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

SNI update December 2013

Words from the Editor

At the SNI, a new phase has started. The NCCR Nano was successfully terminated - the PhD school, the nanocurriculum, Argovia projects and Argovia professors will carry on. We will also continue numerous of our communications activities, like this newsletter, to inform the public about our research activities and to raise interest in nanoscale sciences.

In this issue of *SNI update*, we report on one of the research topics of the Argovia professor Martino Poggio. His papers have recently found a lot of attention in the scientific world and in August he has received an eligible Starting Grant of the European Research Council (ERC).

In previous issues of *SNI update*, we have already informed you about the new PhD school of the SNI. Until now, we have mostly written about our plans, in the meantime the program became reality. Since several months, the first SNI PhD students are working in various labs and departments at the University of Basel and the Paul Scherrer Institute. We met these students at our first welcome apéro in October. It was a great opportunity to get to know them a bit and to share some important information for a good start here in Basel. In this issue of *SNI update*, we will introduce two of the PhD students as representatives of all who have started this year. The first, Michael Gerspach, represents a bit of SNI history, as he was one of the first nano students in Basel. He was able to stand up against the international competition of applicants and has started his work in April 2013 in the lab of Yasin Ekinci at the Paul Scherrer Institute. The second introduced candidate, Davide Cadeddu, only joined the SNI with the start of his PhD. His example demonstrates that the SNI is an attractive working place for students abroad and that we do not have to shy away from the international comparison.

No matter if you only recently joined the SNI or are connected since a long time – I wish all of you a peaceful Christmas time, a couple of calm days over New Year and a healthy and good start of the new year. I am already looking forward to further fruitful collaborations.

Best regards

Christian Schönenberger

Director Swiss Nanoscience Institute, University of Basel

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Cover Story

With magnetic fields to detailed diagnoses

In medicinal diagnostics, Magnetic Resonance Imaging (MRI) is fully established and indispensible for different diagnoses. Inflammations, injuries and tumors can be detected without burdening the patient with high radiation doses. On the nanometer scale, MRI is a research area that has only developed in recent years. The Argovia professor Martino Poggio is one of the pioneers who is finding ways to image the nanoworld with even finer resolution.

The Argovia professor Martino Poggio and his team are the first who can manipulate, control, and capture fluctuations of spin polarizations in real-time.

Hydrogen as tiny magnet

Magnetic resonance imaging (MRI) utilizes the fact that hydrogen atoms in our body act like little magnets. Their nucleus possesses a spin that produces a small magnetic field. Under normal conditions, the orientation of this field is random. With the application of an external magnetic field, the nuclear spins can be polarized. In MRI measurements, such an external magnetic field is generated and the hydrogen nuclei align parallel to the magnetic field -- something experts call spin polarization. The MRI device additionally produces radio waves of a specific frequency in short intervals that disturb the spin polarization. When the nuclear spins relax back along the direction determined by the external magnetic field, they then emit detectable signals. If the number of atoms is large enough, these signals allow a computer-based analysis that leads to detailed three-dimensional images of the analyzed tissue. From such images, specialists obtain valuable information about water content, density, structure and chemical composition allowing them to make their diagnoses.

