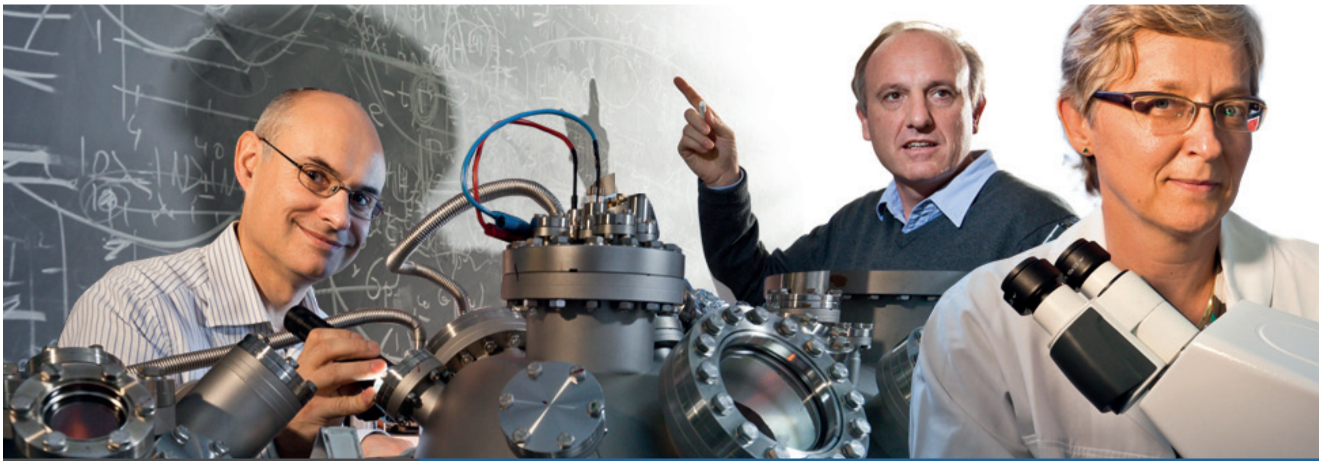


SNI SWISS NANOSCIENCE INSTITUTE
EINE INITIATIVE DER UNIVERSITÄT BASEL UND DES KANTONS AARGAU

SNI update June 2012

Words from the Editor

Dear colleagues

Summer is around the corner. Before many of you will leave for their well-deserved holidays I would like to report on some activities of the Swiss Nanoscience Institute.

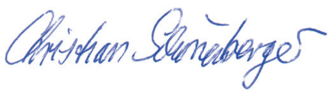
We begin this issue of *SNI update* with the introduction of the first Georg-H.-Endress endowed professor Patrick Maletinsky who was appointed at the beginning of this year. He is currently building up his team and lab at the Department of Physics at the University of Basel. His research is the topic of our cover story. During an interview he told us some details about himself and about his career. His professorship is named after Georg H. Endress, the founder of the locally based but globally acting corporation Endress + Hauser.

Endress + Hauser is also one of the companies that is engaged in the new Argovia projects. In the last issue of *SNI update* we already presented four of the most recent projects. In this summer issue, we give a short introduction to the remaining new projects. How excellent these Argovia projects are, is demonstrated by the fact that three of our applied research projects were recently selected as transfer projects by the Swiss National Science Foundation. Together they will receive funding of one million Swiss Francs for the next two years. Congratulations to the project teams!

Applied Argovia projects will stay a major pillar of the Swiss Nanoscience Institute after the NCCR is finalized in May 2012. As we would like to remain a center of excellence in basic research as well, we currently plan to establish a graduate school. You will find more information about this project in this issue of *SNI update* as well.

Now I wish all my colleagues and everybody who is interested in the activities of the SNI a nice and relaxing summer time.

