Universität Basel

Swiss Nanoscience Institute

SNI SWISS NANOSCIENCE INSTITUTE

EINE INITIATIVE DER UNIVERSITÄT BASEL UND DES KANTONS AARGAU

SNI update April 2015

Editorial

Dear colleagues,

At the start of the year, the SNI annual report is always top of the SNI management team's to-do list. We have employed the same concept as last year and combined a general section, which describes some of the highlights from the past year in a generally understandable manner, with a scientific supplement. We are happy to send the annual report to anyone who is interested. Otherwise, you can also find it on our website.

One of the highlights described in the annual report is the outstanding collaboration between the mechanics workshop at the Department of Physics and a team of scientists. The other workshops at the Department of Physics – also supported by the SNI – make a crucial contribution to the success of internal and external customers, as well. We have chosen a successful collaboration between the electronics workshop and an external partner – the Swiss Gemmological Institute – as the lead story for this edition of *SNI update*. The portrait in this issue introduces Sylwia Nowakowska, a young physicist working toward her doctorate under the supervision of our titular professor Thomas Jung. She was the lead author on a paper published in *Nature Communications* at the start of the year.

Another young physicist will join the SNI management team in mid-April as the new outreach manager. Dr. Kerstin Beyer-Hans will assume the tasks performed by Meret Hornstein, who left the SNI at the end of March. Meret set up the entire outreach section of the SNI together with Tibor Gyalog, who took up a professorship at the University of Applied Sciences Northwestern Switzerland (FHNW) a little over a year ago. Meret did excellent work here and helped develop the SNI's reputation beyond Basel as an institution making a valuable contribution to the communication of scientific knowledge. I wish Meret all the best for the future and Kerstin a good start to her time at the SNI.

The beginning of the year also saw the start of more new Argovia projects. Every year, I am delighted that we at the SNI are in a position to promote and fund these diverse and innovative applied projects. To give you an overview of these collaborations with industry, the new Argovia projects will again be introduced in *SNI update*. Please also note the announcement of the Swiss NanoConvention 2015, which this year takes place in Neuchâtel, and the numerous media releases that have appeared since the start of the year by and about SNI members.

Best wishes,

Director Swiss Nanoscience Institute, University of Basel

Real, Synthetic or Imitation?

The Electronics Workshop Builds Automated Testing Device for Small Diamonds

The workshops at the Department of Physics, which are also supported by the SNI, play a key role in the success of researchers from the Department of Physics and the SNI. However, the technicians and engineers are not only contacts who support the scientists on site, but also take on commissions from external departments at the University of Basel, foundations and industrial companies. One successful collaboration, for example, has been running for nine years between the electronics workshop at the Department of Physics and the Swiss Gemmological Institute (SSEF). One project conducted as part of this cooperation, which led to the construction of a fully automated machine for examining small diamonds, was completed in 2014.