Too much noise in the nanocosmos

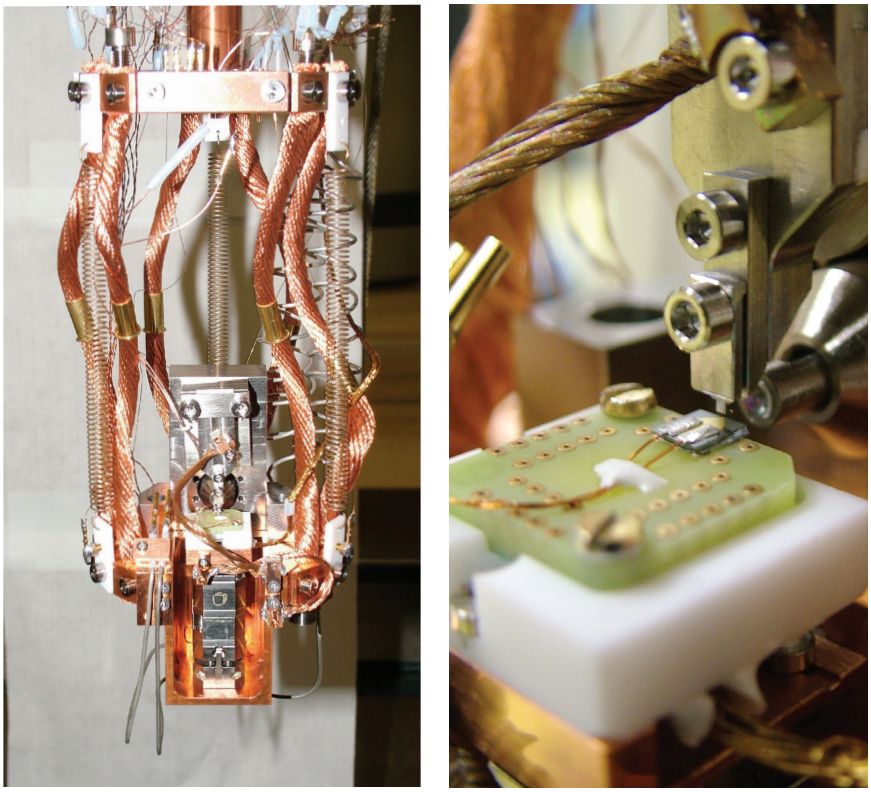
The MRI technique works extremely well in the macroworld. However in the clinical setting, the resolution is limited to around 1 mm. MRI on the nanometer scale, where objects can consist of only a few atoms or molecules, is extremely challenging. If the number of nuclei is small, the natural fluctuations of the spin polarization become very large and magnetic resonance signals cannot be differentiated from natural so-called “spin noise”.

Martino Poggio investigates how to circumvent these issues so that MRI can be applied to nanostructures as well. He uses a device that combines the advantages of MRI and Atomic Force Microscopy (AFM). In this instrument, the sample is attached to a tiny cantilever that is brought close to a magnetic tip. Periodically, the device emits radio waves of a specific frequency that lead to oscillations of the spin polarization in a small volume of the sample. This in turn produces vibrations of the ultrasensitive cantilever. As with a classical AFM, these vibrations can be optically measured and a three-dimensional image can be calculated. This microscope, called a Magnetic Resonance Force Microscope (MRFM), was developed in the last 20 years mostly by researchers from the IBM Almaden Research Center (California). It is the first device that allows for three-dimensional MRI of tiny nanostructures.

Application for semiconductors

During the last years, Martino Poggio has worked on increasing the sensitivity of the microscope and on applying the technique to semiconducting nanostructures. Most recently, in collaboration with researchers from the Technical Universities of Eindhoven and Delft, he introduced a method to monitor, control and capture the natural fluctuations of the nuclear spin polarization. "In this way, we are able to produce polarizations that are much larger than what can be created by applying a large magnetic field. It is the first report of the real-time manipulation, control, and capture of fluctuations arising from nuclear spin noise," Martino Poggio comments. The results are immediately relevant to nuclear magnetic resonance of nanostructures. The method may provide a route for enhancing the sensitivity of nanometer-scale MRI or possibly even for the implementation of solid-state quantum computers.

These techniques enable the Poggio group to examine tiny biological samples like viruses as well as semiconductor structures like single nanowires. The scientists have plans to image the inner structure of nanoscale electronic devices. Polymer films and self-asssembled monolayers are additional targets that can be chemically analyzed with the new method. These studies may provide new findings in basic science as well as advances in the sensitivity of MRI itself.



The Magnetic Resonance Force Microsope.

A short video on the webpage of the Poggio lab demonstrates the principle of magnetic resonance force microscopy.

http://poggiolab.unibas.ch/full/TMVmovie.wmv

We introduce...

The first PhD students of the SNI PhD school have started their work in spring 2013. Reason enough to introduce two of them.

