduced in Basel in 2002, block courses were launched to provide students with access to current research at an early stage of their education and enable them to gain initial laboratory experience. Currently, students in the third year of their Bachelor's program can choose from over 30 block courses ranging from biology to chemical syntheses and analyses, producing computer chips in clean rooms, quantum transport experiments, and atomistic simulations. SNI members from the Biozentrum and Departments of Chemistry and Physics at the University of Basel offer most of these courses. The range of topics available is extended through collaboration with academics from the SNI network (FHNW, PSI, and D-BSSE) and the Adolphe Merkle Institute in Fribourg. There are no thematic specifications when selecting block courses, allowing every student to focus on the areas that interest them most.

To prepare themselves for the topics offered in the block courses, fourth-semester nanoscience students attend a lecture in which some of the research groups involved present their fields of research. This enables the students to familiarize themselves with and gain an insight into different areas that they can then choose when selecting their block courses.

Opening the door to later projects
In the block courses, students spend one to three weeks with the different research teams. They receive practical insights into the subjects examined, learn to work independently with high-tech devices and machines, gain valuable experience in writing reports, and establish contact with the team members. Elise Aeby, Master's student in nanosciences, comments: "The block courses were the first time that I had really worked in a research group. I helped by performing analyses and minor experiments and learned many things that proved useful later in my studies. The block courses also open doors to different research groups and institutions."

In addition to the current topics covered by the courses, the students particularly appreciate the outstanding supervision. Often, 2–3 students will come together in one laboratory in each block course; sometimes there is even 1:1 supervision. "Despite the short course time, the intensive supervision means that you get to know each other well and build up a valuable network," states Elise Aeby. "For example, I found out about an internship at the PSI via my block course."

Preferences differ greatly
When asked about their favorite courses, students give very different answers, ranging from the microscopy course at the Center for Microscopy (ZMB) to the course on scanning tunneling microscopy in the Department of Physics. Some students sing the praises of nanochemistry and the course about self-organizing polymers, while others are fascinated by working in clean rooms, finding out more about carbon nanotubes, learning how computer chips are produced, or gaining an insight into particle physics. Dr. Katrein Spieler, who coordinates the program, comments: "The various options on offer enable the students to make truly individual choices and pursue their personal interests for the first time in their Bachelor's program."

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 2015, 108 students were enrolled on the Bachelor's degree program and 27 students took Master's courses. By September 2015, eighteen students had finished their Bachelor's degree and ten had completed their Master's degree with a pleasing overall average score of 5.8. As in the previous year, the University of Basel was again able to welcome Erasmus students from Spain to the nanoscience program. Six students from Basel also successfully completed their project work or Master's theses abroad and added to their experiences gained during their studies.

The nanoscience program is now well known outside the borders of Switzerland. The SNI's communication team was asked to describe the training of young nanoscientists in a book chapter. The book "Global Perspectives of Nanoscience and Engineering Education" will be published in 2016 by Springer.

Students on the Bachelor's degree program particularly value the block courses, which allow the students to participate actively in research groups. They gain insight into applied research, gain practical work experience, and expand their network by making contact with research teams from the whole SNI network. In 2015, students were able to choose from more than 30 different block courses. In addition to these mandatory courses, the SNI continuously expands the choice of courses for an optimal education. In 2015, for example, the career workshop "Meet & Connect Career Nano – Now?" took place for the first time. Students and PhD students were given practical guidance on a successful transition from university to the world of work.

Transition to Basel for the Master's Program

Sara Freund receives award for best Master's thesis

Sara Freund, a young Frenchwoman who first came to the University of Basel for her Master's in nanoscience, received the award for the best Master's thesis in nanoscience in 2014 at the SNI's second Annual Meeting. During her award-winning work in the group led by Professor Ernst Meyer, she used a newly developed non-contact atomic force microscope to study different surfaces in non-contact mode for the first time.

Master's thesis with a new AFM
SNI Director Christian Schönenberger was delighted to present several awards at the 2015 SNI Annual Meeting. One of these went to nanoscientist Sara Freund for her excellent Master's thesis. In February 2014, Sara joined Professor Ernst Meyer's team in the Department of Physics at the University of Basel to work with a novel non-contact atomic force microscope (AFM). This AFM had been developed over the previous years by Dr. Gregor Fessler, one of Meyer's former doctoral students. He had successfully used it to take some friction measurements, but it had not yet been used in non-contact mode to generate images of different surfaces.

Studying benzylammonium
Sara then used the new AFM, which works at room temperature, to investigate the surfaces of benzylammonium (BNL) crystals. These organic compounds are the result of a collaboration between the Meyer group and Professor Decurtins of the University of Bern. Gregor Fessler had already conducted a detailed study of BNL, which (among other distinguishing features) has anisotropic properties. This means that the physical and chemical forces in BNL work differently in different spatial directions, a fact that is reflected in the variation in orientation on the surface of the crystals.

A bumpy start
However, the atomic imaging of BNL proved more difficult than Sara had originally anticipated. Noises and vibrations in the building were the first problem. They interfered with the measurements until Sara eventually acquired some insulating underlay. Next, she ran into difficulties when preparing the samples. The standard approach of attaching samples to the holder with glue, for instance, did not work because the glue melted onto the sample when heated up. Sara then tried an approach similar to the initial production of graphene, using sticky tape to remove a thin slice of hot BNL. This meant she could prepare the samples in a way that would enable measurements to be made in the ultra-high vacuum.

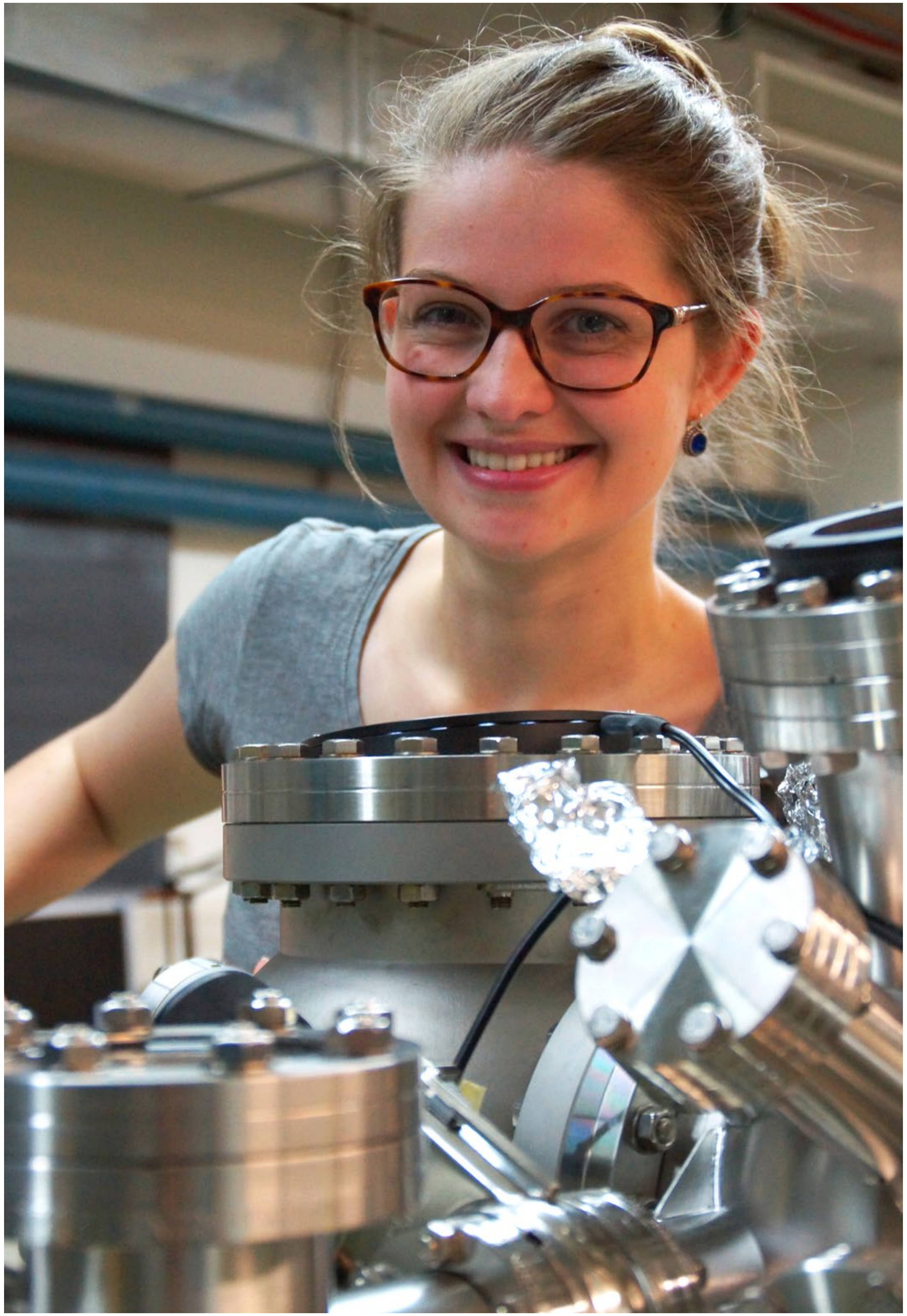
C_{60} molecules form islands
Once Sara had successfully imaged the crystals, she investigated how C_{60} molecules arrange themselves on BNL. She showed that they form relatively small islands, which is different to their behavior on metals or ionic crystals. These islands contain roughly 1,000 to 2,000 molecules and are either triangular or hexagonal in shape. Using the AFM tip, Sara was able to change the shape of the islands by turning triangles into hexagons and vice versa.

Seeing atoms was a dream come true
Sara's supervisor, Ernst Meyer, is delighted with the work of the 25-year-old from Hegenheim: "Sara really deserves the award for the best Master's thesis. She did excellent work and didn't let the teething problems faze her. Her thesis shows that the new non-contact AFM is ideal for studying sensitive samples."

Sara is just as fired up as her supervisor. From the moment she first learned about atoms and molecules at school, she dreamed of being able to see them one day. And her motivation remains undimmed, even after completing her nanostudies. Nine days before taking her Master's examination in October 2014, Sara began working on her doctoral dissertation in Ernst Meyer's group. Sara is now using the same microscope – albeit with some alterations and improvements – to study dye-sensitized solar cells in collaboration with the group led by Professor Ed Constable and Professor Catherine Housecroft.

A tough but worthwhile transition
Sara feels at home at the University of Basel and is particularly settled in her research group. She is enjoying her doctoral dissertation and has never regretted moving to Basel for her Master's in nanoscience after completing her Bachelor's degree in physics in Strasbourg – even if it meant putting in some extra work. "I only did a bit of chemistry in Strasbourg and no biology at all," Sara recalls, "so it was really tough in Basel at first. As well as starting my Master's program, I also had to catch up on block courses and other Bachelor's courses. But I knew straight away that I absolutely loved it!"

Sara also communicates her enthusiasm for nanoscience to others. In November 2015, for example, she visited a school in Porrentruy in the Canton of Jura and presented the nanostudies program to several classes. For the SNI, it is very fortunate that some students, like Sara, act as ambassadors for their degree program and the nanosciences. They play a significant role in sharing their fascination for the nanosciences with school pupils and sparking their interest in studying the subject.



A Resounding Recommendation

Sebastian Castilla organized a research stay at the SNI as part of the ERASMUS program

The ERASMUS program has made it easier for many students to gain experience abroad. Nanoscience student Sebastian Castilla also took part in the program and travelled from Barcelona for a research stay at the University of Basel. He worked on superconductive contacts on graphene in the nanoelectronics group run by SNI Director Professor Christian Schönenberger.

Basel: The most attractive destination

Basel is not the only place to study nanoscience. For example, the Universitat Autònoma de Barcelona now offers Bachelor's and Master's degree programs in nanosciences. Sebastian Castilla began his studies there in 2011 because, as he explains, he was fascinated by phenomena on the nanoscale. Since he also wanted to experience life outside of his university, he began investigating options for a research stay at a different European university during his Bachelor's studies. With the SNI and diverse research groups, Basel appealed to him the most. He contacted Dr. Katrein Spieler, nanostudies coordinator at the University of Basel, who recommended that he look at the websites of the SNI research groups and apply to them directly. Initially, Sebastian was not sure whether he wanted to focus on biology- or physics-related topics. In the last year of his Bachelor's degree, however, physics proved most inspiring, and so Sebastian joined Christian Schönenberger's nanoelectronics group in February 2015.

Current research project on graphene

Here, he investigated superconductive contacts on graphene under the supervision of Dr. Peter Makk and doctoral student Simon Zihlmann. He became acquainted with nano production techniques and constructed an electronic component in which graphene is covered with a layer of boron nitride and connects two gold contacts. Sebastian then used a central superconductive contact as a spectrometer, which allowed him to measure electron distribution in the graphene.

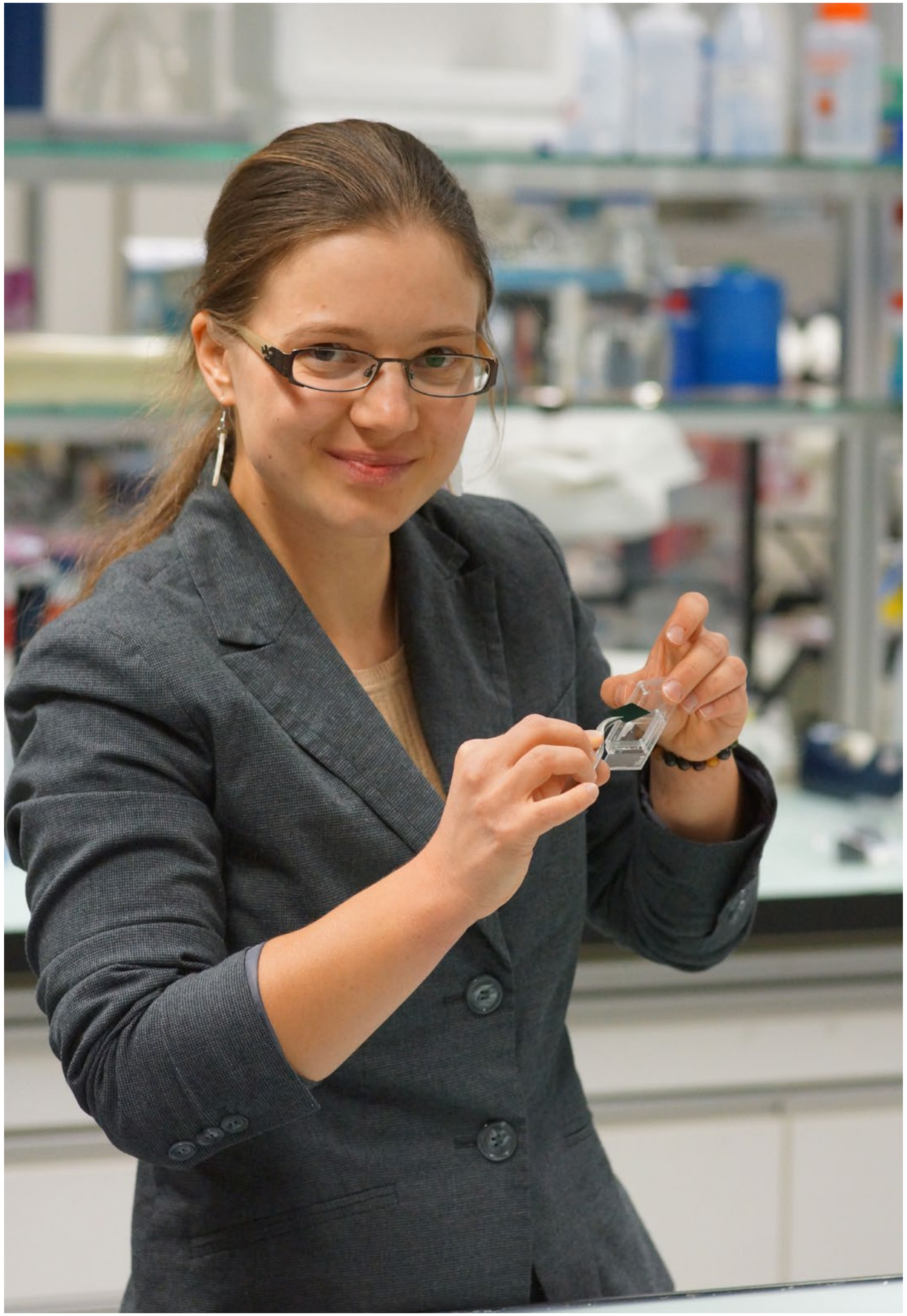
Sebastian has fond memories of his six months at the SNI in Basel: "I learnt a great deal and made huge progress. Everyone in the group was extremely helpful and supportive." Sebastian has spoken very positively of his stay to his colleagues back in Barcelona and highly recommends the University of Basel and the nanoelectronics group in particular: "If you are motivated and really want to learn more about nanosciences, then I definitely recommend the SNI. It is an excellent place for nano research."

Positive lasting impressions

Research was not the only thing in Basel about which Sebastian was enthusiastic. He also enjoyed the city, skiing excursions with his team from the laboratory, swimming in the Rhine, and his 15-day trip through Switzerland. The Matterhorn, the Eiger, raclette, fondue, and chocolate – all things that Sebastian learnt to love during his stay and will not forget in a hurry.

His experiences abroad have also inspired Sebastian Castilla to complete his Master's degree outside of Spain, his homeland. He is currently enrolled on a Master's program at the Université Pierre et Marie Curie. He wishes to complete his studies in June 2016 and continue on to a doctorate. He has not yet decided what he will study or where he will live. Who knows, perhaps we will see Sebastian Castilla again in the SNI PhD School?

PhD School



Focused on Membranes

Nadia Opara develops methods for examining proteins

In 2015, 33 young nanoscientists were enrolled in the SNI PhD School. One of these students, Nadia Opara, had started her doctorate the year before, developing new methods to more efficiently analyze the structure of proteins. The young chemist's work is supervised by Dr. Celestino Padeste of the Paul Scherrer Institute (PSI), Dr. Thomas Braun, and Professor Henning Stahlberg of the C-CINA at the University of Basel. At the SNI's Annual Meeting in 2015, Nadia Opara gave an entertaining and memorable presentation about her interdisciplinary work and won the "Best Talk Award".