Even the small can play a major role

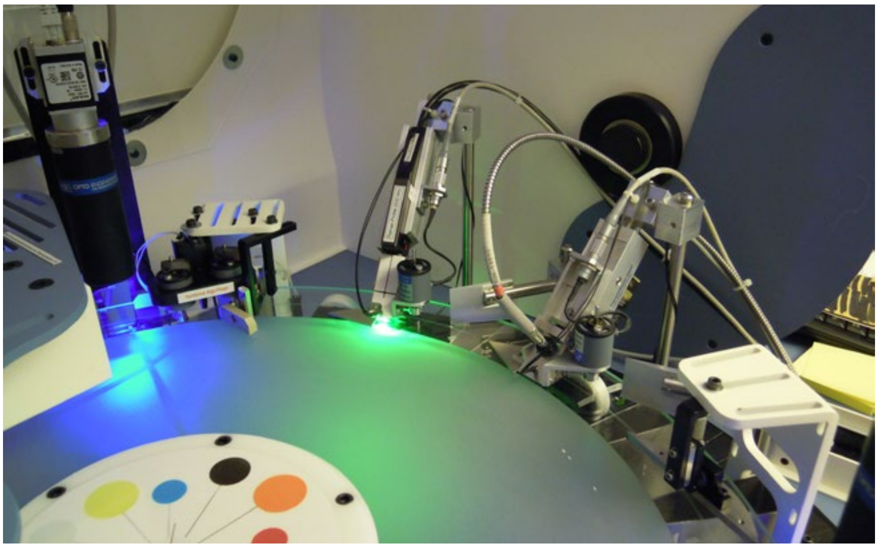
When it comes to diamonds, many people initially think of huge rocks glittering in solitaire rings or adorning ears and necklines. However, smaller natural and colorless diamonds also play an important economic role. They are used in large quantities in the jewelry and watch industry, for example on clock faces in luxury watches. Here too, natural diamonds must be distinguished from synthetic or imitation diamonds made from zirconia (ZrO_2), corundum (Al_2O_3) or glass. While experts (gemologists) always check each large diamond separately and then issue a certificate, individual manual checks are not viable for smaller stones with diameters of less than around 3 mm. Back in 2006, Professor Hänni – then a gemologist at the University of Basel and Director of the SSEF – approached the workshops at the Department of Physics to develop an automated solution for colorless small diamonds. It soon became clear that the main challenges presented by the project related to optical measurement technology and evaluation electronics. Dipl.- Ing. Michael Steinacher, head of the electronics workshop at the Department of Physics, therefore became the main contact for the gemologists at the SSEF.

Checking in two stages

Based on a machine used to automatically measure the size of diamonds, the team developed a fully automatic device (ASDI: Automated Spectral Diamond Inspection) that can check the authenticity of 3,000 – 6,000 stones per hour. A high measurement speed is required because several thousand stones must be analyzed. Selection takes place in two stages. First, a Raman measurement is used to identify imitations. The stones, which lie on a rotating glass plate, are individually exposed to a strong green laser (532 nm). The reflected light is analyzed. The inelastic scattering on the diamond's carbon lattice produces a weak Raman signal at 572.6 nm, which is detected by quick and highly sensitive optoelectronics. Imitations made from zirconia, corundum and glass do not produce this specific Raman signal and can be separated by the machine.

Synthetic diamonds do produce a Raman signal of this type because they also have a carbon lattice. However, they differ from the most common natural diamonds due to their complete lack of nitrogen, which is normally embedded in the carbon lattice in small quantities. The nitrogen strongly absorbs the short-wave ultraviolet (UV) light. In the second selection stage, the diamond is therefore exposed to UV light (270 nm) and the transmission is measured. Due to the lack of nitrogen, the synthetic diamonds demonstrate strong UV transmission and can be identified.

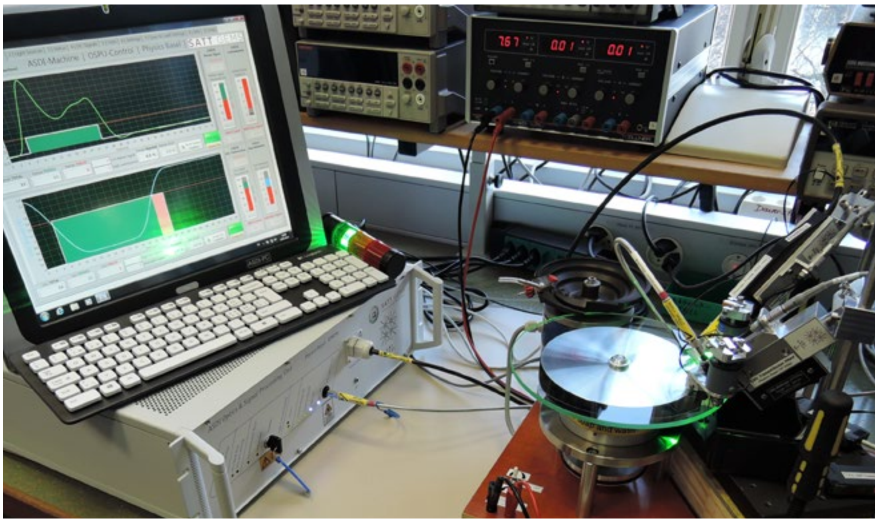
However, around 2% of all naturally occurring diamonds have such low levels of nitrogen that they are also removed during this second test. Manual measurements can then sort the separated stones into natural and synthetic diamonds. This is done by detecting various spectral characteristics (primarily lattice defects) that occur when diamonds are formed naturally. If these typical characteristics are lacking, the stone is a synthetic, industrially produced diamond. These are not accepted in the watch and jewelry industry for emotional reasons, or must be specially labeled.