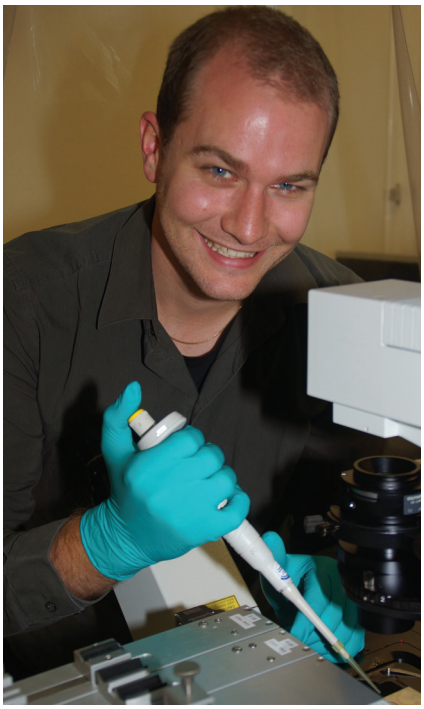
Michael Gerspach

Michael Gerspach was born in Freiburg (Germany). He is a new PhD student in the PhD program but an "old hand" at the SNI. Already in 2006, he came to Basel for the nano curriculum, after Prof. Güntherodt had fascinated him with the possibilities of nanoscale science. During his studies at the biotechnological gymnasium in Lörrach, Michael had visited an information event at the University of Basel and had learned that novel microscopes open new possibilities for the discovery of the nanoworld. He was fascinated by this new research area and decided to study - not as originally planned biology or microsystems technology - but nanoscale sciences.

Today, he is glad that he made this decision and is convinced that the nano curriculum in Basel offers an excellent education. However, he was not certain about it all the time. When he had finished his bachelor in nanoscale sciences, he was doubtful, even looked for alternatives. "At that time, I had the feeling to be not fully qualified", he reports. "We studied three topics simultaneously– biology, chemistry and physics – but none of them as detailed as students of the specific field. Within the master program, his skepticism disappeared. During his project work and master thesis, he was able to study and look into a topic in detail. "The interdisciplinary studies of the curriculum became very helpful. It was great that we could work independently and with our own responsibilities. Even as students, we were allowed to use the latest high-tech instruments and gained unique experiences", he remembers.

Michael used the chance to complete his studies with different partners of the SNI. He stayed at the IMT (Institute of Microengineering) in Neuchâtel, at C-CINA in Basel and finished his master thesis at the London Centre for Nanotechnology. There, he worked in the group of Professor Rachel McKendry and developed an low-cost diagnostic tool to determine different phases of the HIV. The device should be applicable without major technical effort even in remote areas and deliver important information for an effective medical treatment.

According to his own evaluation, the broad experience he gained during his studies helped him to get one of the positions in the newly founded SNI PhD school. In April 2013, he was one of the first students to start his PhD in the SNI program. Again, he has the chance to get to know new working groups. His PhD project is a collaborative project between the Paul Scherrer Institute and the University of Basel. Four days a week, he works at the Paul Scherrer Institute in Villigen in the group of Dr. Yasin Ekinci and once a week at the University of Basel in the group of Professor Thomas Pfohl. His goal for the next years is to build a nanodevice, which helps to study single biomolecules in solutions. Currently, he is manufacturing nanofluidic devices on silicon chips. The walls of these channels are electrically charged. Due to the resulting electrostatic forces, single molecules such as DNA can be captured and analyzed. In a first step, Michael tests his devices with gold nanoparticles and polymer beads in order to see the performance of his devices that he fabricated with the state-of-the-art nanofabrication tools. In solution, the overall electrostatic forces strongly depend on the devices geometry. Therefore he would make several attempts for fabricating geometries for best capturing of the molecules.



Michael Gerspach is one of the first PhD students of the newly founded SNI PhD school.

Michael Gerspach is very enthusiastic about his interdisciplinary research where he applies the knowledge and skills that he acquired during his education. He enjoys his daily work in the lab where he finds the excellent expertise and infrastructure that he needs for his project. Although he is only at the beginning of his scientific career, he already is an ideal ambassador for nanoscale sciences. Since several years, he is involved in the "Verein der Nanostudierenden" and often commits his time for information events about the nano curriculum in Basel. It is very likely, that one day he will fascinate others to study nanoscale sciences.