Yours sincerely

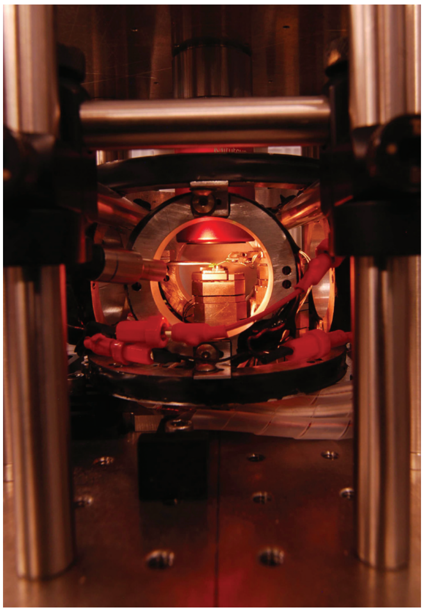


Director of the Swiss Nanoscience Institute, University of Basel

Cover Story

With diamonds into the nanoworld

The recently appointed Georg-H.-Endress professor Patrick Maletinsky explores new sensors that measure tiny magnetic and electric fields on the nanometer scale. He takes advantage of special features of some diamonds. He is not interested in flawless gems but in those that have certain defects. In the case of the precious gems, these defects (also called color centers) are responsible for a particular color of the diamond, give a distinctive design and its value. The carbon lattice in the color centers of Patrick Maletinsky's research is modified in two adjacent positions: one carbon atom is replaced by a nitrogen atom and just next to the nitrogen is a vacancy. These so-called nitrogen-vacancy centers (NV-centers) can occur naturally and are responsible for a reddish color in diamonds. For the research projects of Patrick Maletinsky these diamonds with NV-centers are artificially produced. The nitrogen atoms are implanted into pure synthetic diamonds using ion accelerators. Then they are heated to 800°C. At these temperatures, the vacancy moves. If it meets a nitrogen atom it will remain in its vicinity, producing a nitrogen-vacancy center



To measure magnetic fields with optical methods - that is the goal of Patrick Maletinsky's research.

Free electrons

Why are these diamonds so interesting to Patrick Maletinsky and his colleagues all over the world? In these NV-centers, single electrons occupy well defined energy levels. These electrons can be stimulated, can be manipulated and they respond to magnetic and electric fields around them. In addition, electrons have an intrinsic quantity of angular momentum (spin), which is also suitable for different measurements. This spin behaves similar to a compass needle. If the diamond is influenced by a magnetic or electric field, the direction of the spin changes, which can be measured with different methods.

It is also interesting for scientists that for a short time the spin of an electron is not fixed but can be directed upwards or downwards. Worldwide, research teams are trying to sustain this superstition (to keep up the so called coherence of the system) as long as possible and to use this phenomenon for the development of a quantum computer. Already during his time as a post-doc at Harvard University in Cambridge, Patrick Maletinsky benefitted from the fact that the coherence in NV-centers is relatively stable and can be maintained for a comparably long time. Other systems need extreme cooling, while in diamond the superstition can be maintained in the millisecond range even at room temperature. For lay people these are unimaginably short times. However, physicists who work on these projects are able to carry out many precise measurements during this period. Therefore, it is already clear that NV-centers will have applications as novel sensors.

For Patrick Maletinsky and his team that he is currently building, the first goal is to improve existing sensors. One approach is to create the NV-centers closer to the surface. But then effects of the surface influence the sensor's properties. Therefore, he is collaborating with colleagues from material sciences at the University of Applied Sciences (FHNW). Together they are trying to bond different atoms to the surface of the diamond so that the characteristics of the sensor are optimized.