Diamants are exposed to a strong green laser to identify imitations.

Development goes further

The development of the ASDI machine was successfully completed in 2014. In addition to the sophisticated measurement technology and electronics, the quick and reliable software was also developed entirely within the Department of Physics. To date, the electronics workshop has produced and sold five devices with the support of the mechanics workshop, which supplies numerous parts. “The successful collaboration with the SSEF allows us to finance an additional position, funded externally that benefits the entire department,” comments Michael Steinacher. “And the development continues.” Nowadays, synthetic diamonds can also be produced that contain a little nitrogen and would therefore be classed as “natural” in the second selection process. The experts are considering a remedy for this situation using automatic color measurement. Synthetic diamonds containing nitrogen have a slightly yellow hue that can be detected using measurement technology. Michael Steinacher and his team are therefore working with the experts from the SSEF to develop and improve the ASDI machine to ensure that only genuine articles are labeled as “natural”.



The ASDI machine sorts out imitations and synthetic diamants.

SNI PhD Program: Call for Projects

Researchers from academic institutions in Northwestern Switzerland can submit project proposal for the PhD School of the Swiss Nanoscience Institute until 31st May 2015. Please submit your proposals in a single file to *claudia.wirth@unibas.ch*.

More information at:
phd.nanoscience.ch

We Introduce...

Fascinated by Playing with Individual Atoms

Even at school, Sylwia Nowakowska was fascinated by the idea of controlling individual atoms. Today, as a doctoral student at the Nanolab run by Professor Thomas Jung, this is exactly what she's doing. She condenses xenon atoms in quantum wells and examines how their arrangement in the quantum wells changes according to the number of atoms and how the quantum wells communicate with one another. For Sylwia, this is a childhood dream come true. Despite the fascination this basic scientific work holds for the young doctoral student, she sees her long-term future in industry, working on applied research topics. At the moment, however, she is dedicated to her research and is successfully tackling the basics of physical bonds in the Department of Physics at the University of Basel.

The path to physics

Sylwia Nowakowska comes from Bytów in Poland and studied technical physics in Posen. However, it was not her physics lessons at school that inspired her and led her to study the subject, but articles about nanotechnology. She was immediately fascinated by the possibilities of "playing" with atoms. In 2007, when the time came to choose a subject for her studies, it was the nanosciences that interested Sylwia most. At that time, however, nanosciences were only available in Poland at an advanced level, and Sylwia therefore opted for technical physics to begin with. She received an interdisciplinary education in physics, chemistry, mathematics and engineering and gained insights into industrial applications from an early stage.

Master's in the Nanolab

While studying for her Master's, she completed several internships, including one at the Leibniz Institute for Innovative Microelectronics in Frankfurt. "I actually wanted to write my Master's thesis in Frankfurt, but the supervising professor became sick, so my plans fell through," recalls Sylwia. Together with her husband, Jan Nowakowski, who is also a physicist and nanoscience researcher, she began looking for a new destination. The couple found what they were hoping for in the laboratory of Professor Thomas Jung, who (as titular professor) is supported by the SNI and leads a research group at the Paul Scherrer Institute and at the Department of Physics at the University of Basel. Sylwia completed her Master's thesis here on the polymorphism of two-dimensional, self-assembling layers and made such a good impression that Thomas Jung recruited her as a doctoral student in 2012.