Davide Cadeddu

Davide Cadeddu, who was born in Milan, only joined the Swiss Nanoscience Institute in May this year. He started as one of the first PhD students in the newly founded PhD school in the group of professor Martino Poggio. New institutions and new programs obviously have a special attraction for Davide. He began his university studies at the newly founded faculty for Physical Engineering at the Politecnico in Milano. He is also very interested in new technologies and worked as a test user for novel smartphones and tablets for a large IT company.

Since his childhood, Davide was keen to learn more about physics and technology. Therefore, he decided to study physical engineering at his hometown Milan. For his master thesis, he joined the group of professor Roman Sordan at the department of Physics of the Politecnico Milano in Como. During his thesis, he used graphene to build

In May, Davide Cadeddu joined the Swiss Nanoscience Institute.

and to combine tiny transistors. Originally, he had planned to look for a job in industry afterwards. However, he changed his mind and started to search for a position as PhD student instead. He planned to leave Italy because salaries for PhD students in Italy do not support a living and additionally, he was looking for a new challenge abroad. So Davide began to screen the web and discovered the newly launched website of the SNI PhD school. He applied for a project, was invited and interviewed by Martino Poggio and selected.

Since May, he is now working on the development of a new sensor for force microscopy. Until now, tiny cantilevers are used as tips of atomic force microscopes. Davide aims to replace these with nanowires and consequently increase the sensitivity and precision of the microscope. Currently, Davide studies the nanowires themselves. He is, for example, interested in the quantum dots inside the nanowires, as these can be controlled and their photoluminescence later could be used as signal. Finally, he plans to use the nanowires to study other materials. The PhD thesis of Davide is part of a project of his supervisor Martino Poggio, who recently won an ERC grant with the aim of developing such a new microscope.

Davide enjoys the work in the Poggio lab: "I was really lucky to join such a great team. Everybody is very competent and helpful – and additionally, we are very well equipped." All together, the move to Basel was positive for Davide. "The University of Basel is not so big, but sometimes smaller is better", he comments. "Here I can do my research, I get the great opportunity to teach and to build up excellent contacts with professors and other students."

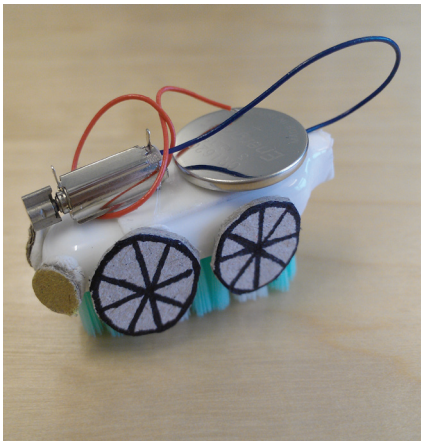
By now, Davide also feels comfortable in Basel. He enjoys that no car is required to get around in the city. The beautiful surroundings that can be reached by train within half an hour are perfect for mountain biking - his new hobby. He misses rugby games, his friends and family in Milan – but the new aspects he has discovered here in Basel seem to dominate and make the move to Basel a positive experience.

Events

Nano cars in the Europapark

Since 13 years, the SNI has participated in the yearly Science Days at the Europa Park in Rust (Germany). By now, the event attracts thousands of kids and teens from the whole region - not to overcome gravity with wild roller coasters like during the rest of the year, but to get inspired by science.

This year at the SNI stand, the young scientists could tinker with making nano cars out of toothbrushes and vibration motors. The concept worked perfectly! Meret Hornstein and her colleagues from the SNI were totally occupied in supporting the enthusiastic kids who designed and crafted their cars. For sure, the three-day event increased the number of children, who find nano really "cool".



At the SNI booth, children crafted their own nano cars.

Even more nano for kids and teens

After the great success of the show TuN at the public exhibitions MUBA in Basel and BEA Expo in Bern, a TuN took place for the first time at the Züspa in Zurich. The « TuN – Technologie und Wissenschaft" concept offers children the opportunity to slip into the role of researchers and to experience science first hand. The SNI participated in all events with a team of students who presented a child-friendly program including a variety of exhibits and activities in nanoscale sciences.

Under the umbrella of the initiative "TecDay", the SNI has visited several high schools in order to raise the interest in natural science among teenagers. This year, the SNI team discussed possible applications of nanoscale sciences with almost 400 students. For the first time, a TecDay was held in French in Geneva. With the extension of the initiative into the French speaking part of Switzerland, new opportunities to inform about the nano curriculum in Basel arise. Nowadays, the TecDays in Switzerland are the most efficient tool to fascinate young high school students with natural sciences.