Proteins as the subject of experimentation
Proteins play an elementary role in all life on the Earth. Among their many functions is their role as biocatalysts in chemical reactions. They also give cells their skeleton. In humans, numerous diseases such as Alzheimer's and Parkinson's are associated with a change within the structure of certain proteins. Determining the shape of the proteins is key to a better understanding of the processes that occur within the human body to distinguish healthy from diseased cells. To gain insights into the actual geometry of the proteins, scientists around the world use so-called "crystal structure analysis". The most common procedure is to crystallize the proteins, place them onto a type of support, and display them using a specific kind of X-ray. When the electromagnetic radiation hits the protein crystal, diffraction patterns are produced that can be used to calculate the distribution of electrons, which in turn makes it possible to determine the amino acid sequence, as well as the spatial structure of the individual proteins. For reliable results, researchers require three-dimensional protein crystals of sufficient size and quality, which are not always available.

Crystallization directly on the support
In her doctoral research, Nadia Opara is designing a new and effective procedure to facilitate crystal structure analysis. In her approach, she allows crystals of

varying size to grow from comparatively little sample material and analyzes them in detail at high resolution at room temperature. The young researcher has chosen lysozyme, which is present in substances such as the human tear fluid, for testing purpose.

In her experiments, Nadia Opara allowed the protein to crystallize in situ, directly on a solid support that she has specifically developed for her research. The support protects the protein crystals from dehydration and denaturation. Furthermore, the materials used for the support need to be as transparent as possible to the X-rays. In the initial tests, thin membranes made from silicon nitride performed well. “First, the silicon wafers are coated with silicon nitride, next, I etch tiny windows to give space for the proteins to crystallize,” Nadia Opara explains. In the next step, she adds a second chip to form a sandwich-like structure. The silicon nitride layer protects the proteins as though in a chamber, while the X-ray radiation penetrates the windows with very little scattering or absorption. In addition to developing the solid supports, Nadia Opara examines various crystallization conditions. A major development in her research was when she was able to grow large, single crystals, as well as depositions of numerous small ones.

Diffraction patterns provide the necessary information

Scientists use free-electron lasers such as the SwissFEL being built at the PSI for crystal structure analysis because they generate coherent X-ray radiation of extremely high brightness in very short time intervals. These properties allow for high quality data to be collected from the experiments. Typically, the crystals are no more than a few hundred nanometers in size and are rapidly destroyed through the exposure to X-rays. However, specific detectors are fast enough to record the diffraction patterns that are needed to gain the crucial information about the protein’s structure.

Award at the Annual Meeting

Nadia Opara was the last presenter at the SNI’s Annual Meeting in September 2015, and talked about her successful work in the previous few months. She succeeded in enthralling the audience just before the end of the event and convinced them all of just how fascinating her work at the SNI PhD School can be. The young chemist is “making her dreams come true,” enjoys the interdisciplinary work, and appreciates the outstanding supervision provided by both C-CINA at the University of Basel and the PSI.

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 2015, 33 doctoral students from 14 different countries were enrolled in the SNI PhD School. The five new projects advertised in 2015 received several hundred applications from young scientists.

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, the Swiss Tropical and Public Health Institute, the 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. All doctoral students in the SNI PhD School participate in the various SNI conferences with the opportunity to present their work in an interdisciplinary environment. In addition, the SNI offers various courses and meetings that are specially developed for the doctoral students. In 2015, the focus was on rhetoric and presentation and academic exchange during the annual Winter School “Nanoscience in the Snow” and the SNI’s annual event. In 2015, several PhD students of the SNI became actively involved in the organization committee for the “International Nanoscience Student Conference” (INASCON), that took place in Basel supported by the SNI.

Mental Images

First rhetoric and presentation workshop at the SNI PhD School

At the start of May 2015, 11 doctoral students from the SNI PhD School left their laboratories and experiments behind for a while to learn more about rhetoric and presentation techniques in the conference rooms of Mariastein Abbey. The two coaches – actor Sasha Manzotti and Dr. Ralf Stutzki of the National Center of Competence in Research (NCCR) Molecular Systems Engineering – put together a varied program that offered the participants ample scope to implement everything they heard and learned.

Famous speakers

The workshop began with a discussion and range of examples of how good talks are structured and the tools speakers can use to keep their audiences enthralled. From Cicero to George W. Bush, Steve Jobs to William Faulkner, Ralf Stutzki provided the participants with numerous examples to clearly illustrate the fundamental aspects of successful presentations. Many speakers employ clear and distinctive imagery; however, these images must be formed in the speaker’s mind before they can be conveyed to an audience.

Common theme

The idea of “mental images” therefore became a common theme throughout the two days – particularly in the sessions led by Sasha Manzotti. When tackling the question of the ideal posture, all participants were asked to picture a ribbon on the crown of their head holding their head and body. The shoulders can then hang loosely rather than rising, our automatic response to tension. The attendees had very different images in mind when practicing various sounds to train their voices. An outsider would probably have thought the room was full of spiders as cries of “eeeyyy” echoed around the room. Late the first evening, the doctoral students practiced creating images in the audience’s minds through emphasis and expression alone. They read stories or recipes in their native languages, aiming to actively involve the others in the story or make their mouths water – even if they did not understand Italian, Polish, or Slovenian. “I learned that not only what I say counts, but also the way I convey it,” commented Nadia Opara on the exercise.

Ideal introduction

Even more imagination was required when all the doctoral students were asked to picture the ideal opening scene for their academic presentation. The presentation was to begin not with a standard sentence, but with a strong image. Michael Gerspach, for example, started his talk by eating cherries. He noted that some of the cherries were sweet and some were sour. "If I put them all in one blender, I can only taste a medium sweetness," he commented. However, such average values are exactly what the young scientist does not want to analyze when examining proteins. Instead, he wants to investigate the characteristics of individual proteins. He has therefore developed a method to collect and analyze individual nanoparticles. The cherry analogy provides a simple introduction to the problem, particularly for audience members not familiar with the subject, and makes it more memorable.

Illustrative parallels

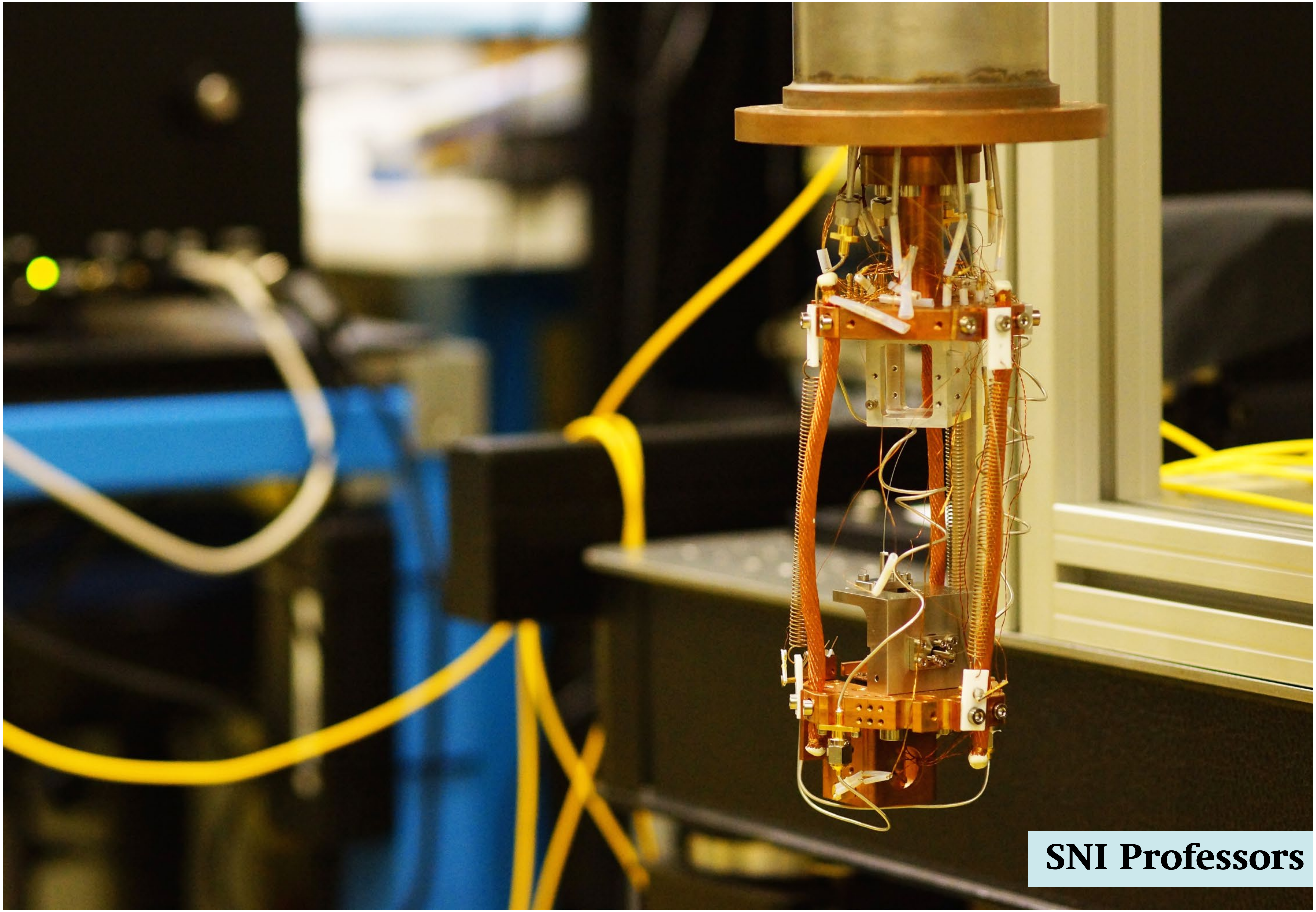
The attendees also had the opportunity to work with such images when Ralf Stutzki invited them to a simulated radio interview in two-person teams. The young academics were given the task of explaining their research to an imaginary lay audience. However, they were interrupted every time members of the audience struggled to understand a word or explanation. A difficult task, and without any preparation! Participants who managed to incorporate everyday comparisons and images from the outset were particularly successful. The different layers of graphene became a pile of paper. Biofilm became a city of bacteria and the function of a catalytic converter was compared with vodka – something that can ease the process of making new friends at a party.

Comfortable silences

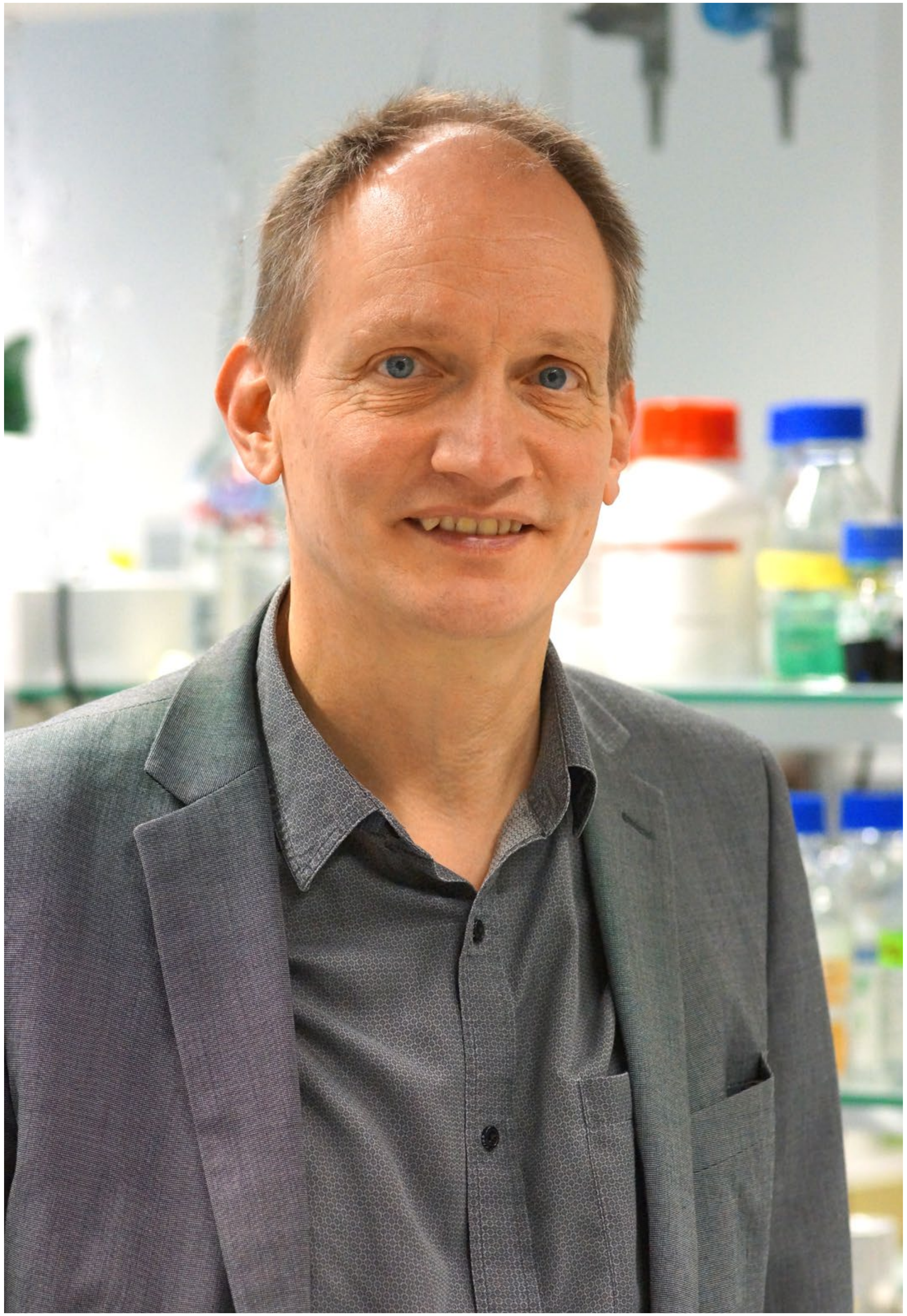
The many useful exercises did not only focus on talking; they also covered comfortable silences. Sometimes presenters have to wait a few minutes rather than launching straight into their talk. The participants all discovered how difficult it is to stand before an audience and remain natural and relaxed. "These two minutes of silence in front of an audience were a really interesting and valuable experience," recalls Clevin Handschin, for example.

Difficult situation

How do I deal with unplanned situations? How can I skip over errors with confidence? What do I do if my time is up but I still haven't come to my conclusion? Following general recommendations on structuring academic presentations, Ralf Stutzki's closing session addressed these and similar questions. Although very general recommendations can be made, people's demeanors, gestures, and facial expressions can differ greatly. The two coaches addressed this issue throughout the entire workshop. They provided each individual participant with specific tips and recommendations to enable the doctoral students in the SNI PhD School to deliver good presentations and remain authentic, natural, and relaxed in the future.



SNI Professors



Studying the molecules of life in their natural environment

Jan Pieter Abrahams has a vision for his research in Basel and at the PSI

Since May 2015, the Swiss Nanoscience Institute (SNI) has been sponsoring another professor, who is teaching at Basel University and carrying out research both in Basel and at the Paul Scherrer Institute (PSI). Professor Jan Pieter Abrahams moved to Northwestern Switzerland from the University of Leiden in May 2015. The things that impress him here are the collegiate environment, the availability of first-rate microscopes, and the long-term research strategies in place at his new workplaces in Basel and Villigen. The goal of his research is to analyze the 3D structure of molecules in their natural environment. In pursuit of this challenge, he has already secured funding for an Argovia project and a doctoral position within the SNI's PhD School.

Analyzing molecular structure in situ is key
Large molecules such as proteins are of vital importance to our cells. They are responsible for basic processes like transporting oxygen and fending off pathogens. They play an important role in metabolism and movement and give cells their structure. The 3D structure of proteins is critical to how they function, but it is not yet possible to examine these highly complex forms in their natural environment. The methods available to us today require time-consuming preparation of samples, which can affect protein structure. Until now, the 3D structure of proteins has often been analyzed when they are in crystal form, but in their natural environment in the cells proteins do not normally crystallize. In the cells, most proteins work in tandem with a number of other proteins. It is therefore difficult to arrive at a full understanding of their biological activity if we study them only as isolated molecules.

Developing a new method step by step
Jan Pieter Abrahams's goal is to find a way of analyzing the molecular and atomic structure of proteins and other large molecules without influencing or changing them significantly. He sums up his vision as follows: "I want to look at the molecules of life in atomic detail in their natural state and environment, to gain a better understanding of how they function and interact." Although there is still no suitable way of doing that, at the University of Basel and the PSI Jan Pieter Abrahams will have the ideal conditions to develop a new method, and the devices that requires, step by step.

Electrons less damaging than light and X-rays
For the time being, Abrahams and his team are continuing to work with protein crystals. Only when they are able to examine the structure of those molecules without difficulty will they move on to natural samples. The researchers are using electron beams to analyze the samples, as these inflict far less damage than X-rays, and visible light is unsuitable. However, they are not

using the high-energy electrons to generate images, as with a traditional electron microscope; instead, they are looking at the electron diffraction produced by the sample. This happens because electrons possess wave properties and behave in a similar way to light waves when they hit an obstacle. Using this technique to examine molecules produces a specific diffraction pattern from which the arrangement of atoms in the sample can be inferred. As it requires only one hundredth the number of electrons needed to produce an electron image, it is also much less damaging to the sample. To carry out these analyses, Jan Pieter Abrahams has at his disposal the superb electron microscopes at the Biozentrum's Center for Cellular Imaging and NanoAnalytics (C-CINA), which enable him to examine a sample hundreds of times without damaging it significantly. He is currently still grappling with the problem that the intensity distribution of the diffracted electron wave can be determined, but not its phase. However, he and his team have already found solutions, which they are in the course of publishing.

Developing a better detector through the Nano-Argovia program
If electron diffraction is to be used successfully to analyze big molecules, better detectors will need to be developed. On January 1, 2016, Abrahams and Tim Grüne of the Paul Scherrer Institute launched an Argovia project to do just that. Working alongside colleagues from C-CINA, the PSI and the Swiss firm Dectris, the team will seek to modify a detector developed by Dectris and incorporate it within an electron microscope. Abrahams hopes that this new detector will provide better resolution, allowing the atomic and molecular structure of proteins to be determined more accurately.