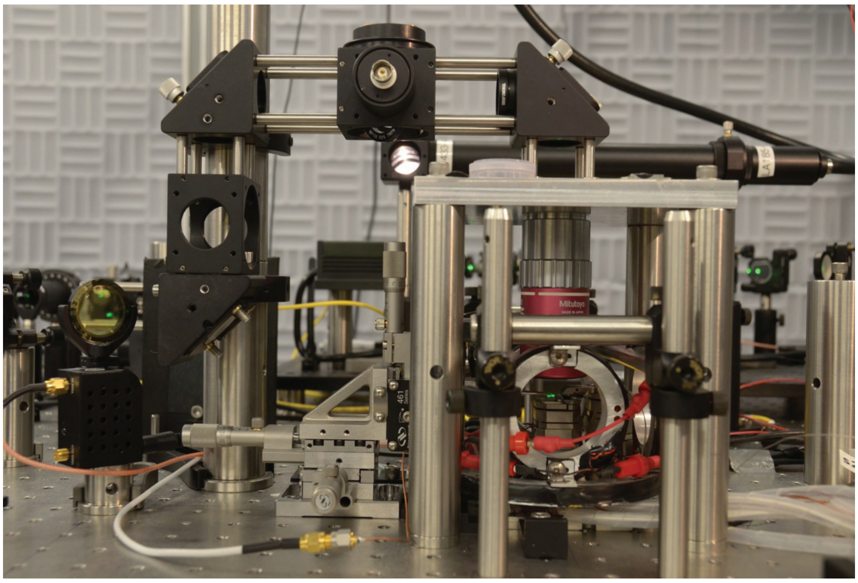
Different applications

There are several different applications for Patrick's research. On the one hand the system could work like magnetic resonance tomography (MRT) on the nanometer scale. The diamonds with an NV-center would then be placed on the tip of a scanning probe microscope or would be placed into a cell. Their internal structures like the nucleus or organelles could be imaged in detail. On the other hand it may be that NV-centers can be applied to explore the chemical structure of macromolecules. “Biological systems present totally new challenges”, replies Patrick to the question about the timeline of these applications. “Until now we have studied static systems with comparably large magnetic fields. In biology, we are dealing with moving matter and much weaker magnetic fields. It will take some years before applications like this become reality.”

Other applications that will also be realized in close teamwork with colleagues from the Swiss Nanoscience Institute (SNI) will be implemented much faster. One central research focus are magnetic phenomena in solid state matter at low temperatures in a size range of 1 to 100 nm length. Additionally, Patrick plans to establish a method to analyze magnetic phenomena in graphene. For example it has been speculated for many years now that the edges of this two-dimensional carbon compound are magnetic. However, until now there has been no appropriate method that could confirm or dismiss the theoretical models. There are a number of open questions concerning transport of electrical charge in graphene. Each passage of electrical charge generates a magnetic field, therefore if would be interesting to track this charge transport in graphene using Patrick’s method to measure magnetic fields.

One further research area will be magnetic properties of superconductors. These fascinating and technologically relevant materials are characterized by a vanishing electrical resistance at low temperatures. In addition, superconductors develop special magnetic properties below this critical temperature. To image these on the nanometer scale was not possible using existing experimental techniques. However, the experimental analysis could bring new insights into the complex characteristics of superconductors and their microscopic behavior,

The next years will show if diamonds will not only be worn on fingers but also contribute to a better understanding of various biological, chemical or electrical systems. Maybe these studies with diamonds will help to discover tiny modifications in human cells and contribute essential aspects for the development of a quantum computer. In any case, Patrick Maletinsky and his team will be at the forefront of this research.



Currently, Patrick is building his set-up at the Department of Physics at the University of Basel - soon it will look like this.

We introduce...

Patrick Maletinsky, the first endowed Georg-H.-Endress professor for experimental physics at the University of Basel

Young, athletic, open-minded, with lots of different interests – that is not the image that some people have in their mind thinking about a professor for physics. But this is exactly how Patrick Maletinsky presents himself. The 32 year old physicists, who was born in the canton Aargau, reflects a new generation of professors who put a focus not only on their research but also on personal contacts, who enjoy interdisciplinary teamwork and who are engaged in areas outside their research field.

Interested in physics and mathematics

Already after his high school diploma in Schaffhausen Patrick Maletinsky showed a variety of interests. He liked physics as well as mathematics and could not really make his mind up which discipline he would like to study. As the ETH in Zurich teaches both topics almost identically in the first two years and is located close to his previous home in Schaffhausen, Patrick began his studies in 1998 at the ETH. More and more it crystallized that experimental physics suited him more than math, so he took quantum optics and neuroscience in the second part of his studies. Working with nerve cells fascinated him. But when his supervisor Prof. Matteo Carandini left the ETH and he developed an increasing interest for quantum optical phenomena, he decided for a diploma thesis in the team of Prof. Tillmann Esslinger. So his affinity to light and optics began.