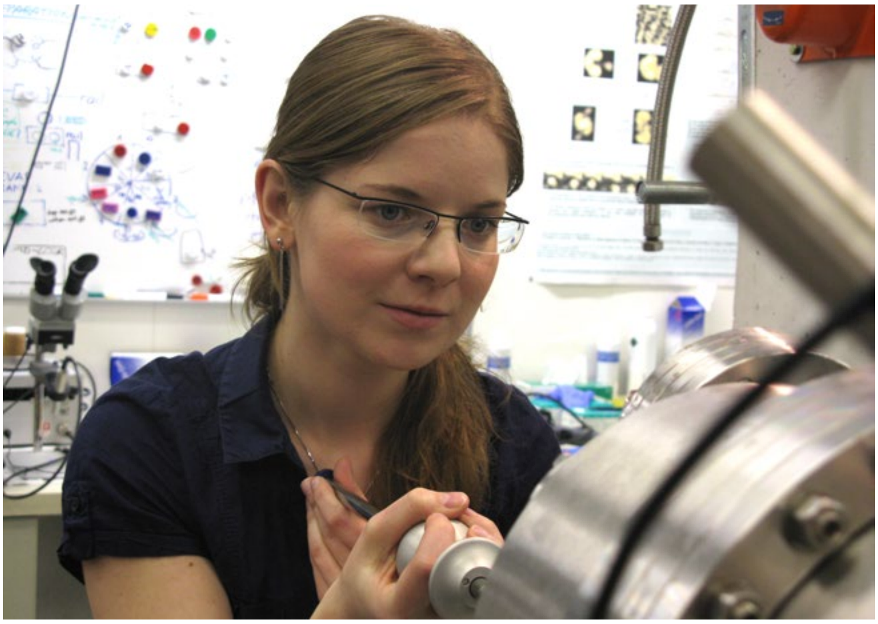
Success in the second project

The 27-year-old physicist has now been working on her doctorate in the Nanolab in Basel since July 2012. After a first project failed after eight months, everything is now running smoothly. Sylwia is now investigating the properties of molecular structures on surfaces that assemble themselves in a bottom-up process. In January, she was the lead author on a paper in

Nature Communications outlining the initial results. In the work presented, Sylwia was able to demonstrate how xenon atoms condense in quantum wells. The quantum wells organize themselves on a substrate surface made from specifically "programmed" molecules. They serve as measuring beakers with a precisely defined size, form and atomic structure of the base and walls. With the aid of scanning tunneling microscopy, Sylwia was able to show that the xenon atoms always arrange themselves according to a specific principle. The results also suggest that the electronic state of individual quantum wells depends not only on the number of xenon atoms, but also on the number of xenon atoms in the neighboring wells. "This shows that electrical communication takes place between the quantum wells," states Sylwia, explaining her latest findings, which is she currently compiling for another publication.

Happy to stay longer in Switzerland

Speaking to Sylwia, it is clear just how fascinated she is by her research. In the long term, however, she sees herself working in research and development at an industrial company rather than a university. To ensure that she is perfectly prepared for this step, she also took part in last year's *Antelope* careers program at the University of Basel. In particular, the in-depth discussions with an HR representative and a mentor from Novartis gave Sylwia plenty of important information. She now feels well prepared to find a position in industry upon completing her doctorate. She would be happy to remain in Switzerland because she is very fond of the mountains and the outdoors, which offer a perfect counterbalance to her laboratory work, "playing" with atoms.



Sylwia Nowakowska is fascinated by her research.