New microscope using structured electron waves
For Abrahams, the next step is to develop an entirely new microscope. This will not be able to take images of the sample, like a traditional electron microscope, but will be used solely to analyze electron beam diffraction. Abrahams says of his plans, "This microscope will be less complicated but will produce more precise data for our purposes." In pursuit of this goal, he and Dr Soichiro Tsujino (PSI) have secured funding for a doctoral project at the SNI's PhD school, to be launched in 2016. The aim of the project is to develop a programmable device to produce an electron beam that is no longer generated as a simple wave but already has its own structure. The electron diffraction undergone by a simple wave differs from that undergone by a structured wave, providing scientists with additional information about the arrangement of atoms within the molecule. Commenting on the timescale for the project, Abrahams notes, "I think that in one or two years we will be able to show that the concept works in principle. It will take us longer to make the new microscope a reality."

Off to a good start in Switzerland
Jan Pieter Abrahams only started work at the University of Basel's Biozentrum in May 2015 and has been head of the Laboratory of Biomolecular Research at the PSI since January 2016. However, he has already settled in well and has already launched two SNI projects. When asked about his experiences over the few months, he replies, "I am impressed by the superb facilities here and the way in which colleagues work together across departments. The academic environment in Basel and at the PSI is fantastic. I am really pleased to see the long-term investment that is being made in research here and the links that are being forged between basic sciences and engineering sciences, between biology and physics and the latest technology, to drive research forward."

Use of Findings for Applications

SNI scientists focus on nanopores

Argovia Professor Roderick Lim and his team study natural and artificial nanopores. On one hand, they aim to understand in detail how nuclear pore complexes control the selective exchange of molecules between the nucleus and cytoplasm in living cells. On the other hand, the Lim team uses this fundamental knowledge as a source of inspiration to create "smart" bio-synthetic nanopores with potential technological applications.

Biological machines that sort molecules
The nuclei of higher organisms are separated from the surrounding cytoplasm by a biomembrane. This membrane has tiny nanoscale holes known as nuclear pores that facilitate the exchange of molecules between the nucleus and cytoplasm. For water and small metabolites, this exchange is driven by diffusion. However, large molecules cannot automatically bypass the nuclear pores, which are protected by a molecular filter consisting of barrier-forming proteins known as FG Nups (phenylalanine-glycine nucleoporins). In fact, only specific molecules can selectively transport through the FG Nup barrier. Nonetheless, an understanding of how the FG Nups work remains a "holy grail" in the field given that they have never been seen inside NPCs. Therefore, it remains a mystery whether they are arranged in a static manner or fluctuate dynamically in time.

Captured on film for the first time
Argovia Professor Roderick Lim has been investigating this nanoscopic transport process for some years. Now, using a high-speed atomic force microscope, his team has become the first to watch natural nuclear pore complexes at work in situ. Yusuke Sakiyama, a doctoral student in Roderick Lim's laboratory at the SNI PhD School, has recorded these observations as movies. Their findings have been submitted for publication and are anticipated to contribute to a better understanding of the transport processes through the nuclear pores.

Creating artificial nanopores that mimic biology
Ludovit Zweifel, another doctoral student (and ex-Nano student) in the Lim team creates artificial nanopores from glass capillaries that mimic nuclear pores. In collaboration with Ivan Shorubalko at the Swiss Federal Laboratories for Materials Science and Technology

(EMPA, Dübendorf), Zweifel uses scanning transmission ion microscopy to determine the geometry of these glass nanopores. Applying this accurate analytical method, Roderick Lim and his colleagues could optimize the fabrication process of the nanocapillaries. They produced capillaries with several tip geometries and opening angles and analyzed the transport processes of single molecules depending on theses different parameters.

Sensing single molecules using electrical currents
The scientists use these glass capillaries as nanopores to detect single molecules. They place an electrical potential across two small salt-solution-containing reservoirs connected via a glass capillary. This establishes a steady stream of ions through the nanopore. If DNA or proteins are added to one of the reservoirs, these partially block the nanopore, which leads to a decrease of the ionic current. Based on the duration and amplitude of the current changes, researchers get important information about size and charge of the respective molecules. Importantly, this is anticipated to significantly improve single molecule biosensors and DNA sequencing.

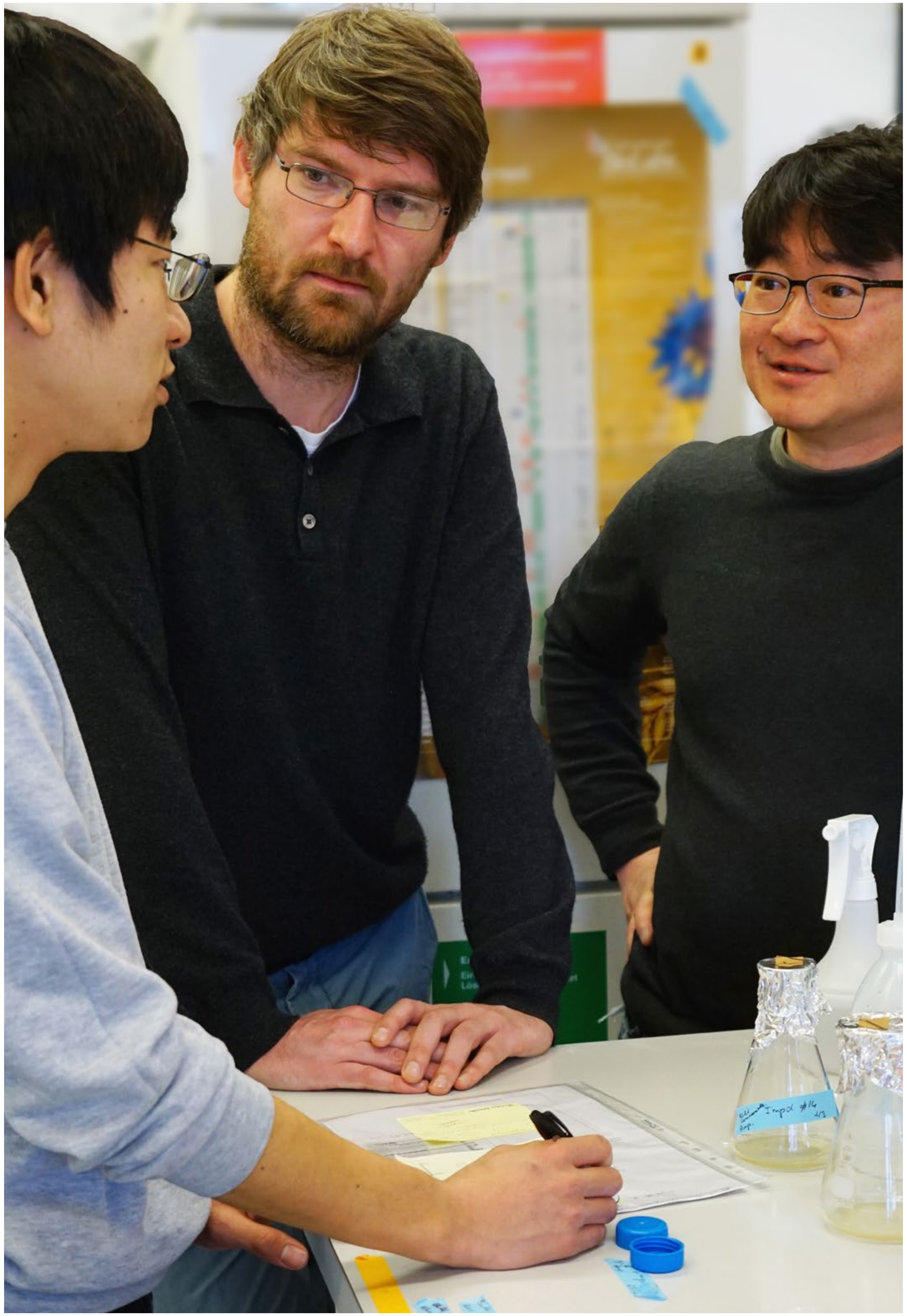
Nanopores for molecular engineered systems
In living cells, different biochemical processes run in parallel. This is only possible because each cell is separated in different compartments by membranes. Various research programs aim at developing nanotechnological systems with membrane-bound machines based on nature as example. In this respect, the Lim team is contributing to the efforts of the National Center for Competence in Research “Molecular Systems Engineering” by designing nanoporous synthetic vesicles (proteoliposomes) that function as “artificial nuclei”. Specifically, their goal is to import, compartmentalize and accumulate specific macromolecular modules against concentration gradients.

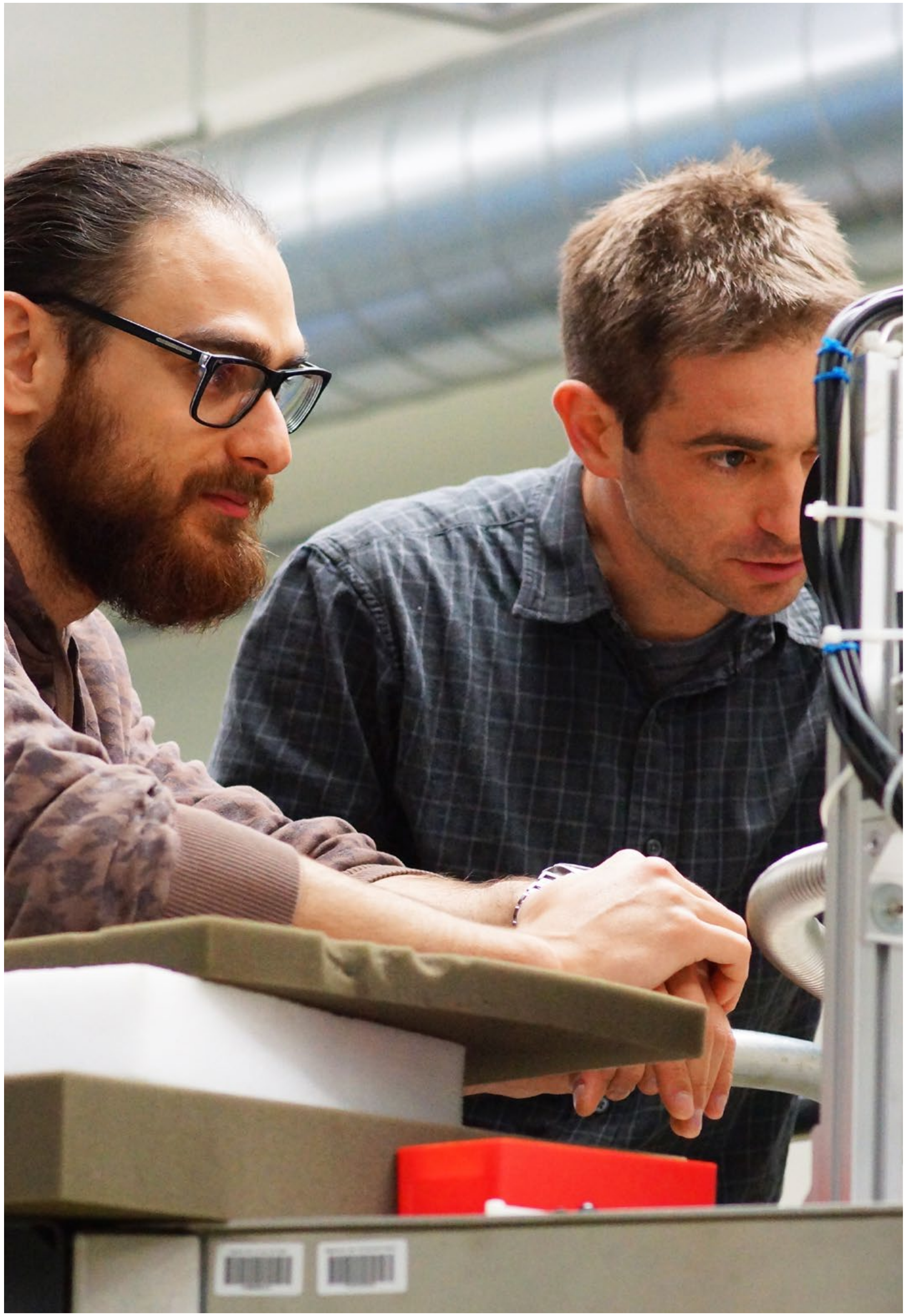
SNI professors in brief

The Swiss Nanoscience Institute has supported the two Argovia professors Roderick Lim and 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, they study nanowires and their application as multifunctional sensors.

In 2015, Lim and Poggio and their teams presented their research results in eight papers in peer-reviewed scientific journals and in twenty-nine lectures 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 1.5 million for their research.

Since May 2015, the SNI has supported the work of Professor Jan Pieter Abrahams, who came to Basel from the University of Leiden. His research at the University of Basel’s Biozentrum and at the Paul Scherrer Institute focuses on the spatial structure of molecules in their natural environment. The three titular professors Thomas Jung, Michel Kenzelmann, and Frithjof Nolting, who are supported by the SNI, also work at the Paul Scherrer Institute. They teach in the Department of Physics at the University of Basel. Thomas Jung additionally heads the Nanolab at the Department of Physics.





Fiber-Pigtail with Photon Source

SNI team develops robust, easy-to-operate source of quantum light

In the last couple of years, Argovia professor Martino Poggio has been studying nanowires, especially their application as multifunctional sensors. Nanowires only have a diameter of a few nanometers. They either self-assemble from molecular components or are produced from larger structures by micro fabrication techniques. Because of their small dimensions and their large length-to-width ratio, nanowires possess special electronic, optical, and mechanical properties. In a recently published paper in Applied Physics Letters[1], the Poggio team together with colleagues from Basel and Grenoble describe how they developed a robust source for quantum light using specific nanowires. The researchers attach a tapered nanowire that contains quantum dots at its tip to the center of a single optical fiber. The quantum dots emit single photons without functionalization or an external electric field. This tiny "quantum fiber pigtail" can easily be integrated into an optical system and, for example, be used as a sensor.

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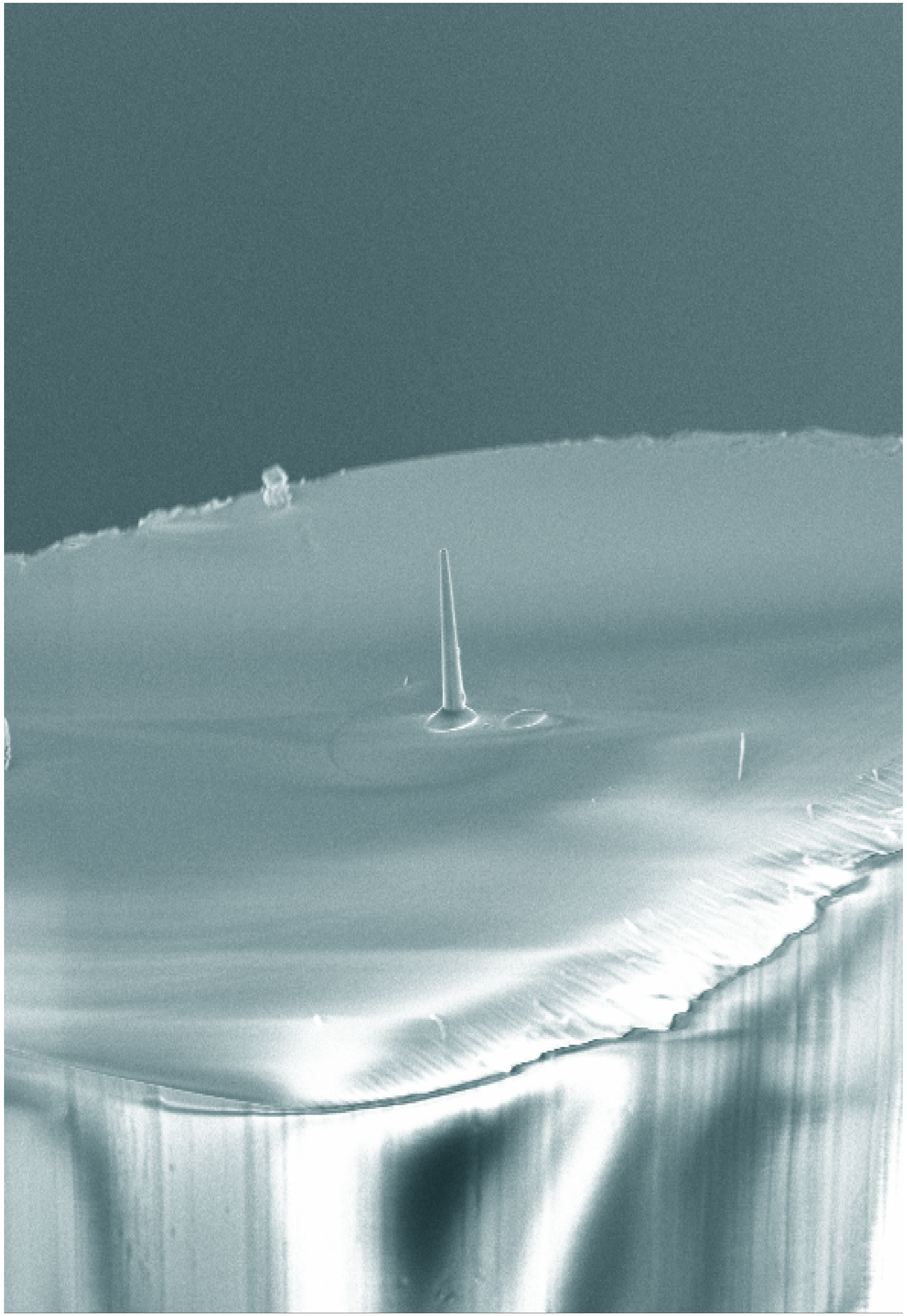
Ubiquitous optical fibers
Today, optical fibers are widely used. The thin flexible, transparent fibers are made from finely pulled glass and are frequently used as a means to transmit information. Fiber-optic links have largely replaced copper wire in core communications links as signals travelling along optical fiber suffer fewer losses than wire cables and are immune to electromagnetic interference. Typically, optical fibers are bundled to multi-fiber cables and are terminated with connectors, so that they can be easily attached to other equipment. Short lengths of fiber with a connector on one end and an exposed fiber on the other end are known in the industry as “fiber pigtails” and are generally used for making connections to individual fibers of a multi-fiber cable or for direct connections to photo-receivers or other optical devices.