Award-winning dissertation

During his diploma thesis Patrick got to know Prof. Atac Imamoglu. He was fascinated by his research and decided to study applications of quantum optics on the nanometer scale for his PhD thesis. His work concentrated on the examination of nuclear spins in quantum dots and their interaction with electrons with optical methods. His work may make a contribution to the development of a quantum computer because the spins of electrons and atomic nuclei might once be used for its realization. For this approach it is essential to keep the state in which the direction of the spin is not fixed as long as possible. With his thesis Patrick contributed to a prolongation of this phenomenon called spin coherence. How successful his PhD thesis was, is shown by the A.F. Schläfi award that he received in 2010 for his dissertation that he had finalized in 2008. During his time as PhD student, Patrick first came into contact with the Swiss Nanoscience Institute as his work was funded by the National Center of Competence in Research (NCCR) Nanoscale Sciences.

Diamonds as sensors

The applications that Patrick Maletinsky envisaged during his post-doc time at Harvard University in Cambridge, USA, could be realized faster than a quantum computer. So Patrick planned to develop a microscope that can measure magnetic fields in nanometer dimensions. “The idea was simple”, Patrick reports on his projects. “But the implementation was difficult and lasted more than two years.” It is not trivial, to place a single electron on the tip of an atomic force microscope and to use it to measure the magnetic field while scanning the sample. However, using diamonds, that possess a so-called nitrogen-vacancy center (see cover story), Patrick was able to develop and apply these nanosensors.

The studies that Patrick did in the team of Prof. Amir Yacoby and in close collaboration with Prof. Mikhail Lukin were a crucial factor that in January 2011 he was elected as the first Georg-H.-Endress professor at the Department of Physics at the University of Basel. This professorship is endowed by the Georg-H.-Endress foundation based in Reinach, BL. During his work Patrick will be heavily involved in activities of the Swiss Nanoscience Institute und will work closely together with colleagues from chemistry and biology. His professorship also includes a close collaboration with the University of Applied Sciences (FHNW). For Patrick these interdisciplinary projects, the interaction with FHNW, industry and the foundation are very appealing. Together with his team that he currently builds up he will develop novel nanosensors for various different applications. Teamwork with groups from physics, material sciences, chemistry and biology will be essential for this task. Again he will work with vacancy centers of diamonds and is aiming to give novel impulses for sensor technology in biology and physics.

Working conditions are important

To do research in a stimulating academic environment was always Patrick's vision. But as important for him are personal relationships, a positive working atmosphere and good contact with colleagues – all points that he appreciated at the University of Basel during his first months. " For me Switzerland is an extremely attractive research place", he confirms. "There is more funding and support than in the US. At the Ivy League Universities you find a huge pool of excellently educated people, but the climate is more competitive and you have less freedom in your research."

With the nomination as assistant professor Patrick has done an important step in his career. When he looks back and thinks about his recommendation to young students, there are two topics that he covers: "It is important to get into contact with research groups early in your studies, to work in the lab to experience what you can expect. The second point is to stay mobile and to integrate an internship abroad in your studies. The place where you stay should not be dependent on the beauty of the beaches but on the quality of research and education."

Patrick himself has not always planned his education and career. He has always been open for new input, has orientated himself and been inspired by friends and supervisors; in this way he discovered his own path. He balances his work that apparently fascinates and stimulates him, with movies or in nature - preferably climbing in the mountains.

SNI plans graduate school

In May 2013 the National Center of Competence in Research Nanoscale Sciences (NCCR Nano) comes to an end. Already in 2006, the successor organization Swiss Nanoscience Institute (SNI) was founded. Until the termination of the NCCR Nano, the SNI also functions as an umbrella for the NCCR and the Argovia program for applied research projects. After May 2013, the SNI will still fund Argovia research projects as an important pillar. However, as established in past years, the SNI is aiming to stay a well renowned institution for excellent basic research. Therefore, the SNI plans to establish a graduate school that will fund PhD theses in nanoscale sciences from the beginning of 2013.

Excellent education of young scientists is an important concern at the SNI.

The SNI will cover expenses for 30 PhD students including their running costs over a period of at most four years. Shortly, project leaders within the SNI will be invited to submit project proposals for these PhD theses. Each thesis must be proposed by two researchers from research organizations in Northwestern Switzerland (University of Basel, PSI, FHNW, CSEM Muttenz or ETHZ-Basel). One of the proposers must be a member of the Faculty of Natural Sciences of the University of Basel. The projects will be scientifically evaluated. Only the approved ones will be advertized in international science journals.