At the TuN Zurich, lots of children visited the SNI booth.

Visit of the Great Council president

On 7th November, the SNI hosted a welcome apero for the recently nominated president of the Great Council of the canton Basel-Stadt Conradin Cramer. Cramer had invited his office and selected journalists to a presentation including a guided tour through the SNI. After the tour through the different research areas, he was obviously impressed by the achievements of the SNI.

Annual report 2013

We are currently working on the SNI annual report 2013. Therefore, we need information about projects and activities from all Argovia project leaders and from all PIs of the PhD school. Audrey Fischer has already sent out an email with the respective templates. Please submit the requested information by 20th December. For questions, please contact

Meret.Hornstein@unibas.ch.

Awards

Honorary appointment for Christoph Gerber

The University of St. Andrews in St. Andrews, Scotland, renewed the position of Professor Christoph Gerber as Honorary Professor in the School of Chemistry. He has received this honor already ten years ago.

Press releases and uninews

Basel, 19.11.2013. Electrified Diamonds: Basel Physicists on the Trail of Quantum Information

With the help of tiny diamond crystals, physicists at the University of Basel have discovered new possibilities in quantum information: The scientists discovered that under specific circumstances electric currents make it possible to identify defects in the carbon lattice of single diamonds measuring only a few nanometers. The results have been published online in the magazine «Nano-Letters».

Basel, 04.11.2013. Basel scientists are developing a highly stable quantum light source for applications in quantum information

Physicists at the University of Basel have been successful in generating photons - the quantum particles of light – with only one color. This is useful for quantum information. The scientists have actively stabilized the wavelength of the photons emitted by a semiconductor thereby neutralizing the charge noise in the semiconductor. The results were developed in close collaboration with the Universities of Bochum, Paderborn and Lyon and have been published in the magazine «Physical Review X».

Basel, 04.10.2013. Chemistry with sorted Molecules

To gain complete control over chemical reactions is one of the main goals of chemists around the world. For the first time, scientists at the University of Basel and the Center of Free-Electron Laser Science in Hamburg were able to successfully sort out single forms of molecules with electric fields and have them react specifically. Analysis of the reaction rates showed a relation between the spatial structure of the sorted molecules and their chemical reactivity. The results have been published in the renowned magazine «Science».

04.09.2013. Nano carrier system for the application in drug delivery and gene therapy

Researchers at the University of Basel have developed an intelligent nano carrier system on the basis of peptides. In water, these peptides assemble themselves into spherical nano beads of approximately 200 nm because of their special structure. This new nano carrier system can be applied for the transport and protection of different molecules e.g. in gene therapy. The findings were published in the «Journal of Biomedical Materials Research Part A».

26.08.2013. First Report of Real-Time Manipulation and Control of Nuclear Spin Noise

Basel Physicists in collaboration with Dutch researchers have demonstrated a new method for polarizing nuclear spins in extremely small samples. By monitoring and controlling spin fluctuations, the method may provide a route for enhancing the resolution of magnetic resonance imaging (MRI) on the nanometer-scale, allowing researchers to make 3D images of smaller objects than ever before. The results have been published in the journal «Nature Physics».

Basel, 20.08.2013. Graphene conducts electricity almost without loss

Nano scientists at the University of Basel were the first to show that the carbon material graphene allows an almost resistance-free current transport. This allows novel applications of the material in electronics. The researchers have published their findings in the journal «Nature Communications».

Basel. 30.07.2013. Natural channel protein incorporated in artificial membrane

Artificial membranes are well suited to study fundamental principles of living systems. Researchers at the University of Basel have managed for the first time to incorporate a natural channel protein in a synthetic membrane and to control the ion transport through the membrane. They have reported these results in the journal «Scientific Reports».

Full press releases and uninews under: www.nanoscience.ch/nccr/media/recent_press_releases

Please contribute

Please give feedback and submit ideas, success stories and news that might be of interest for the SNI community to the editorial team:

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Dr. Tibor Gyalog (tibor.gyalog@unibas.ch).