Source for quantum light
Researchers in the labs of Argovia professor Martino Poggio and professor Richard Warburton from the Department of Physics in Basel have recently developed a so-called “quantum fiber pigtail” that is a source for quantum light which makes it promising for applications in quantum communication and in precision sensing. The fiber pigtail has semiconductor quantum dots attached to one end, which provide on-demand single photons. Unlike conventional sources for quantum light, which are often complex networks of bulky free-space optical components, the “quantum fiber pigtail” is robust, compact and easy-to-operate and promises to bring single photon sources to any user able to work with optical fiber.

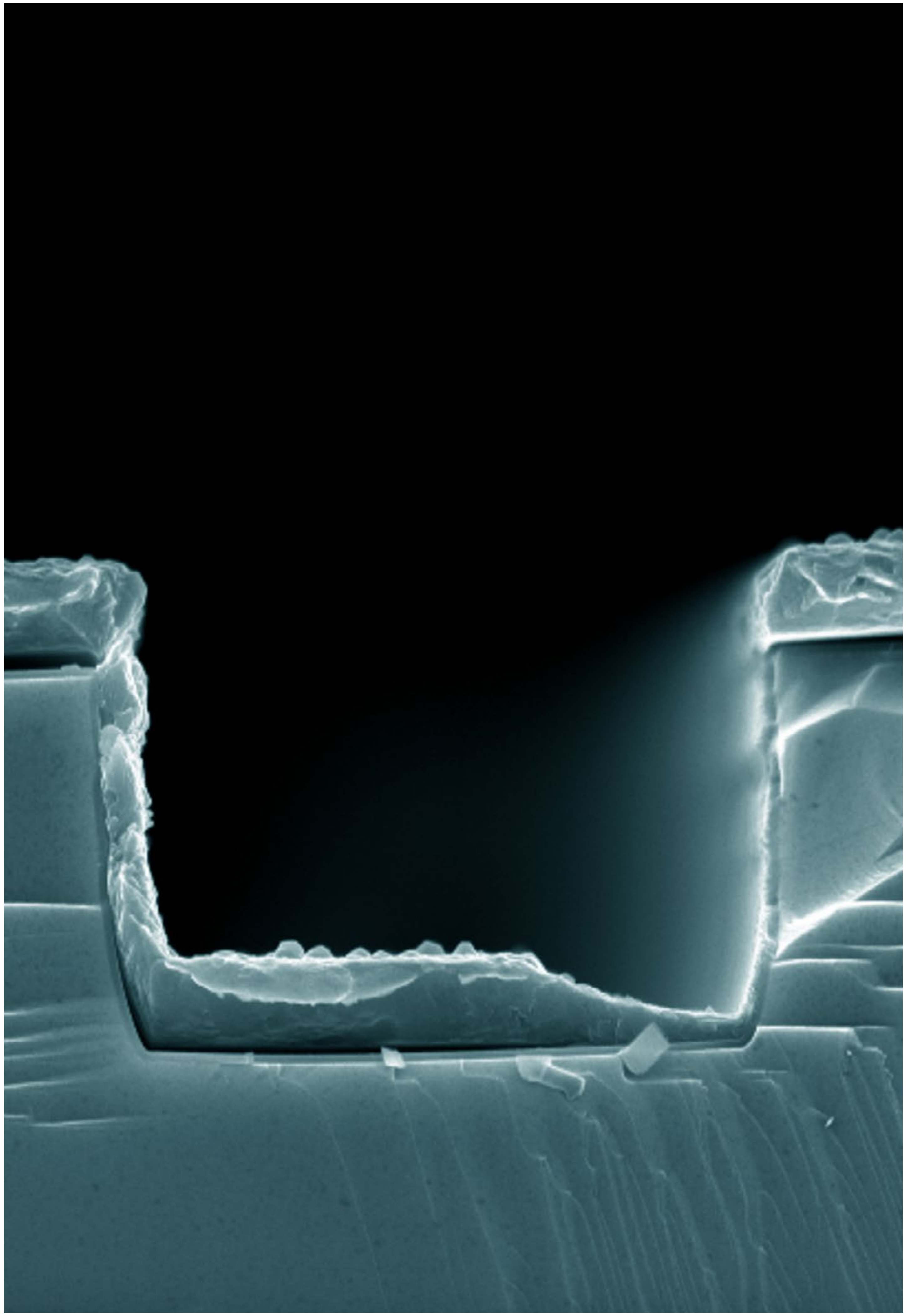
Combination of quantum dots and nanowire
In order to realize the “quantum fiber pigtail”, the Basel researchers, led by SNI-PhD student Davide Cadeddu and post-docs Mathieu Munsch and Jean Teissier, used a short tapered nanowire. They embedded quantum dots, which are efficient single photon emitters, at the tip of the wire. Colleagues from Grenoble produced these specific wires, which are called “photonic trumpets” due to their appearance.

Then, the scientists directly attached the trumpet to the cleaved end of a single mode fiber with a connector on the other end. Because of the tiny dimensions of the objects, the team carried out this attachment process with a hydraulically actuated micro-manipulator under a high-power optical microscope. “The connection between trumpet and fiber is remarkably robust and can be achieved within a couple of hours”, explains Martino Poggio the work of his co-workers, who show the entire process on YouTube (https://youtu.be/E_A3y_K3kRw).

Application to other quantum systems
“The results demonstrate that it is possible to develop an easy-to-operate single photon source, which is straightforward to integrate and has potential applications in quantum optics or metrology”, adds Poggio. “Our approach provides a solution for maximizing light extraction from quantum dots, however, it is generic and could be applied to other quantum systems, including in emitters in diamond or silicon.” Furthermore, easily addressable quantum dots or other emitters at the end of a nanometer-scale tip have obvious potential as scanning probes.



Nano-Argovia Program



Trenches Reduce Electrical Resistance

Argovia project confirms theoretical approach

The SNI's Nano-Argovia program supports applied research projects between academic research institutions in Northwestern Switzerland and industrial companies. In one such successful Argovia project, researchers from the CSEM in Muttenz, the Paul Scherrer Institute (PSI), the University of Basel, and the ABB Corporate Research Center investigated and optimized a novel type of transistor for power electronic applications. This transistor should also be suitable for high current densities and voltages, and could offer better properties than current, commercially available products.

Increasing demand for energy requires new electronics
We live in an age in which demand for energy is constantly growing, and it is intended that renewable energies will supply an increasing share of this overall demand. This presents new challenges in terms of practical application and for the scientific community. Electricity generated in offshore wind farms, for example, must be efficiently transported across long distances without significant losses. Wind power and solar facilities produce alternating and direct currents of relatively low voltage. However, an alternating current of 50Hz and high voltage is required for the transport. "Special smart power electronics is required for such conversions that is also compatible with high current densities and voltages," explains Dr. Holger Bartolf from the ABB Corporate Research Center, who initiated the project. With the ABB Corporate Research Center in the Canton of Aargau and experts from the CSEM, PSI, and the University of Basel, Northwestern Switzerland is perfectly equipped to play a major role in developing new technologies in this important area.

Silicon carbide could replace silicon
An effective power converter requires a number of digital switching operations. Each of these switches changes between an OFF state and an ON state. Ideally, no electric current (or only a very small leakage current) should flow through such a switch in the OFF state. When turned ON, however, lots of current flows with as little resistance as possible. It is also important that the switching operation is as fast as possible to keep the associated switching losses as low as possible.

Today, metal-oxide semiconductor field effect transistors (MOSFETs/IGBTs) are primarily used as switches. "Silicon-based semiconductors are currently dominating the market, but for scientists around the world, silicon carbide (SiC) seems to be an energy-efficient alternative," explains Holger Bartolf. The properties of silicon carbide enable the design of smaller converters that are simpler to cool and which dissipate less electric power due to leakage currents when in the OFF state. However, silicon carbide switches have a higher resistance when in the ON state, thereby the conduction losses increase as compared to silicon semiconductors. These resistances are caused by defects in the interface layer between silicon carbide and silicon dioxide, in which an electronically conductive channel may form under certain conditions. Here, the silicon dioxide functions as an isolator between the operating gate electrode and the semiconductor.

Production is complex
Researchers from the "Nano SiC Trench MOSFET" Argovia project, led by Dr. Marc Schnieper from the CSEM in Muttenz, examined MOSFETs with microscopically small U-shaped trenches to solve the problem of lower

electron mobility in the SiO_2/SiC channel. “We have examined and optimized the manufacturing process for producing these specially structured semiconductors,” explains Marc Schnieper. These specially structured MOSFETs are much more complex and expensive to produce than planar MOSFETs. “It depends on the exact form and depth of the trenches, and their roughness is also key to their properties,” adds Professor Jens Gobrecht, whose laboratory at the PSI has being used for production.

Simulations have been confirmed
The scientists involved from the CSEM, the PSI, the University of Basel, and ABB also characterized the electronic switching behavior of these new transistors and compared their properties with those of planar MOSFETs. Theoretical simulations predicted a lower resistance, which was confirmed by the experiments performed last year. “Improving transistors is a highly significant challenge for us,” comments Professor Ernst Meyer from the University of Basel. “Around the world, more transistors are now being produced each day than grains of rice. Even the smallest improvements to their energy consumption will have a massive global impact.”

The Nano-Argovia program in brief

The Nano-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 2015, fifteen Argovia projects received total funding of approximately CHF 1.3 million.

Nine of the collaborations (60%) involved companies from the canton of Aargau. Industrial companies that participated in finalized Argovia projects were highly pleased about the outcome of the projects. Several follow-up projects developed from the joint projects with the SNI network and in a survey the companies confirmed that they would participate in another Argovia project.

Successful Collaboration Between University, University of Applied Sciences, and Industry

Innovative biocatalysts thanks to nanotechnology

In 2014, scientists from the University of Applied Sciences and Arts Northwestern Switzerland (FHNW), the University of Basel and Basel-based company INOFEA AG launched the NANOzyme Argovia project, and with it a successful collaboration to make enzymes more attractive for biotechnological applications. To achieve this, the interdisciplinary research team developed a system in which different enzymes are combined, immobilized on nanoparticles and protected by a protective layer of organosilica. The researchers were able to show that this enzyme system effectively catalyzes a cascade of different chemical reactions and is suitable for a range of biotechnological applications.

Regeneration required
Enzymes play a vital role in all organisms. They specifically catalyze the conversion of a wide range of chemical compounds in life processes such as digestion and reproduction. Enzymes are also suitable for biotechnological applications because they work highly effectively and specifically. For example, enzymes can be used to oxidize or reduce chemical compounds. Almost all enzymes are proteins. Besides the protein part, many enzymes require a low molecular weight molecule – called cofactor – that is, together with the substrate, also subject to chemical change during the enzymatic

reaction. These cofactors are often unstable and must be replaced or regenerated before the enzyme can catalyze another chemical conversion. Due to their instability and the need to regenerate the cofactors, such enzymes are often too complex and expensive for industrial biotechnology applications.

The combination is the key

As part of the NANOzyme Argovia project, the teams of Professor Patrick Shahgaldian, Professor Philippe Corvini (both FHNW), and Professor Thomas Ward (University of Basel) collaborated with Basel's INOFEA AG and have identified ways to solve this problem. In a first step, the scientists combine a natural enzyme with an artificial enzyme. The natural enzyme catalyzes the desired chemical reaction; the artificial enzyme then ensures the immediate regeneration of the cofactor so that the natural enzyme can work again. Additionally, the researchers have developed a chemical strategy to immobilize this enzyme combination on the surface of silica nanoparticles and then shield it within a protective layer. This layer of organosilica particles not only protects the sensitive enzymes, but also creates a tailored compartment in which the exchange of substrate and product is restricted. This ensures that there is always sufficient substrate available which leads to increased product levels.

Optimal conditions created

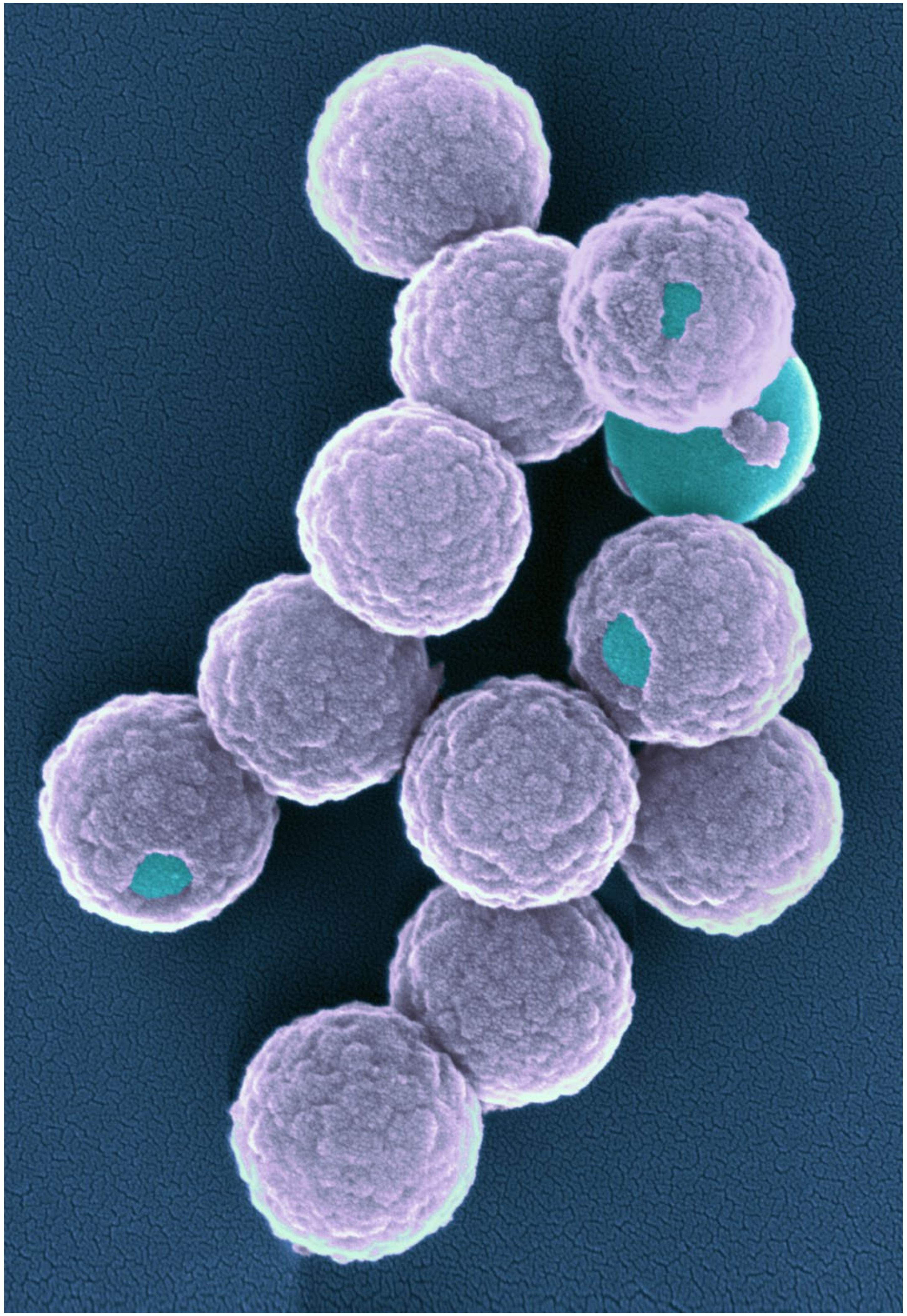
"In our experiments, we have not only tested the optimal enzyme combinations and evaluated the best conditions for forming the protective layer, but also investigated the adequate ratio of the different enzymes involved," comments project leader Patrick Shahgaldian.

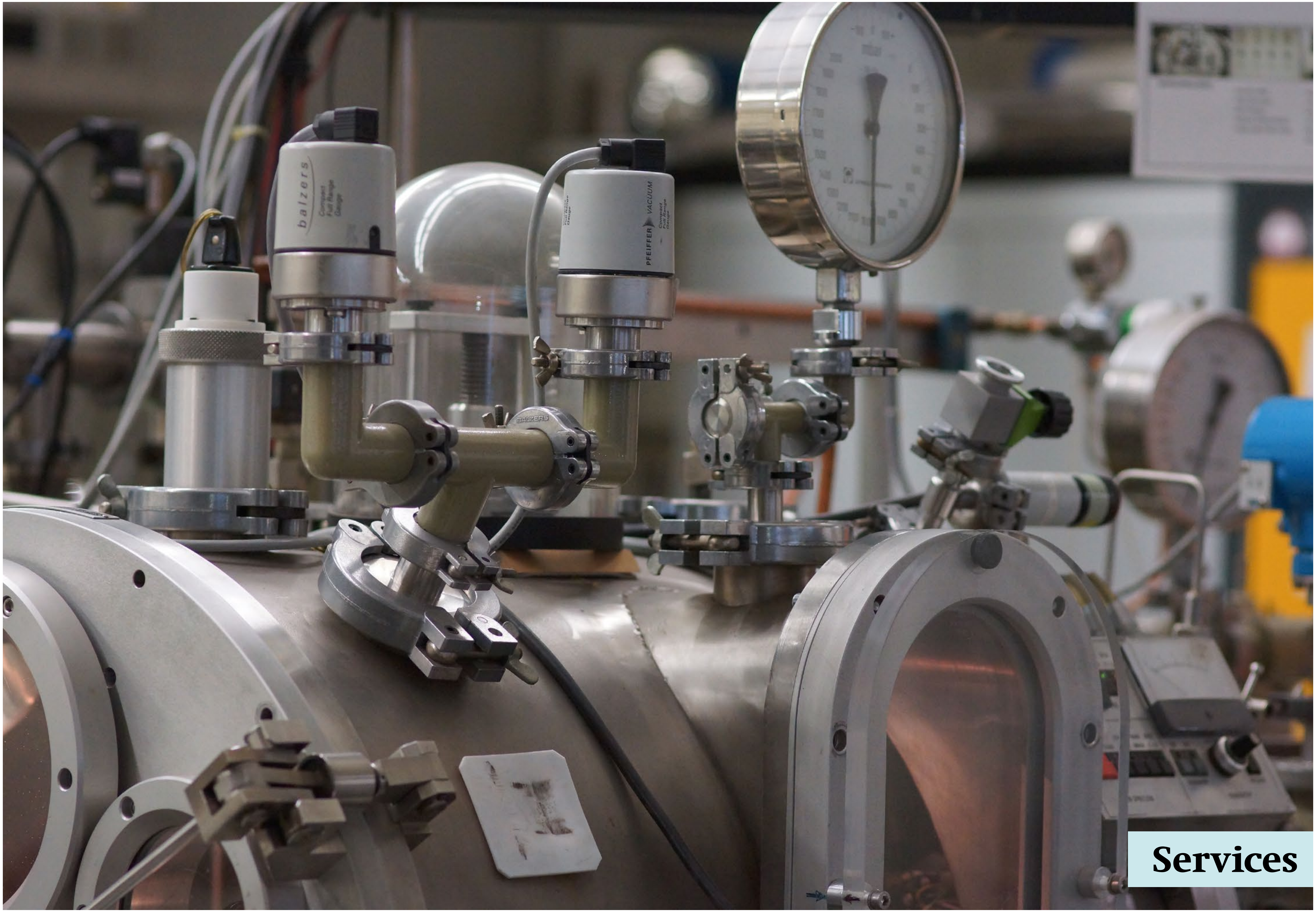
For their experiments, the scientists chose a natural enzyme that converts Flavin mononucleotide (FMN) into its reduced form ($FMNH_2$). NADH (Nicotinamide adenine dinucleotide) is the cofactor required for this enzyme. It transfers a hydride ion H^- and is oxidized to NAD^+. An artificial enzyme (transfer hydrogenase) regenerates the NAD^+ back to NADH so that it can continuously produce more $FMNH_2$ utilizing cheap formic acid as hydride source. The success of the cascade enzymatic reaction is proven using the soluble enzyme luciferase, which oxidizes $FMNH_2$ to FMN in the presence of oxygen. Over various stages a colored complex is formed whose concentration can be measured spectroscopically. The increasing formation of this colored complex is a clear proof that the cofactor has successfully been regenerated.