The respective principal investigator as well as one representative of the SNI decides in an interview process on the approved candidates who have to enroll at the University of Basel. Within their thesis the young scientists will not only benefit from the stimulating interdisciplinary research environment at the SNI but will also participate in specifically designed workshops. Here they will learn management tools for leadership and for the identification of strengths. They will also learn about intellectual property and assignments in different industries.

The first call for the first ten doctoral theses is planned already in July 2012. The first graduate students can then start their work in January 2013.

Interested?

If you would like to participate in the graduate program you find more information at:
www.nanoscience.ch/nccr/research

Project applications should be submitted by 31st August 2012.

New Argovia projects

In the previous issue of *SNI update* we introduced the first four new Argovia projects. More about the projects Nano-LTB, NanoMorph. NoViDeMo, and WBG-NPA is presented here:

Nano-LTB

Within the project Nano-LTB scientists from the Paul Scherrer Institute (PSI: Prof. Helena Van Swygenhoven and Dr. S. Van Petegem), the University of Applied Sciences of Northwestern Switzerland (FHNW: Prof. Arne Wahlen, Prof. Nobert Hofmann) and the Swiss company ABB (Dr. Chunlei Liu) study an innovative, new method to bond electronic chips to their substrates. They analyze the microstructure of the bonding layers, their thermo-mechanical properties, load cycling capability and fatigue.

Currently, major changes are underway in the power electronics industry. It is becoming more and more important to transport and convert large amounts of power, for example, for hybrid electric vehicles or for the conversion of power generated by wind generators or solar collectors. The core electrical processing units in many of these power systems are multichip modules consisting of power semiconductors attached on ceramic substrate. As the transported power in the systems increases, the temperature in the chips and connecting layers will be raised from 125°C to 175°C and beyond.


Professor Helena Van Swygenhoven leitet das Projekt Nano-LTB.

Nowadays, the chips are bonded to the substrate by a high-lead solder. At temperatures of 175°C that will be reached in the future, these bonding layers fatigue under cyclic loading. Consequently, it is essential to find an alternative fixation of the chips to their substrate that is reliable at higher temperatures. Several companies are currently studying a low-temperature bonding using nano-silver sintering. This lead-free die-attach seems to be more robust and better suited than the traditional solder alloy, when temperatures become higher. However, currently limited experimental measurements of these sintered silver layers exist.

Within Nano-LTB the research teams from PSI, FHNW and ABB now work closely together to analyze the thermo-mechanical deformation behavior of these porous silver layers and to compute a lifetime prediction of these die-attachments. Results from the studies will be used to develop quality control methods and to predict lifetime of the modules. Additionally, they will be used to further optimize the production process.

NanoMorph

Within the project NanoMorph scientists from the teams of Prof. Patrick Shahgaldian (FHNW), Prof. Thomas Jung (PSI and University of Basel) and the Swiss company RPD Tools work closely together to develop a device for the screening of different crystalline polymorphs of active pharmaceutical ingredients in a high-throughput fashion.

Active compounds of drugs often exist in different crystalline polymorphs. These polymorphs may be different in their physicochemical as well as their biopharmacological characteristics. Therefore, patents are granted from the respective medicine authorities (like FDA and EMEA) only for one specific polymorph with in-depth described properties. For pharmaceutical companies it is of great importance to identify the various polymorphs of an active substance and to define its characteristics already in an early stage of development.

For this task, nanostructured surfaces based on self-assembled supramolecules, offer a novel approach. Crystallization of a dissolved compound in a test solution is initiated, if the surface structure matches the crystal lattice. It seems that the highly organized two-dimensional surface structure is transferred into the third dimension. The surface functions as a template seeding the crystallization. The chemical composition of the surface layer plays an important role in the process as well as their packing density and assembly. By the variation of these factors crystallization of specific polymorphs can be controlled.