Six New Argovia Projects Started

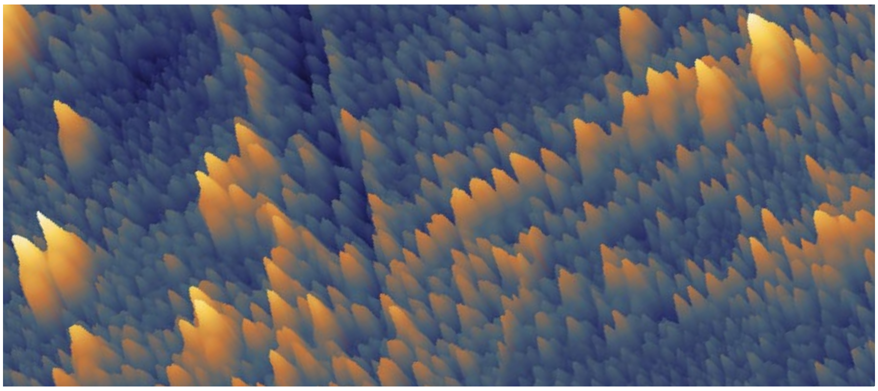
At the end of 2014, the Argovia review panel selected six new Argovia projects to start in early 2015. In this and the next edition of *SNI update*, we will present the topics and objectives of these new applied projects in collaboration with industrial companies from Northwestern Switzerland.

Mimicking Cicada Wings

In the *Nano Cicada Wing* Argovia project, scientists from the Department of Physics at the University of Basel, the School of Life Sciences at the FHNW, and the company DSM in Kaiseraugst are exploring an innovative method of adding bactericidal properties to surfaces without using antimicrobially active substances. In doing so, the researchers are following nature's example by recreating the structure of cicada wings, which – based on a purely mechanical principle – possess bactericidal properties. They are covered with tiny, nanometer-sized columnar structures that make the wings highly water-repellent. However, bacteria adhere extremely well to the nanocolumns – so well that their cell membranes stretch when the column moves and ultimately break, causing the bacteria to die. The bactericidal effect is based on a purely mechanical principle and not on bactericidal substances or substances with an antibiotic effect. It is hoped that resistance to this mechanical principle will form at a slower pace.

Bactericidal synthetic surfaces with broad application

Having already succeeded in emulating this principle on silicon and titanium surfaces, the researchers in the *Nano Cicada Wing* project want to apply the results to synthetic surfaces too, because the spectrum of potential applications is much larger. The team – including project leader Professor Ernst Meyer, Dr. Thilo Glatzel, Dr. Marcin Kisiel (University of Basel), Dr. Joachim Köser (FHNW) and Dr. Hubert Hug (DSM) – will then begin by producing polymers with various nanostructured surfaces similar to a cicada wing. The surface will also be subjected to different chemical treatments to boost the effect. The scientists will then address the activity of the bacteria and their biomechanical characterization based on atomic force microscopic investigations. If the project is completed successfully, it could open the door to numerous applications – from medical products such as catheters, which will be populated by significantly fewer bacteria, through to bactericidal foodstuffs packaging, in which food will last longer.



The surface of an artificial cicada wing imaged by AFM.

Following Nature's Example

The research team led by project leader Dr. Sonja Neuhaus from the FHNW in Windisch is also following nature's example. In the *RepAll* Argovia project, they are working on the basics for novel surfaces that will repel water and other liquids. To achieve the best result, the research team is examining structured surfaces which are chemically functionalized.

Particular morphology and special coating

As nature has evolved, it has found various ways to prevent surfaces from wetting. The most famous example is the leaf of the lotus flower. Water also rolls off duck feathers and the *Salvinia* floating fern. The surfaces of lotus flowers, floating ferns, and feathers all demonstrate particular structures. In the case of the lotus flower, particular morphological properties are combined with a water-repellent, wax-like coating that increases the repellent effect even more.

SNI-Lecture

The next SNI lecture will be held by Professor Lee Cronin of the University of Glasgow. He will talk about the exploration of complex chemical systems.