The results clearly demonstrate the validity of the concept working with protected, immobilized enzymes. With both soluble enzymes and immobilized enzymes without a protective layer, the amount of dye produced was significantly lower than with the immobilized enzymes protected by the organosilica layer.

Interest from industry

An enzyme cascade of this type, which is connected with an in-situ regeneration of the cofactor, can be implemented in various oxidation and reduction reactions for biotechnological applications. The researchers in the NANOzyme Argovia project are currently focusing primarily on developing a rapid test for specific resistant bacterial strains. They will also examine whether the nanocatalysts are suitable for degrading chlorinated hydrocarbons. Based on the successful results the project was just recently prolonged for another year. "We are actively supporting the continuation of NANOzyme because the excellent collaboration has produced a range of promising industrial applications," comments Dr. Yves Dudal, chief executive officer of INOFEA, on the success of the project.





Services

With Head, Hand, Heart, and Humor

Peter Reimann has been researching and developing for almost 35 years

Academic research in the nanosciences is often based on state-of-the-art technologies. An innovative technology group – such as the well-established section of the Department of Physics at the University of Basel – is therefore an important requirement for many researchers. Dr. Peter Reimann has been running this group, which is also supported by the Swiss Nanoscience Institute, since it was founded in 1985. Peter Reimann does not only build and modify machines and devices for scientific purposes; he has also been conducting research in the Department of Physics for over 30 years and has made a name for himself as a builder of bridges between industry and the university. And he is highly skilled at sharing his fascination for his work to a wide range of audiences and introducing them to the exciting world of the nanosciences at numerous events.

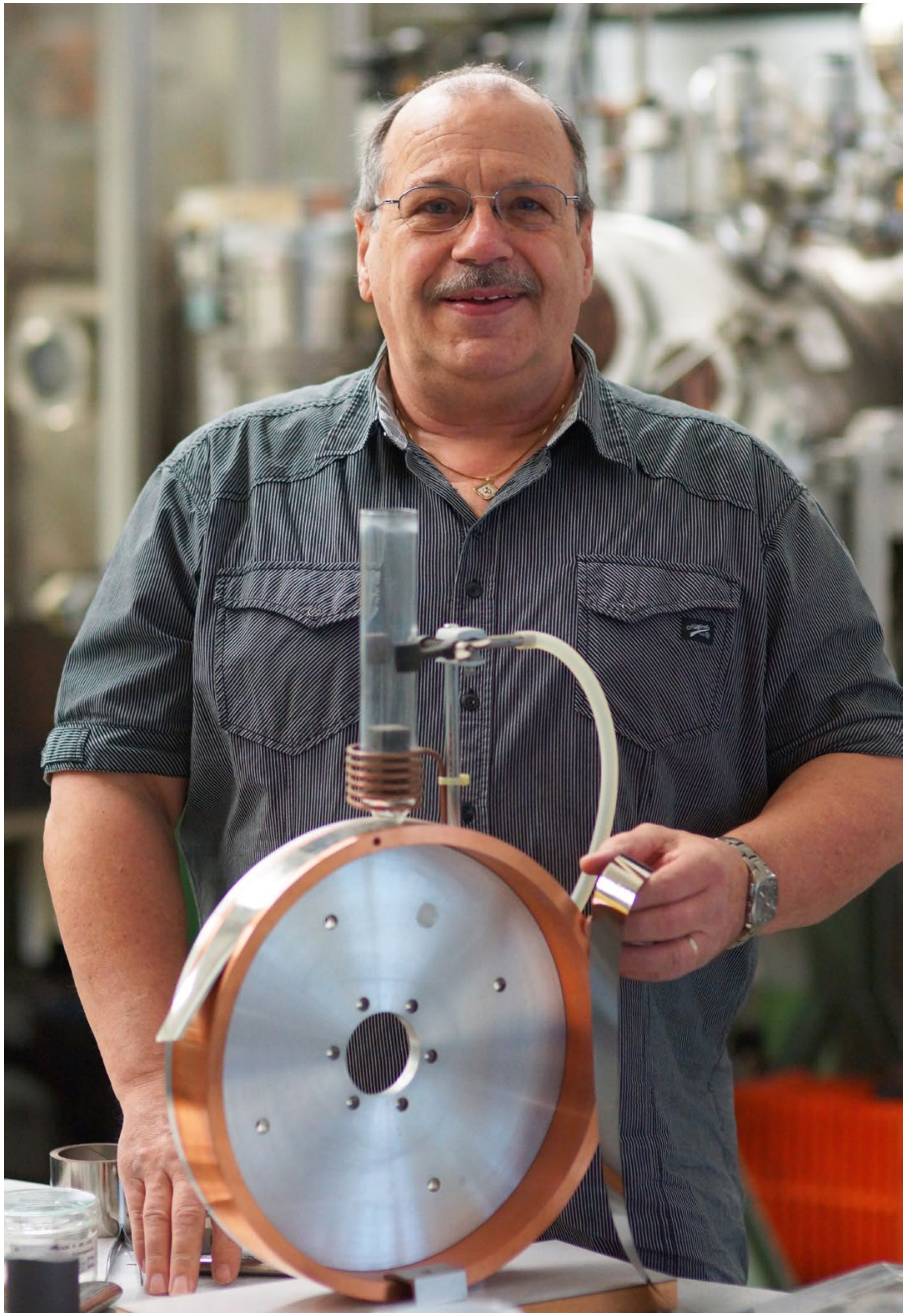
No regrets

Peter Reimann's unique career at the University of Basel began in 1981. After training as an electrical mechanic, studying electrical engineering, and spending some years in industry, the 30-year-old graduate electrical engineer wanted to channel his passion for technology and science into basic research. "I simply called Professor Hans-Joachim Güntherodt at what was then the Institute of Physics to enquire about the chances of a position becoming available," he recalls. Although there were no jobs vacant, Hans-Joachim Güntherodt spontaneously offered him a six-month position following a personal meeting. And so began a fruitful collaboration with Professor Güntherodt and his colleagues in the Department of Physics. This move into academic research was not without risk for Peter Reimann, but he describes it as a "stroke of luck" that he has never regretted.

Decades of collaboration

His initial tasks included providing technological support to the research groups and maintaining, servicing, and developing a range of equipment. His own application-oriented research projects gradually increased. In the mid-1980s, a personal relationship between Georg Endress and Hans-Joachim Güntherodt led to a collaboration with the company Endress+Hauser (E+H), for which Peter Reimann was responsible. The collaboration continues to this day and has produced several follow-on projects, including the Georg H. Endress Professorship.

At the time, E+H was searching for a reliable method of soldering ceramic components for premium pressure sensors. The Department of Physics had prior experience with particular alloys that would be suitable under certain conditions. A research project commenced to produce and examine these specific metallic glasses. Alloys made from zircon, nickel, and titanium were heated to melting point and then quickly cooled from over 1000 degrees to room temperature within one thousandth of a second by spraying them onto a rapidly rotating copper roller. This process turns the massive alloy into an elastic metal strip of around 50 μm in



strength with significantly different properties to the original material. While the atoms in the original material are arranged in a crystal lattice, the quick cooling of around 1 million degrees per second means that the atoms in the metal strip are essentially snap-frozen and thus unordered (amorphous). Heating this material again without atmospheric oxygen to solder the ceramic produces a chemical reaction with the oxygen molecules in the ceramic components, permanently binding the components together.

A surface specialist
Collaborations with the industry and transferring knowledge to companies in the region became two of Peter Reimann's main tasks. The invention of the scanning probe microscope in the mid-1980s provided Peter Reimann with more and more insights into the nano world, and he increasingly focused on developing and applying this new technology. Examining surfaces became his favorite pastime. From spectacle lenses, car headlights, and paint samples to dialysis machines, coffee powder, and fabrics – Peter Reimann and his team analyzed a wide range of surfaces, providing their partners with whole new perspectives on the materials they use and leading to considerable improvements. Peter Reimann was and remains an expert advisor for the university's own research groups in the development and application of scanning probe microscopy. It was also his suggestion to set up the Nanotech Service Lab, which is supported by the SNI, run by Dr. Monica Schönenberger, and takes on commissions from industrial companies and internal research groups.

Enjoying PR work
For many years, Peter Reimann has also been heavily involved in passing on his knowledge to a range of people. He supervises students and doctoral students. Children who attend various events to find out more about the nanosciences are just as thrilled with his presentations and experiments as the school groups that visit the physics laboratories and the politicians looking for more information on opportunities in nanotechnology. Peter Reimann always has practical ideas on how to present wide-ranging phenomena in an accessible manner and on ways to share his enthusiasm for technology and science.

Special recognition
By awarding him an honorary doctorate in 2006, the University of Basel highlighted Peter Reimann's PR achievements as well as his successes in applying and expanding scanning probe microscopy and the successful technology transfer projects between the university and industry. "Being recognized by my own university was a very special and totally unexpected honor," recalls Peter Reimann. "I was very moved and now appreciate the university even more."

Variety of further tasks
Alongside the activities mentioned, Peter Reimann's day-to-day work presents him with many more tasks. For example, he is in charge of coordinating the workshops in the Department of Physics. He is responsible for technical safety in the Department of Physics and, together with Bernd Heimann, is responsible for all technology in the department. This variety is just what he wants; no two days are the same, and work never becomes boring.

This variety continues in Peter Reimann's private life. Numerous colleagues in the Department of Physics have already had the privilege of enjoying his entertaining poems and hearing him sing with his quartet. He also likes to ride his bicycle and motorbike and to fly model airplanes. His planned retirement at the end of this year will offer more time to pursue these activities. "I'll be leaving with very mixed feelings," he comments. "I can count on one hand the days when I didn't really want to come into work." However, he also has some goals for his time without AFM and STM. He wants to improve his piano playing, dedicate more time to his family and to recreational sport, and he might even get another Bernese mountain dog. This is still some time away, and until then Peter Reimann will continue in his laboratory with the same passion as ever, taking on all his tasks with head, hand, heart, and humor.

Thickness Is Key

Atomic force microscope is the device of choice

The Nanotech Service Lab (NSL) at the SNI helps companies and academic partner institutes in the region to perform detailed analyses of technical surfaces. Dr. Monica Schönenberger, Head of the NSL, was commissioned by Endress+Hauser GmbH + Co. KG to examine electrodes deposited on ceramic tiles. After the initial laser microscopy analysis returned only satisfactory results, she developed a reliable and efficient method of measuring the thickness of the electrodes using atomic force microscopy.

Metallic glasses come from Basel
Endress+Hauser GmbH + Co. KG (E+H) has been working closely with the Department of Physics at the University of Basel for some years now. Dr. Peter Reimann and his team have been producing metallic glasses for E+H for over 20 years. These metallic glasses are used as active brazing materials in a soldering process to permanently bond ceramic tiles (which are used in pressure sensors) while still maintaining a gap between them. If the pressure alters the distance between the ceramic tiles, the side of the membrane deforms and the metallic condenser electrodes deposited on the inside register this change.

Thickness of electrodes is significant
These metallic electrodes consist of a thin layer of gold-, chromium- and nickel-vanadium, which is added to the ceramic carrier through physical vapor deposition. Following maintenance work and to establish new vapor deposition processes, it is important for E+H that the thickness of these electrodes can be determined reliably and using the simplest methods possible. Dr. Sascha Koch, then a process engineer in E+H's production department, asked the NSL to determine the thickness of the deposited layers using 3D laser microscope measurements. However, E+H did not provide the ceramic carriers for these measurements itself because the surface is very rough, making it impossible to precisely measure thin layers. Instead, the experts at E+H vapor-

ized silicon wafers under the same conditions as the production of ceramic tiles with gold-, chromium-, and nickel-vanadium.

Atomic force microscopy for reproducible results
When taking measurements with the 3D laser microscope, Monica Schönenberger quickly established that the method was not suitable for this application due to the metal's different reflection and absorption properties. Instead, she analyzed the samples under the atomic force microscope (AFM) and received good, reproducible results.

"With the laser microscope, we identified deviations between the measurements attributable to reflections on the reflective surface. In addition, the precision with which the thickness could be determined lay significantly below the precision of an AFM tip. With the AFM, we can record the thickness of the gold-, chromium-, and nickel-vanadium layers to within a few tenths of a nanometer," explains Monica Schönenberger.

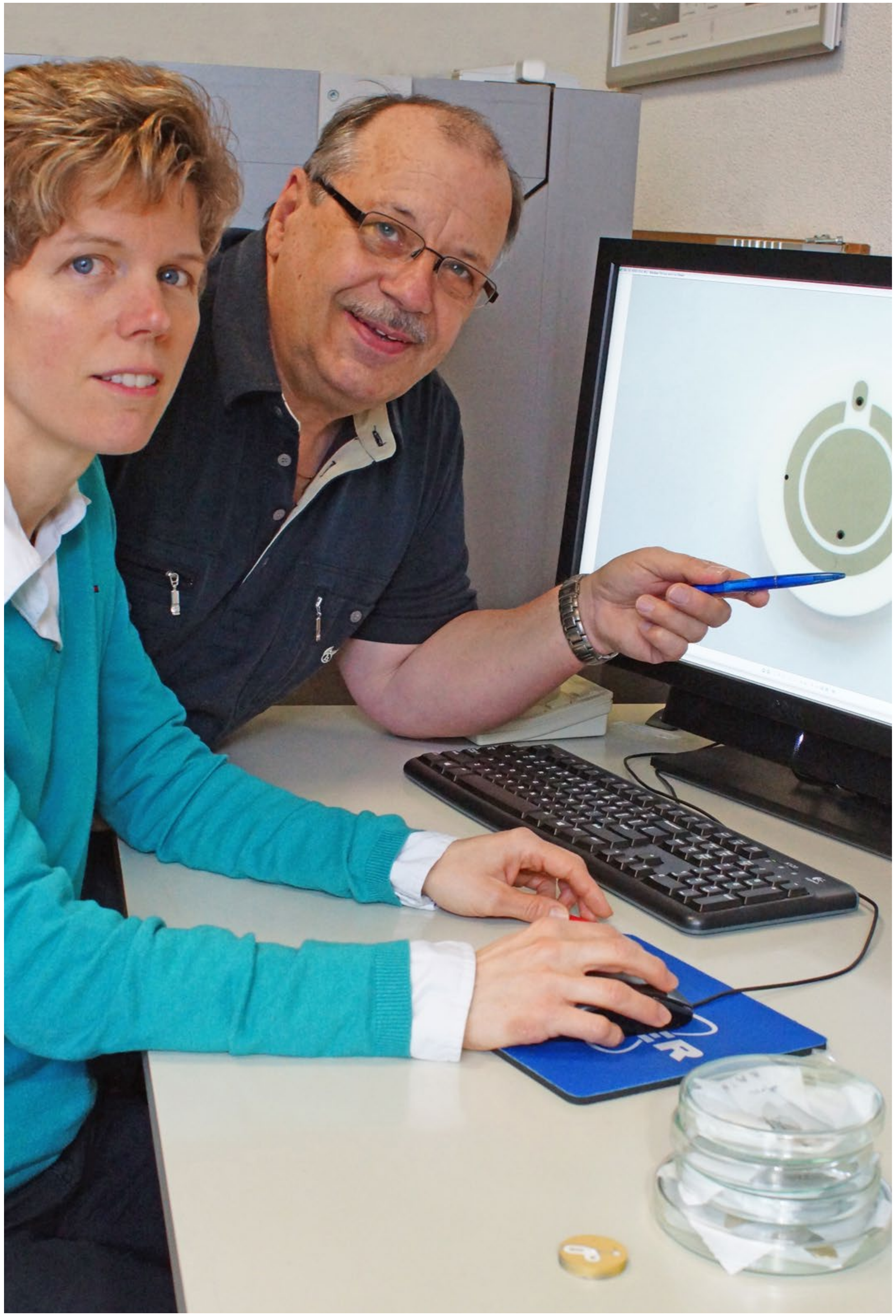
The commission to develop a solid method of determining electrode thickness was therefore fulfilled. It is possible that the project may now be extended. E+H could produce a range of coatings with different growth rates that could then be measured using both contactless conductibility measurements and Monica Schönenberger's AFM. The layer conductance determined here allows a specific conductance value to be assigned to a certain thickness.

SNI services in brief

The SNI offers various technology services for internal and external partners from science and industry. In particular, the technology group and the electronics and mechanics workshops in the Department of Physics and the Nanotech Service Lab (NSL), 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.