The scientists of the Argovia project NanoMorph first produce novel self-assembled nanosurfaces and analyze these spectroscopically and microscopically. Then they test the crystallization of different pharmacologically active compounds. In the final part of the project a commercial system will be build up that allows the fast and effective high-throughput screening of numerous substances.

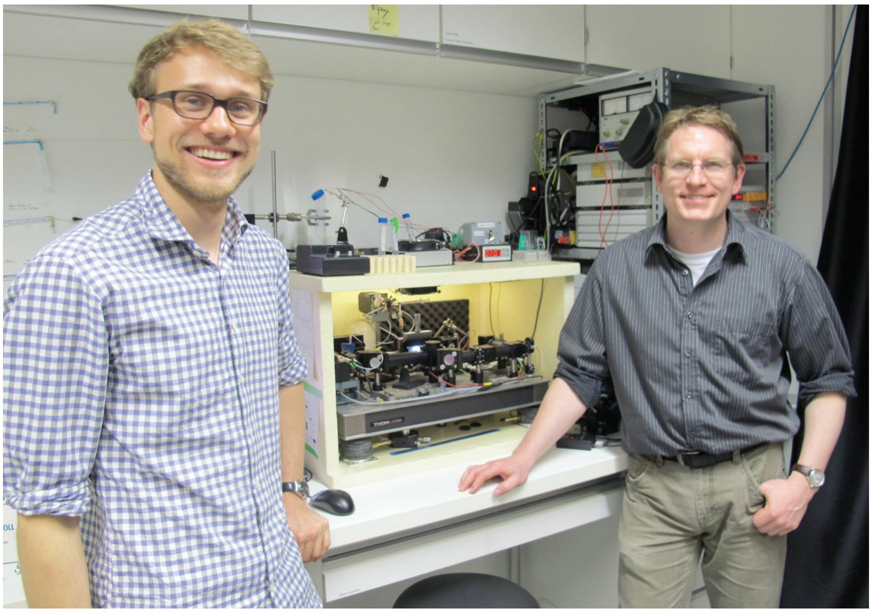
Project leader Prof. Patrick Shagaldian (left) together with his team.

NoViDeMo

The goal of the project NoViDeMo is to develop a nanomechanical real-time viscosity- and densitometer for small fluid volumes. To achieve this, scientists from the teams of Dr. Thomas Braun (University of Basel), Dr. Joachim Köser and Dr. Olfa Glaied (FHNW), Dr. Jürgen Hench (Universitässpital Basel) and Mike Touzin (Endress + Hauser Flowtech AG) join their expertise and work hand in hand.

The scientists follow an approach based on cantilever technology. Herewith tiny cantilevers operate in a dynamic vibration mode. Each alteration of this vibration, for example by a change in viscosity or in density of the fluid, can be precisely measured. The method does not require any labeling and is applicable for volumes of less than 50 μl.

In a first step of the project, an existing sensing platform will be tested and optimized. Later researchers will examine the application of the test for different industrial settings. Among these are quality control of a large variety of liquids and real-time monitoring of chemical polymer reactions. The viscosity of a solution is highly sensitive against structural changes of the dissolved polymers or proteins. Therefore the nanomechanical viscometer can be used to observe chemical and biological reactions. A continuous monitoring could be important, for example when the polymerization should be terminated at a specific polymer length. Besides further approaches the interdisciplinary team of scientists tests the application of the platform as sensor for biomedical research. Here they study the aggregation of the tau protein that is discussed to play a major role in the development of Alzheimer's disease. Substances that inhibit or stimulate the aggregation process could be identified rapidly and effectively.



Project leader Dr. Thomas Braun together with his PhD student Benjamin Bircher in front of their instrument that they will use to measure viscosity of small fluid volumes.