When: 12th May, 17.15
Where: Small lecture hall Organic Chemistry (St. Johann-Ring 19)
Title: *Exploring Complex Chemical Systems*
The talk will be followed by an apéro.

Annual Report 2014

The Annual Report 2014 is online and can be downloaded or ordered at:

www.nanoscience.ch

SNC 2015

The Swiss NanoConvention 2015 takes place from 27th – 28th May 2015 in Neuchâtel. The SNI actively participates in this event. As gold sponsor, the SNI has a number of free tickets available.

Do not miss to register on time:

http://swissnanoconvention.ch/2015/

In the *RepALL* project, Dr. Sonja Neuhaus (FHNW), Dr. Robert Kirchner (PSI) and their industrial partner are investigating various methods of producing surfaces inspired by nature. To do so, they are combining the possibilities of gray-scale electron beam lithography and electron beam-induced grafting. Scalable processes such as roller and hot stamping are used to duplicate the structures.

From Theoretical Calculations and Experiments to Improved High-Performance Semiconductors

In the *Atolys* Argovia project, teams of scientists led by Professor Stefan Goedecker from the Department of Physics at the University of Basel are investigating specific components of transistors that are designed for high currents. In the project, researchers from the University of Basel, the Paul Scherrer Institute and ABB in Baden-Dättwil combine theoretical and experimental methods to examine interfaces between silicon carbide and silicon dioxide in semiconductors. The studies, which aim to provide the most precise data about the structure of the semiconductors, will help to further improve devices designed for high currents.

ABB researches high-performance semiconductors

The global trend for increased use of sustainable energies means that innovative and efficient systems must be developed for generating and distributing power. The ABB Corporate Research Center (CRC) in the Canton of Aargau conducts research in this area and develops power electronics that can also intelligently handle large currents at high voltages. A large part of these efforts is devoted to developing and researching materials for high-performance semiconductors. These are used, for example, to convert direct current into alternating current. This is necessary, among other things, to feed power generated through photovoltaics into the grid or to transport power across large distances.

Silicon carbide – the material of the future

The semiconductors of the future may not be made from silicon, but from silicon carbide. Its properties allow smaller devices to be built that are easier to cool and have less resistance. In special semiconductor elements (MOSFETs), the boundary layer between silicon carbide and the insulating material silicon dioxide plays an important role. There is empirical evidence that the number of defects can be reduced with nitrogen and other elements. The microscopic mechanisms that lead to this passivation – the formation of a protective layer – are as yet unknown. To investigate these mechanisms and thus to clarify related questions, the scientific team – including Professor Goedecker, Professor Thomas Jung (PSI), and Dr. Jörg Lehmann and Dr. Holger Bartolf (both ABB) – will combine theoretical simulations with experimental studies and analyze the atomic structure of the boundary layers.

Media releases and uni news from SNI members

Basel, 10th April 2015. Clean mirrors for the fusion reactor

Optical measurement systems play a central role for the operation of the planned fusion reactor (ITER), which is currently being built in Southern France. Researchers from the Department of Physics at the University of Basel including SNI Vice-Director Professor Ernst Meyer have successfully tested a method to clean inaccessible diagnostic mirrors inside the reactor.

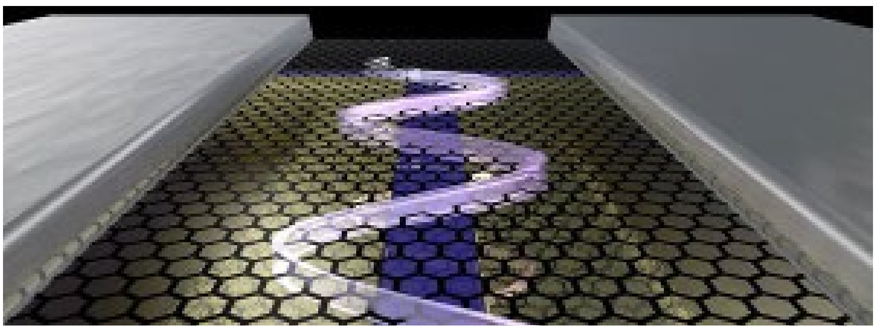
Lausanne, 10th April 2015. Breath test for detecting head and neck cancer