In 2015, the NSL worked on projects for the companies Endress+Hauser in Maulburg (Germany) and Reinach (Switzerland), Rolic Technolgies (Allschwil, Switzerland), and Ziegler Papier AG in Grellingen (Switzerland). In 2015, a close collaboration was also developed with the Institute of Pharmaceutical Technology of the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) and the Pharmaceutical Technology group at the University of Basel, resulting in two publications.

The NSL's services include analyses and consulting based on various microscopic tests (scanning probe microscopy, light microscopy, confocal laser color scanning microscopy, scanning electron microscopy, photoelectron spectroscopy, electron spectroscopy, X-ray structure analysis and RAMAN spectroscopy).



Communication & Outreach

Interactive Programs

The SNI is committed to interesting children and young people in the natural sciences

In 2015, as in previous years, the SNI communications team concentrated its outreach activities on children and young people, taking part in science festivals, Uni-Nacht, and the Future Day with an interactive program. Dr. Kerstin Beyer-Hans, SNI outreach manager since April, has also implemented a new concept for school group visits involving increased exchange between school pupils and students. To reward the wide-ranging commitment of nanoscience students and doctoral students to these events, Kerstin Beyer-Hans has launched an Outreach Award that will be presented for the first time in 2016.

Interactive program at Uni-Nacht
The United Nations declared 2015 the "Year of Light", and so the SNI made light the focus of its activities at the University of Basel's Uni-Nacht event. A creative workshop allowed children and young people to make kaleidoscopes, solar-powered flowers, and spectrometers until late into the night. More than two hundred girls and boys took them up on the offer. Even more participants proved their skill and dexterity in the laser labyrinth, constructed by the SNI together with colleagues from the Department of Physics. The line remained long until just before midnight and many would have happily continued until the next morning to try to beat the record for negotiating the obstacles. And with live experiment demonstrations and a range of presentations, there was plenty to interest all those who came for the science.

Generating energy with light
Light was also the focus of the 2015 Science Days, Germany's oldest and largest science festival. The three-day event, which marked the 15th anniversary of the Science Days, drew around 20,000 visitors to the Europa-Park in Rust. The SNI stand, which attracted a large crowd, looked at how light can be used to generate energy. Around 500 pupils of all ages visited the stand over the three days to make small fans powered by solar cells. Kerstin Beyer-Hans and Sandra Hüni from the SNI were supported by six dedicated nanoscience and PhD School students in the building of these fans. The team also used a small exhibition to explain and show many more interested visitors what nanoscience actually is and where nanotechnology is used today.

Lively Future Day
The joint program by the SNI and the Department of Physics at the Future Day on November 12, 2015 also proved very popular. SNI Director Professor Christian Schönenberger kicked things off with a show about light. The "Triple L – Lamps, Light, and Lasers" challenge took an even more practical approach. As at the previous Uni-Nacht, the laser labyrinth proved a big hit. The tricky puzzles relating to light were also a welcome challenge for the children. Additionally, the young researchers used various microscopes to investigate the micro and nano worlds and, as last year, showed a steady hand in a game of soldering skill in the electronics workshop of the Department of Physics.

Which topics are particularly interesting?
In 2015, the SNI was once again a popular destination for the region's school children, who wanted to find out about the latest nano research in the place where it all happens. To make these visits even more interesting

and improve discussions between pupils and students even further, Kerstin Beyer-Hans has expanded the program for school visits of this type. There are now 2–4 talks and 1–2 laboratory tours tailored to the age and subject focus of the young people in question. If time permits, these are followed by an interactive, hands-on session before a reception that is also attended by students and doctoral students ready to answer questions and take part in discussions.

It is not always clear to the SNI communications team what teachers expect from these visits and which topics are relevant for secondary-level pupils. To gain an even better insight into teachers' wishes, the SNI organized a teacher event in October 2015 together with the Departments of Physics and Chemistry. The 15 teachers in attendance gained an insight into current research and expressed a desire for further exchange, helping to improve the flow of information between the University and schools even further.

Strong support from students
These various events would not be possible without substantial support from nano students and doctoral students. In addition to the activities mentioned, some students also return to their former schools to present and raise awareness of the nano curriculum. To reward these dedicated students, the SNI has launched an Outreach Award. Points are allocated to participants in the various events based on a defined system. Those who have gained the most points over the previous year will receive an award at the SNI's next Annual Event.

Communication and outreach in brief

In 2015, the small communications team successfully participated in various science events such as the Science Days in Europa-Park Rust, the Uni-Nacht and the Future Day of the University of Basel in order to fascinate children and young people about nanoscale sciences. As in previous years, the presentations that were held during the TecDays also raised great interest among school pupils. At the beginning of 2015, the SNI participated in an exhibition by the Swiss Academy of Natural Sciences that could be seen throughout Switzerland.

In 2015, the SNI team produced a small brochure aimed at children and young students giving an insight into the world of the nanometer in an entertaining way. The SNI provided information about research highlights and activities in four editions of the electronic newsletter "SNI update". Moreover, the SNI teams supported the press office at the University of Basel in compiling press releases about notable publications that created enormous media resonance in 2015.

In 2015, our outreach manager Dr. Kerstin Beyer-Hans has implemented a new concept for school group visits involving increased exchange between school pupils and students, taking into consideration the wishes of teachers. Eight school classes and individual school students who themselves initiated the visits availed of the offer to experience the exciting research at the SNI.

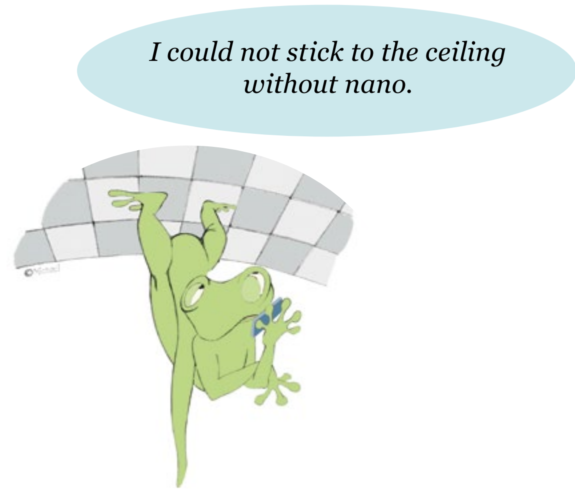
What is Nano?

A little gecko explains clearly the world of the nanometer

What exactly are nanosciences? Is there a way to explain the world of the nanometer to children and make them a little more familiar with the nano world? For years, the Swiss Nanoscience Institute has taken part in numerous events aimed at helping children and young people to experience the fascination of nano research. In 2015, Dr. Christel Möller produced a pocket-sized brochure in which a cartoon gecko provides a short, concise, and entertaining introduction to the nano world, asking and answering many questions about the nanosciences and nanotechnology.

Nanotechnology and nanosciences can be found in everyday life
Nanotechnology is already a part of our day-to-day lives. Cosmetics contain nanoparticles. Nanomaterials provide the lightweight and mechanically resilient sports equipment we use in our leisure time. Minute silver particles with antibacterial properties reduce unpleasant odors in sports socks and keep food fresh for longer in fridges. However, nanoparticles and structures are nothing new. They have always been produced by forest fires and volcanic eruptions. Back in the 17th century, Persian blacksmiths manufactured swords with Damascus steel blades that contained carbon nanotubes. And the shade of red seen in many church windows is based on gold nanoparticles that absorb the blue and green spectral range of the white light to create a red effect.

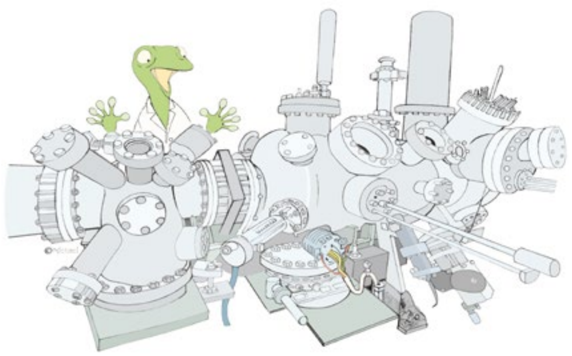
Nature too works with nanotechnology
In a great many cases, nature demonstrates the very special properties that nanotechnology provides. The special nanostructure of a gecko's foot, with billions of little adhesive hairs, allows the creature to grip onto roofs. The nanometer-sized wart-like bumps on the surface of lotus flower leaves mean that water and dirt simply roll right off. The arrangement of nanocrystals in the skin of chameleons is responsible for the way they change color depending on their activity and mood.



These examples alone indicate the highly varied areas in which the nanosciences play a role. What they all have in common are structures and objects of just a few nanometers – a millionth of a millimeter – in size. The nanostructures behave differently than larger structures because the surface properties of a material become more important than its volume.

New microscopes reveal the nano world
Exploring the nano world requires totally new methods, and innovative microscopes are the main point of

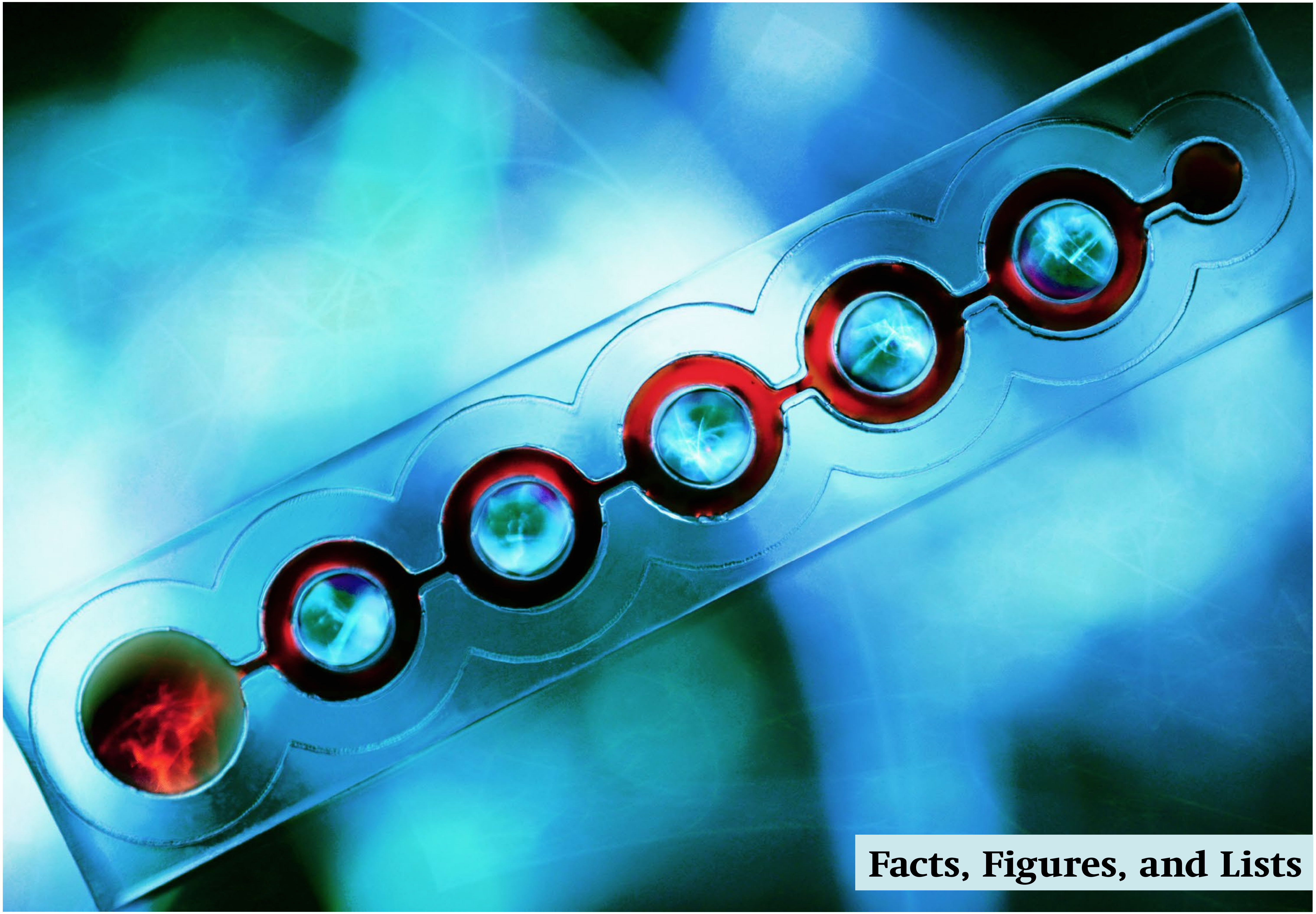
access to these minute objects. Rather than using lenses, these scanning probe microscopes scan the surface of a sample point by point.



Different types of microscope are used depending on the material – some for conducting and semiconducting samples, and others for biological samples. The microscopes allow scientists not only to generate images of the minute structures, but also to take a variety of measurements.

Broad range of research
The nanoscientists at the University of Basel's Swiss Nanoscience Institute work on a wide range of topics. Some focus purely on basic scientific questions, while other projects look at applications, and some look for solutions to very specific problems experienced by a partner company, for example. The brochure briefly presents a selection of topics studied by the SNI. It also provides details of the nanoscience degree program and sources of further information about nanoscience research.

Tailored to target groups
The "What is nano" brochure adds to the communication materials available for various target groups. The SNI also regularly attends various events and tells people about its work via the general part of the annual report, an image brochure, its flyer, a brochure about industrial collaborations, and three YouTube videos. In 2015, the SNI was invited by Professor Bharat Bhushan, who has been commissioned by the Springer publishing house to edit a book about global perspectives in nanoscience training to compile a detailed description of how young nanoscientists are trained at the SNI.



Facts, Figures, and Lists

Financial Report

The SNI is a Center of Excellence in Nanoscale Sciences and Nanotechnology. The Canton of Aargau initiated the center and co-finances it with a generous contribution of CHF 5 million per year. It is helpful at this point to recall the purpose as defined in Clause 2 of the agreement reached with the Canton of Aargau in November 2005 on the establishment and operation of a center of excellence for nanoscale sciences and nanotechnology:

1. The University of Basel will use this contribution to establish the Center of Excellence for Nanoscience and Nanotechnology [known today as the Swiss Nanoscience Institute, SNI].
2. The University of Basel will contribute its existing competences to this end and will work with other universities and institutions of higher education, in particular with the FHNW and PSI.
3. The Swiss Nanoscience Institute will engage in teaching, basic research, applied research, and knowledge and technology transfer that benefits the economy.
4. The University of Basel will regularly assess the specialist orientation of the Swiss Nanoscience Institute and will, if necessary, reorient it in line with ongoing scientific developments in nanoscience.

Today, the SNI is an established and respected research institute with a network that incorporates all the research institutes in Northwestern Switzerland that have expertise in nanotechnology. In addition to our two most important partners (FHNW and PSI), these include, in particular, the Basel locations of CSEM and ETHZ, the Hightech Zentrum Aargau, and i-net Basel. Our task is to educate and promote young talents, 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 the research and KTT items have the largest volume. Research is primarily done by doctoral researchers, who are enrolled in the SNI PhD School and all earn their doctorates from the Faculty of Natural Sciences 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 PSI, or at CSEM and ETHZ, while others collaborate with several institutions at once. The 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 University of Applied Sciences and Arts Northwestern Switzerland (FHNW) and of 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 researchers, particularly teenagers and children), *Support* (funding at the professorial level), *Nano Study* (Bachelor's and Master's programs), and the *SNI PhD School*.

The *PhD School*, which supports young scientists, is the largest item in the 2015 budget, accounting for about CHF 2 million. *KTT & PR* is the next largest item, with CHF 1.6 million annually. This item covers knowledge and technology transfer projects such as the highly successful *Argovia projects*, which receive roughly CHF 1.3 million each year. Another large item is *Support*, which totals CHF 1.5 million. These funds are used to support various professors, particularly the two Argovia professors Roderick Lim and Martino Poggio, who are primarily funded via the SNI. The SNI also runs a Bachelor's and a Master's program in nanoscience, for which we collaborate closely with our partners in Northwestern Switzerland. The nominal costs for this amount to CHF 0.5 million annually.

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 1.7 million to the applied research projects (Argovia projects). The share of third-party funding here amounts to more than 56% of total spending. Fifteen Argovia projects were implemented in 2015. Nine of these projects (60%) have an Aargau-based company as their industry partner.

Thirty-three doctoral students were enrolled in the SNI PhD School in 2015, and 135 students were registered for the Nano Study Program. The SNI-funded Argovia professorships are both proving extremely successful. In 2015 alone, the professors raised a combined total of approximately CHF 1.5 million in third-party funding, and have had papers published in world-leading scientific journals.

The SNI assets amounted to CHF 8.05 million on December 31, 2015. To be deducted from that are grants (excluding those for the SNI PhD School) totaling CHF 1.586 million that were made in 2015 but will only become effective in 2016, and all grants made for projects at the SNI PhD School. The commitments per doctoral researcher comprise annual financing of CHF 65,000 for four years, which results in a total outstanding commitment of CHF 6.264 million. The sum of all obligations therefore comes to CHF 7.85 million. The actual balance thus stands at CHF 200,000. Since the Canton of Aargau will cut its financial support by CHF 0.5 million per year for three years starting in 2016, the SNI will be forced to allow for adjustments in its budget in subsequent years.

The following table lists 2015 outgoings by item as per the University of Basel's financial report dated February 25, 2016.

SNI Expenditure 2015 in CHF

		Univ. Basel	Kanton AG	Total
Management	Personnel and operational costs	309'668	232'548	542'216
	Overhead		650'000	650'000
Infrastructure	Infrastructure building	-	-	-
	Infrastructure equipment	234'240	169'723	403'965
KTT & PR	Personnel and operational costs	60'613	122'680	183'293
	Argovia projects		1'318'941	1'318'941
Outreach	Personnel and operational costs	60'148	45'437	105'582
Support	Argovia professors	518'043	831'849	1'349'937
	PSI Professorships		52'810	52'810
Nano Study	Bachelor and master program	313'270	196'378	509'648
PhD School	Research projects	769'392	1'154'089	1'923'481
Total expenditure for 2015 in CHF		**2'265'375**	**4'774'501**	**7'039'876**

The following table shows the balance sheet for SNI funds as at December 31, 2015.

SNI Balance Sheet 2015 in CHF

	Univ. Basel	Kanton AG	Total
Grants	2'333'399	5'000'000	7'333'399
Investment Income		172'649	172'649
Income	**2'333'399**	**5'172'649**	**7'506'048**
Expenditure	**2'265'375**	**4'774'501**	**7'039'876**
Balance year 2015	**68'025**	**398'148**	**466'172**
SNI assets per 01.01.2015	**1'228'385**	**6'353'492**	**7'581'877**
Annual balance	68'025	398'148	466'172
SNI assets per 31.12.2015 in CHF	**1'296'409**	**6'751'639**	**8'048'049**

SNI Members

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J. Isenburg (Coordination Nanocurriculum)
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S. Hüni (Communication & Events)
Dr. C. Möller (Communication & Events)
Dr. M. Schönenberger-Schwarzenbach (Nanotech Service Lab)

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Dr. T. Braun, Biozentrum, University of Basel
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Prof. D. Zumbühl, Physics Department, University of Basel

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P. Fountas, Chemistry Department, University of Basel
M. Gerspach, Chemistry Department, University of Basel
R. Goers, Chemistry Department, University of Basel
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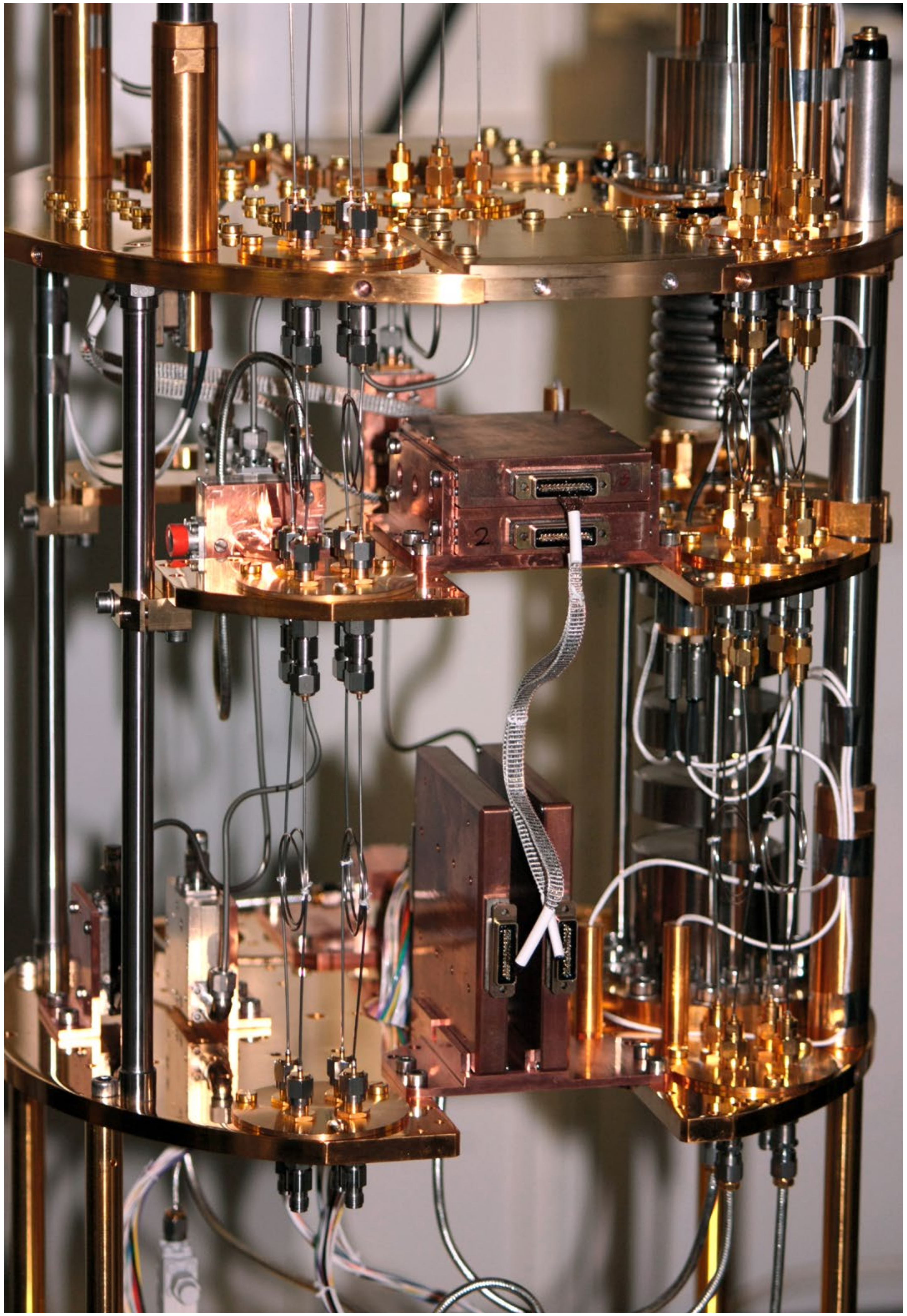


Projects of the SNI PhD School

Started in 2013

Project	Principle Investigator (PI) and Co-PI	PhD Student
P1201 Microfluidics to study nano-crystallization of proteins	T. Braun (C-CINA), H. Stahlberg (C-CINA)	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. 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

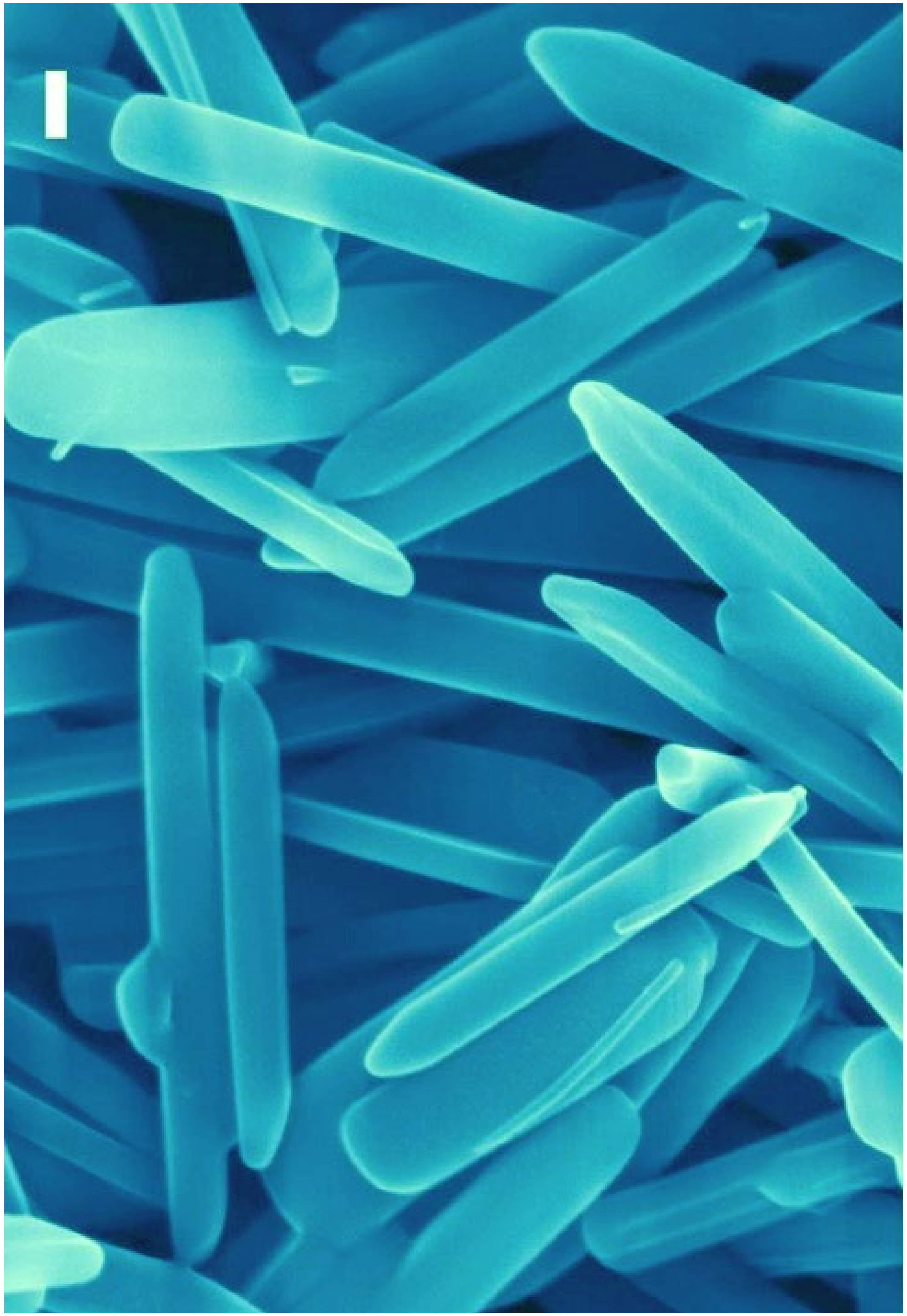
Started in 2014

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)	P. Rios Flores
P1305 Towards X-FEL based dynamic studies on 2D and 3D nanocrystals of membrane proteins on solid supports	C. Padeste (PSI), H. Stahlberg (C-CINA)	N. Opara
P1306 Slow-release nano-pills for mosquitoes for interrupting malaria transmission	P. Hunziker (Univ. Hospital Basel), R. Brun (Swiss Tropical Institute)	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. 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. 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



Argovia Projects

Prolonged projects

(with and without financial support)

Project	Project leader	Project partner
A8.1 Bio-DURACLEAN: Bio-DURABLE self-cleaning painting: development of dirt repellency coatings for large surface	O. Glaied (FHNW)	U. Pieles (FHNW), W. Meier (Univ. Basel), G. Siragna (Walter Mäder AG, Kilwangen)
A8.3 EL-ENA: Electrophoretic active hybrid core shell silica nanoparticles decorated with dendritic structures for colored electronic ink (e-ink) and e-paper applications	U. Pieles (FHNW)	G. Grundler (FHNW), G. Nisato (CSEM Muttenz), R Öhrlein (BASF Research Center Basel), A. Hafner (BASF Research Center Basel)
A8.7 NANOX: Mixed mode nanocomposite catalyst for the effective decomposition of hydrogenperoxide vapour used in sterilization processes of pharmaceutical GMP clean room production facilities and isolator systems	U. Pieles (FHNW)	P. Shahgaldian (FHNW), C. E. Housecroft (Univ. of Basel), O. Scheuber (SKAN AG, Allschwil)
A9.2 em-Select: Polymer emulsion segmented electroconductive nano fibres for antistatic textile finishing	U. Pieles (FHNW)	J. Gobrecht (PSI), C. Denier (FHNW Windisch), M. Height (HeiQ Materials AG, Bad Zurzach)
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, Birr)
A9.7 NanoSiCTrenchFet: Physical studies of SiC Nano-Trench-MOSFETs	M. Schnieper (CSEM Muttenz)	N. Marjanovic (CSEM Muttenz), J. Gobrecht (PSI), E. Meyer (Univ. of Basel), R. Minamisawa (ABB Switzerland Ltd. Baden-Dättwil), H. Bartolf (ABB Switzerland Ltd. Baden-Dättwil)
A9.9 NANOzyme: Novel Nanobiocatalysts based on confined and concerted artificial and natural enzymes	P. Shahgaldian (FHNW)	P. Corvini (FHNW), T. Ward (Univ. of Basel), A. Cumbo (INOFEA GmbH, Basel)
A9.10 PATCELL: Surface-patterning of PLGA for improved cell interaction and tissue integration of resorbable fixation implants	P. 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. of Basel), G. Schlotterbeck (FHNW), G. Dernick (Roche, Basel)
A9.15 SINAPIS: Slurry injection of nanoscale particles into implant surfaces	R. Schumacher (FHNW)	M. de Wild (FHNW), O. Braissant (Univ. of Basel), M. Straubhaar (WATERjet Robotics AG, Oftringen)

Projects started in 2015

Project	Project leader	Project partne
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)
A10.14 VERSALITH: Versatile lithography with multilevel phase masks	J. Gobrecht (PSI)	V. Guzenko (PSI), H. H. Solak (Eulitha AG, Würenlingen), P. M. Kristiansen (FHNW)

SNI Impact

Peer-reviewed articles

C. Adler, M. Schönenberger, A. Telekid, B. Leuenberger, M. Kuentz, Flow-through cross-polarized imaging as a new tool to overcome the analytical sensitivity challenges of a low-dose crystalline compound in a lipid matrix, J. Pharm. Biomed. Anal. 115, 20 (2015)

A. Balan, A. Fraile Rodríguez, C.A.F. Vaz, A. Kleibert & F. Nolting, Effect of substrate interface on the magnetism of supported iron nanoparticles, Ultramicroscopy 159, 513 (2015)

A. Barfuss, J. Teissier, E. Neu, A. Nunnenkamp and P. Maletinsky, Strong mechanical driving of a single electron spin, Nature Physics 11, 820 (2015)

O. Braissant, P. Chavanne, M. de Wild, U. Pieles, S. Stevanovic, R. Schumacher, L. Straumann, D. Wirz, P. Gruner, A. Bachmann & G. Bonkat, Novel microcalorimetric assay for antibacterial activity of implant coatings: The cases of silver-doped hydroxyapatite and calcium hydroxide, J. Biomed. Mater. Res. B 103(6), 1161 (2015)

A. Buchter, R. Wölbing, M. Wyss, O.F. Kieler, T. Weimann, J. Kohlmann, A.B. Zorin, D. Rüffer, F. Matteini, G. Tütüncüoglu, F. Heimbach, A. Kleibert, A. Fontcuberta i Morral, D. Grundler, R. Kleiner, D. Koelle & M. Poggio, Magnetization reversal of an individual exchange-biased permalloy nanotube, Phys. Rev. B 92, 214432 (2015)

C.J. Cattin, M. Duggelin, D. Martinez-Martin, Ch. Gerber, D.J. Muller & M.P. Stewart, Mechanical control of mitotic progression in single animal cells, Proc. Natl. Acad. Sci. USA 112, 11258 (2015)

H. Deyhle, I. Dziadowiec, L. Kind, P. Thalmann, G. Schulz & B. Müller, Mineralization of early stage carious lesions in vitro - A quantitative approach, Dentistry Journal 3, 111 (2015)

H. Deyhle, P. Thalmann, I. Dziadowiec, F. Beckmann, G. Schulz & B. Müller, Micro computed tomography for the investigation of tooth hard tissues, European Cells and Materials 30 Suppl. 1, 36 (2015)

T. Einfalt, R. Goers, I.A. Dinu, A. Najer, M. Spulber, O. Onaca-Fischer & C.G. Palivan, Stimuli-triggered activity of nanoreactors by biomimetic engineering polymer membranes, Nano Letters 15 (11), 7596 (2015)

G. Emilsson, R.L. Schoch, L. Feuz, F. Höök, R.Y.H. Lim & A.B. Dahlin, Strongly stretched protein resistant poly(ethylene glycol) brushes prepared by grafting-to, ACS Appl. Mater. Interfaces 7, 7505 (2015)

B. Eren, W. Fu, L. Marot, M. Calame, R. Steiner & E. Meyer, Spectroscopic ellipsometry on Si/SiO2/graphene tri-layer system exposed to downstream hydrogen plasma: Effects of hydrogenation and chemical sputtering, Appl. Phys. Lett. 106, 11904 (2015)

C.D. Ertl, D.P. Ris, S.C. Meier, E.C. Constable, C.E. Housecroft, M. Neuburger & J.A. Zampese, Sticking and patching: Tuning and anchoring cyclometallated ruthenium(II) complexes, Dalton Trans. 44, 1557 (2015)

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P. Urwyler, A. Pascual, B. Müller & H. Schift, Ultraviolet-ozone surface cleaning of injection-molded, thermoplastic microcantilevers, J. Appl. Polym. Sci. 132 (18), 41922 (2015)

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B. Vogell, T. Kampschulte, M.T. Rakher, A. Faber, P. Treutlein, K. Hammerer, and P. Zoller, Long distance coupling of a quantum mechanical oscillator to the internal states of an atomic ensemble, New J. Phys 17, 043044 (2015)

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Book chapter

M.A. Mangold, A.W. Holleitner, J.S. Agustsson & M. Calame, Nanoparticle arrays: structural, electrical and optoelectronic properties, Handbook of Nanoparticles M. Aliofkhazraei, Springer International Publishing (2015)

R. Pawlak, S. Kawai, Th. Glatzel & E. Meyer, Single-molecule force spectroscopy, Non Contact Atomic Force Microscopy S. Morita, F.-J. Giessibl, E. Meyer & R. Wiesendanger, Springer Japan (2015)

Th. Glatzel, Mechanical and electrical properties of single molecules, Imaging and Manipulation of Adsorbates using Dynamic Force Microscopy P. Moriarty & S. Gauthier, Springer (2015)

Invited talks

T. Braun, Real-time viscosity and mass density sensors, Innovation Landscape Nano, Muttenz (Switzerland), September 9, 2015

M. Calame, From transport mechanisms in molecular junctions to ion sensing using ISFETs, Institute of Electronics, Microelectronics and Nanotechnology (IEMN), Lille (France), March 5, 2015

M. Calame, Formation mechanisms and electrical transport: From individual to arrays of molecular junctions, 8th International Conference on Materials for Advanced Technologies (ICMAT2015), Symposium Z: Surfaces/Interfaces Modification by Molecules, Singapore (Malaysia), June 28-July 3, 2015

M. Calame, Molecular junctions: dynamics of formation and electrical transport, Science et Technologie des Systèmes pi-Conjugués (SPIC 2015), Angers (France), October 12-16, 2015

M. Calame, Molecular junctions: dynamics of formation and electrical transport, Nanoweek 2015, Limerick (Ireland), October 21-22, 2015

M. Calame, Dynamics of formation and electrical transport in molecular junctions, Swiss Federal Laboratories for Materials Science and Technology (EMPA), Dübendorf (Switzerland), November 16, 2015

M. Calame, Does molecular electronics compute?, Federal Office of Metrology (metas), Bern (Switzerland), November 24, 2015