A portable device can detect the presence of certain types of cancer in people's breath. Tested on patients, the new device was developed in part by EPFL researchers as part of an international collaboration that included SNI members Professor Christoph Gerber and Dr. Hans-Peter Lang.

Basel, 20th March, 2015.
Quantum-Spin-Off: Competition for high-school students at the Department of Physics

This week, six school classes from Switzerland presented their ideas to develop specific products from concepts based on natural sciences. The event marked the end of the EU project *Quantum-Spin-Off* that aims at bringing young people into contact with research and industries in the nanosciences and nanotechnologies. SNI Vice-Director Professor Ernst Meyer acted as coordinator from the University of Basel and was member of the jury.

Basel, 3rd March, 2015.
Graphene Research: Electrons Moving along Defined Snake States



Physicists at the University of Basel have shown for the first time that electrons in graphene can be moved along a predefined path. This movement occurs entirely without loss and could provide a basis for numerous applications in the field of electronics. The research group led by Professor Christian Schönenberger at the Swiss Nanoscience Institute and the Department of Physics at the University of Basel is publishing its results together with European colleagues in the renowned scientific journal *Nature Communications*.

Basel, 19th February, 2015. Three researchers from Basel receive SNSF Consolidator Grant

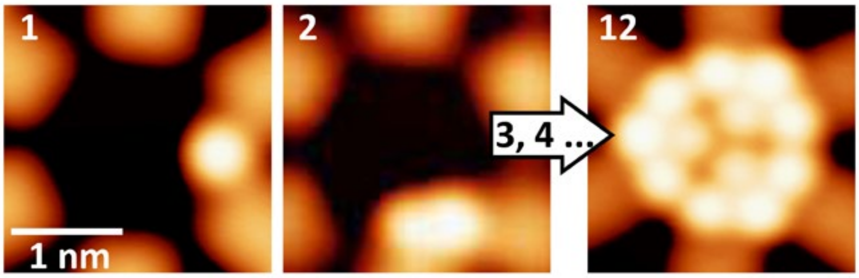
Three scientists of the University of Basel were awarded Consolidator Grants from the Swiss National Science Foundation. Professor Botond Roska (Friedrich Miescher Institute for Biomedical Research), Professor Till Voss (Swiss Tropical and Public Health Institute) and SNI member Professor Stefan Willitsch (Chemistry Department) each receive about two millionen Swiss

Francs during the next five years for their projects.

21st January, 2015.
Nano-Beaker Offers Insight Into the Condensation of Atoms

An international team of physicists has succeeded in mapping the condensation of individual atoms, or rather their transition from a gaseous state to another state, using a new method. Led by the Swiss

Nanoscience Institute and the Department of Physics at the University of Basel, the team was able to monitor for the first time how xenon atoms condensate in microscopic measuring beakers, or quantum wells, thereby



enabling key conclusions to be drawn as to the nature of atomic bonding. The researchers published their results in the journal *Nature Communications*.

Full media releases can be found at:
nanoscience.ch/nccr/media/recent_press_releases

INASCON 2015

The International NAnoscience Student CONference – a conference organized by students for students in nanosciences – takes place from 11th until 14th August in Basel. The SNI is the main sponsor of the event.

More information at:
http://inascon.eu

Save the date

The next Annual Event of the SNI will take place from 3rd-4th September 2015 in Lenzerheide. Please reserve the date!

Please give your feedback

Please share with us your ideas, news, success stories and feedback so that we can include it in *SNI update* (*c.moeller@unibas.ch)*