C. Dransfeld, S. Vogel & K. Masania, Carbon reinforced materials and applications - the challenge of size effects and hierarchies, SNI Annual Meeting, Lenzerheide (Switzerland), September 3-4, 2015

S. Freund, G. Fessler, A. Hinaut, R. Pawlak, S.-X. Liu, S. Decurtins, E. Meyer & Th. Glatzel, Nanomanipulation of C_{60} islands on organic layer compound crystals, 6th European Nanomanipulation Workshop, Giessen (Germany), September 23-25, 2015

Ch. Gerber, Pushing the boundaries in personalized medical diagnostics with AFM technologies, Molecular Biophysics I Lecture Series, Biocenter, University of Basel, Basel (Switzerland), May 5, 2015

Ch. Gerber, Pushing the boundaries in personalized medical diagnostics with AFM technologies, Nano Day 2015, UNAM, Bilkent University, Bilkent/Ankara (Turkey), May 15, 2015

Ch. Gerber, Pushing the boundaries in personalized medical diagnostics with AFM technologies, University of St. Andrews, St. Andrews (UK), July 9, 2015

Ch. Gerber, Pushing the boundaries in personalized medical diagnostics with AFM technologies, Swiss-Japanese Workshop, Les Diablerets (Switzerland), September 7, 2015

Ch. Gerber, Pushing the boundaries in personalized healthcare with AFM technologies CEITEC conference, Masarykova Univerzita, Brno (Czech Republic), December 1, 2015

Th. Glatzel, R. Pawlak, S. Stehlik, S. Koch & E. Meyer, Scanning probe microscopy and spectroscopy of nanodiamonds and graphene, Towards Reality in Nanoscale Materials VIII, Levi (Finnland), Februrary 8-11, 2015

M. Hestericová, Artificial imine reductase encapsulated in silica nanoparticles, Antelope Expert Exchange , Groningen (Netherlands), September 30, 2015

S. Hiller, Molecular mechanisms in outer membrane protein biogenesis, EMBO Young Investigator's Meeting, Barcelona (Spain), May 14, 2015

S. Hiller, Outer membrane protein biogenesis at atomic resolution, Structural Biology Lecture Series, University of Freiburg, Freiburg (Germany), May 28, 2015

S. Hiller, Molecular mechanisms in outer membrane protein biogenesis, 10th European Biophysics Congress (EBSA), Dresden (Germany), July 7, 2015

S. Hiller, Mechanistic aspects of b-barrel membrane protein folding, Gordon Research Conference on Membrane Protein Folding, Waltham (USA), July 23, 2015

A. Kleibert, Towards atomistic understanding of magnetism in nanoparticles, Gordon Research Conference on Clusters and Nanostructures, Girona (Spain), July 5-10, 2015

A. Kleibert, Studying magnetism at the nanoscale using X-PEEM at the SLS, Imaging Workshop BESSY II, Berlin (Germany), October 6-7, 2015

A. Kleibert, Magnetism at the nanoscale studied with X-ray photo-emission electron microscopy, 598th WE-Heraeus-Seminar on 'Frontiers in Scanning Probe Microscopy', Bad Honnef (Germany), November 2-5, 2015

J. Koeser, Bacterial cell rupture by structured surfaces, SNI Annual Meeting, Lenzerheide (Switzerland), September 3-4, 2015

H.P. Lang, Nanosensors for cancer detection, i-net Medtech & Nano Technology Event «Sensors/MEMS in Diagnostics & Medicine», Muttenz (Switzerland), November 12, 2015

R. Lim, Coping with stress: Mechanosignaling into the nucleus during epithelial formation, Epithelial Intercellular Junctions, Leipzig (Germany), January 14, 2015

R. Lim, Spatiotemporal dynamics of barrier FG nucleoporins resolved by high-speed atomic force microscopy inside native nuclear pore complexes, Nuclear Transport Meeting, Sant Feliu de Guixols (Spain), September 18-23, 2015

R. Lim, How to operate a nuclear pore complex by Kapcentric control, Research Seminar Series, European Research Institute for the Biology of Ageing, Groningen (Netherlands), December 10-11, 2015

E. Meyer, Single atom manipulation at room temperature and pulling of molecular chains, 2nd Thermal Probe Workshop, Zurich (Switzerland), January 15, 2015

E. Meyer, A. Baratoff , E. Gnecco, R. Pawlak, T. Meier, S. Freund, A. Hinaut, R. Jöhr, M. Kisiel, U. Gysin & T. Glatzel, Lateral forces during pulling of single molecules?, The International Conference on Understanding and Controlling Nano and Mesoscale Friction, Istanbul (Turkey), June 22-26, 2015

E. Meyer, R. Pawlak, S. Kawai, E. Gnecco, U. Gysin, T. Meier, S. Freund, A. Hinaut, R. Jöhr, M. Kisiel. T. Glatzel & A. Baratoff, Manipulation of single molecules by NC-AFM, Nanoscale Pattern Formation at Surfaces, Cracow (Poland), July 12-16, 2015

E. Meyer, Force microscopy experiments with single molecules, Bayerische Akademie der Wissenschaften: Functional Molecules on Surfaces, Munich (Germany), October 9, 2015

E. Meyer, Nanomechanical inverstigations of graphene by friction force microscopy, Key State Laboratory, Lanzhou (China), October 10, 2015

E. Meyer, Pushing and pulling of single molecules, Superlubricity Workshop: Fundamentals and Applications, Beijing (China), October 18-20, 2015

F. Nolting, Nanomagnets and artificial multiferroics studied with X-ray photoemission electron microscopy, MaxLabIV, Lund (Sweden), June 11, 2015

F. Nolting, X-PEEM studies of magnetic nanoparticles and oxide heterostructures, 22nd International Colloquium on Magnetic Films and Surfaces (ICMFS), Cracow (Poland), July 12-17, 2015

P. Oertle, An in vitro epithelium that bears the mechanobiological hallmarks of living tissue, Biozentrum Symposium, Basel (Switzerland), January 14, 2015

P. Oertle, Feeling the force of cancer: Nanotechnologie in der Krebsforschung, Nanofuture, Institut Physikalische Chemie, University of Basel, Basel (Switzerland), March 5, 2015

C.G. Palivan, Protein-polymer assemblies as artificial organelles, 20th International Symposium in Microencapsulation, Boston (USA), October 2, 2015

M. Plodinec, Nanomechanical cancer diagnostics, Workshop AFM in Life Science, Karolinska Institutet, Stockholm (Sweden), February 4, 2015

M. Plodinec, An in vitro epithelium that bears the mechanobiological hallmarks of living tissue, BRECT Mini-Symposium, Karolinska Institutet, Stockholm (Sweden), February 4, 2015

M. Plodinec, An in vitro epithelium that bears the mechanobiological hallmarks of living tissue, International Meeting of the German Society for Cell Biology, Symposium S11: Epithelial Structure and Function, Cologne (Germany), March 24-27, 2015

M. Plodinec, Nanomechanical cancer diagnostics, Swiss NanoConvention, Neuchâtel (Switzerland), May 27-28, 2015

M. Plodinec, Nanomechanical cancer diagnostics, Physics and Biology of Active Systems, Aberdeen (UK), June 23-24, 2015

M. Plodinec, An in vitro epithelium that bears the mechanobiological hallmarks of living tissue, College of Life Sciences, University of Dundee, Dundee (UK), June 25, 2015

M. Plodinec, Nanomechanical cancer diagnostics, Swiss-Korean Life Science Symposium, Seoul (Korea), October 19-23, 2015

M. Plodinec, Nanomechanical cancer diagnostics, Seminar Basel Breast Consortium, Basel (Switzerland), September 1, 2015

M. Poggio, Nanometer-scale magnetometry, Seminar of the 3. Physikalisches Institut, University of Stuttgart, Stuttgart (Germany), February 10, 2015

M. Poggio, Nanometer-scale magnetometry, Leibniz Institute for Solid State and Materials Research (IFW), Dresden (Germany), March 13, 2015

M. Poggio, Measuring nanometer-scale spin systems by ultrasensitive cantilever magnetometry, Spin Mechanics 3, Munich (Germany), June 22, 2015

M. Poggio, Measuring nanometer-scale spin systems by ultrasensitive cantilever magnetometry, 5th NanoMRI Conference, Waterloo (Canada), July 27-31, 2015

M. Poggio, Measuring nanometer-scale spin systems by ultrasensitive cantilever magnetometry, The 8th International School and Conference on Spintronics and Quantum Information Technology (SpinTech VIII), Basel (Switzerland), August 10-13, 2015

M. Poggio, Scanning nanowires sensors, SNI Annual Meeting, Lenzerheide (Switzerland), September 3-4, 2015

M. Poggio, Nanowires for sensing, Nanowires Workshop (2015), Barcelona (Spain), October 29, 2015

M. Poggio, Nanometer-scale magnetometry, Seminar of Biomedical Magnetic Resonance, Institute for Biomedical Engineering, ETHZ, Zurich (Switzerland), December 10, 2015

P. Rickhaus, Electron optics in graphene, SPS and ÖPG joint annual meeting, Vienna (Austria), September 1-4, 2015

P. Rickhaus, Graphen, Lehrer Event, Basel (Switzerland), October 28, 2015

P. Rickhaus, Electron optics in graphene, Department of Physics at BUTE, Budapest (Hungary), December 1, 2015

C. Schönenberger, Electron optics in ballistic graphene, Gotenborg Mesoscopic Lectures, Gothenburg (Sweden), February 20, 2015

C. Schönenberger, Electron optics in ballistic graphene, Euromet: DC and Quantum Metrology Annual Meeting 2015, Bern (Switzerland), May 27-29, 2015

C. Schönenberger, Electron optics in suspended graphene, International Nanoscience Student Conference, INASCON 2015, Basel (Switzerland), August 11-14, 2015

C. Schönenberger, Electron optics in suspended graphene, Carbonhagen 2015, Copenhagen (Denmark), August 13-14, 2015

C. Schönenberger, Electron optics in suspended graphene, Colloquium at the University of Konstanz, Konstanz (Germany), November 3, 2015

P. Shahgaldian, Protein supramolecular engineering – from giant inclusion to biocatalysis, International Seminar on Inclusion Compounds (ISIC-15), Warsaw (Poland), August 17-21, 2015

P. Shahgaldian, Organic-inorganic functional nanosystems, SNI Annual Meeting, Lenzerheide (Switzerland), September 3-4, 2015

H. Stahlberg, Electron crystallography of 2D crystals of membrane proteins: Towards side-chain resolution from badly-ordered 2D crystals of potassium channels, SwissFEL Workshop on Technical Challenges, Villigen (Switzerland), January 27, 2015

H. Stahlberg, Electron crystallography of 2D crystals of membrane proteins: Towards side-chain resolution from badly-ordered 2D crystals of potassium channels, LS² Annual Meeting 2015, Lausanne (Switzerland), January 29-30, 2015

H. Stahlberg, High-resolution structures of membrane proteins by cryo-EM of small 2D crystals of limited order, Gordon research conference, Three Dimensional Electron Microscopy (3DEM), New London (USA), June 21-26, 2015

H. Stahlberg, High-resolution structure analysis of potassium channels by cryo-EM: Studying the cAMP-modulated K+ channel MloK1 in the lipid bilayer, CEASAR, Bonn (Germany), August 31, 2015

H. Stahlberg, Nano-scale structural characterization of Parkinson's disease, SNI Annual Meeting, Lenzerheide (Switzerland), September 3-4, 2015

H. Stahlberg, High-resolution structure analysis of membrane proteins by cryo-EM: Studying the cAMP-modulated K+ channel MloK1 in the lipid bilayer, SwissFEL Workshop on 2D Crystal Prospects, Villigen (Switzerland), October 22, 2015

H. Stahlberg, Structure determination of membrane proteins in two-dimensional membrane crystals using electron microscopy imaging and direct electron detection, Janelia Research Campus Conference, Washington (USA), October 23, 2015

H. Stahlberg, High-resolution structure analysis of membrane proteins as single particles, in liposomes, and as 2D crystals by cryo-EM: Studying the cAMP-modulated K+ channel MloK1 in the lipid bilayer, LBR Seminar Series, PSI, Villigen (Switzerland), December 18, 2015

P. Treutlein, Hybrid optomechanics: Using cold atoms to cool and control micromechanical oscillators, SFB/ZOQ Colloquium, Hamburg (Germany), January 14-15, 2015

P. Treutlein, Hybrid atom-membrane optomechanics, Niels Bohr Institute, Copenhagen (Denmark), January 21-22, 2015

P. Treutlein, Hybrid atom-membrane optomechanics, ITAMP Workshop on Hybrid Quantum Systems, Tucson (USA), February 16-18, 2015

P. Treutlein, Hybrid atom-membrane optomechanics, NIM Resonator QED Conference, Munich (Germany), August 3-7, 2015

P. Treutlein, Hybrid atom-membrane optomechanics, IFRAF cold atoms conference, Paris (France), November 4-5, 2015

P. Treutlein, Hybrid atom-membrane optomechanics, IOP conference on Hybrid Quantum Systems Far From Equilibrium, Chicheley Hall (UK), November 9-10, 2015

T. Ward, Artificial metalloenzymes: Challenges and opportunities, Biotrans, Vienna (Austria), January 23, 2015

T. Ward, Manipulating metals with biology, Gordon Research Symposium, Metals in Biology, Ventura (USA), January 25-30, 2015

T. Ward, Artificial metalloenzymes for the synthesis of chiral amines and derivatives , Transam 2.0 - Chiral Amines Through (Bio)Catalysis, Greifswald (Germany), March 4-6, 2015

T. Ward, Artificial metalloenzymes: Challenges and opportunities, acib, TU Graz, Graz (Austria), June 11, 2015

T. Ward, Artificial metalloenzymes: Challenges and opportunities, University of Dresden, Dresden (Germany), June 17, 2015

T. Ward, Artificial metalloenzymes: Challenges and opportunities, ISMEC 2015, Wroclaw (Poland), June 25, 2015

T. Ward, Artificial metalloenzymes for synthetic biology applications, GRC Synthetic Biology, Newry (USA), June 29, 2015

T. Ward, Optimization of the performance of artficial metalloenzymes by fine-tuning of the second coordination sphere, ACS, Boston (USA), August 16, 2015

T. Ward, Artificial metalloenzymes for synthetic biology applications, Synthetic Biology UK, London (UK), September 3, 2015

T. Ward, Artificial metalloenzymes: Challenges and opportunities, University of Groningen, Groningen (Netherlands), September 17, 2015

T. Ward, Artificial metalloenzymes: Challenges and opportunities, PSI, Villigen (Switzerland), October 27, 2015

T. Ward, Artificial metalloenzymes: Challenges and opportunities, Bristol University , Bristol (UK), November 10, 2015

T. Ward, Artificial metalloenzymes: Challenges and opportunities, Pacifichem, Honolulu (USA), December 18, 2015

S. Willitsch, Towards precision measurements on single molecules, 47th Conference of the European Group on Atomic Systems (EGAS), Riga (Latvia), July 14-17, 2015

S. Willitsch, Ion-atom and ion-molecule hybrid systems, XXIX. ICPEAC, Toledo (Spain), July 18-22, 2015

S. Willitsch, Next-generation ion-neutral hybrid traps, Workshop on Hybrid Atomic Quantum Systems, Hamburg (Germany), September 27-29, 2015

Contributed talks

A. Barfuss, J. Teissier, L. Thiel, P. Appel, E. Neu, A. Nunnenkamp & P. Maletinsky, Strain-coupling of a nitrogen vacancy center spin to a diamond mechanical oscillator, Summer School: Quantum Optomechanics and Nanomechanics, Les Houches (France), August 3-28, 2015

F.R. Braakman, Mechanical mode coupling and nonlinearity in as-grown GaAs nanowires, NCCR QSIT General Meeting, Arosa (Switzerland), January 7-9, 2015

A. Buchter, Exchange-bias measured in single permalloy nanotubes using a hybrid nanoscale magnetometer, International Workshop on Magnetic Nanowires and Nanotubes 2015, Meersburg (Germany), May 17-20, 2015

D. Cadeddu, Mechanical mode coupling and nonlinearity in as-grown GaAs nanowires, SNI Winterschool «Nanoscience in the Snow», Belalp (Switzerland), January 21-23, 2015

D. Cadeddu, A quantum fiber-pigtail, SNI Annual Meeting, Lenzerheide (Switzerland), September 3-4, 2015

D. Cadeddu, A quantum fiber-pigtail, Nanowires Workshop (2015), Barcelona (Spain), October 29, 2015

P.N. Fountas, Coupling an ultracold ion with a nanomechanical oscillator, QSIT Junior Meeting, Passugg (Switzerland), June 16-19, 2015

S. Fremy, A. Sadeghi, R. Pawlak, A. Baratoff, S. Goedecker, E. Meyer & Th. Glatzel, Controlled switching of a single CuPc molecule on Cu(111) at low temperature, The International Conference on Understanding and Controlling Nano and Mesoscale Friction, Istanbul (Turkey), June 22-26, 2015

S. Freund, A. Hinaut, R. Pawlak, S.-X. Liu, S. Decurtins, E. Meyer & Th. Glatzel, Patterning of C_{60} islands on organic layer compound crystals, Nanoscale Pattern Formation at Surfaces, Cracow (Poland), July 12-16, 2015

M.A. Gerspach, N. Mojarad, Y. Ekinci & T. Pfohl, High-throughput and passive trapping of nano-objects using electrostatic forces, DPG-Jahrestagung und DPG-Frühjahrstagung, Berlin (Germany), March 15–20, 2015

D. Gonçalves, Slow-release nano-pills for mosquitoes for interrupting malaria transmission, SNI Winterschool «Nanoscience in the Snow», Belalp (Switzerland), January 21-23, 2015

D. Gonçalves, Slow-release nano-pills for mosquitoes for interrupting malaria transmission, SNI Annual Meeting, Lenzerheide (Switzerland), September 3-4, 2015

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DU bist Radio, Aargau Juli 2015, NanoMeCo: 2015: Nanomedienprojekt des SNI der Uni Basel, Sendung 1

Du bis Radio, Aargau Juli 2015, NanoMeCo : 2015 : Nanomedienprojekt des SNI der Uni Basel, Sendung 2

Tweet @UniBasel 27/08/2015, Wichtiger Schritt auf Weg zum Stickstoffoxid-Sensor

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