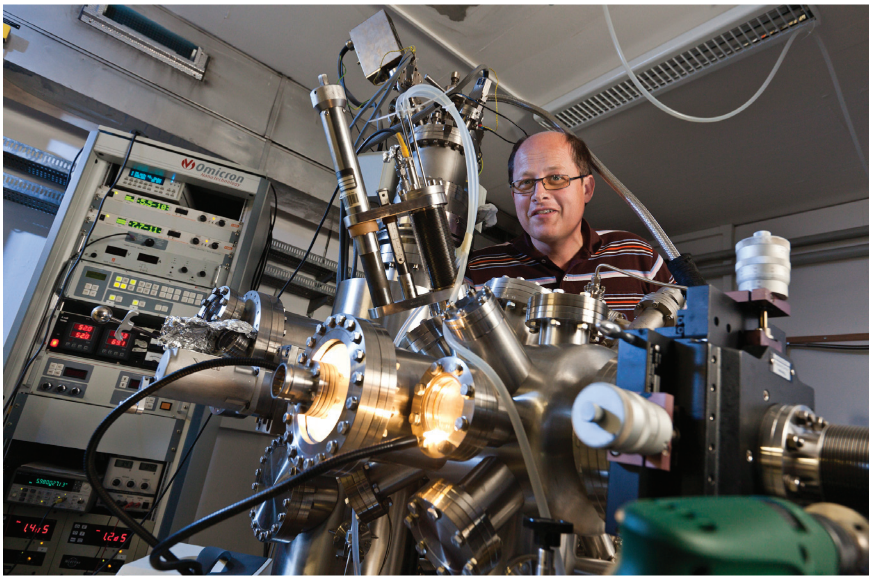
The diversity of tasks within the project NoViDeMo requires a high amount of interdisciplinary teamwork. A prototype of the nanomechanical viscometer has been developed by the group of Prof. Christoph Gerber (SNI). For NoViDeMo experts from the Center for Cellular Imaging and NanoAnalytics at the Biocenter (Dr. Thomas Braun) now work together with scientists from the Institute for Chemistry and Bioanalytics of the FHNW (Dr. Joachim Köser, Dr. Olfa Glaied) and the Pathology unit of the Universitätsspital (Dr. Jürgen Hench). Researchers from Endress + Hauser contribute their expertise from the industrial environment.

WBG-NPA

In the project WBG-NPA research teams of Prof. Ernst Meyer (University of Basel), Prof. Thomas Jung (PSI and University of Basel) and Dr. Holger Bartolf (ABB Corporate Research Center, Power Semiconductors) investigate novel semiconductors that can be used as power electronic switches with different scanning probe microscopy methods.

These new semiconductors are made of so-called "wide-band-gap (WBG)"-materials. They are solid-state bodies that can be used as power switches for large electrical currents. The conductivity of the semiconductor is dependent on the chemical composition and structure, but also on the temperature. By implanting impurities (dopants) into the crystal lattice their conductivity can also be altered. Due to their fast switching capabilities for high current and voltage classes, power semiconductors are used in electronic converters and inverters. These are required, for example, to convert renewable energy generated by wind power or photovoltaic systems in a compatible form for the power distribution grid. Semiconductors, which are used as such power switches, should be able to switch very high currents and exhibit little energy loss under their normal working conditions.

The semiconductors that are examined in the project WBG-NPA meet these requirements. Their electrons need to be stimulated by comparably high levels of energy before the semiconductor becomes conductive. They consist of materials like silicon carbide or gallium nitride. Additionally, various dopants are incorporated into the material, which specifically controls conductivity. The doping process has not been studied extensively on the nanometer scale. Therefore, the project teams plan to examine wide-band-gap semiconductors in different stages using various scanning probe microscopes. They concentrate on the different dopant atoms, they will establish dopant profiles and will determine their concentrations. In a further step, these experimental data will be compared to numerical simulations. These examinations are only feasible thanks to the special atomic force microscopes at the University of Basel and at the PSI.



Prof. Ernst Meyer is the project leader of WBG-NPA.

Argovia-Projects 2012

The submission period for new Argovia projects ends on 31st September 2012.

The process has not been changed in recent years.

If you are interested please find more information at:
argovia.nanoscience.ch

Recent press releases

Sustainable solar cells from common materials

Basel, 02.05.2012: After Fukushima the necessity for alternatives to nuclear power is becoming increasingly clear. Currently, many technologies are being intensively investigated. Often, however, the sustainability of the materials is neglected. A process that is based on expensive and rare resources will not be applied in mass production. Chemists from the University of Basel now describe a groundbreaking approach to build effective and sustainable solar cells based on zinc – one of the most abundant elements in the Earth's crust. The results of this study were recently published in the prestigious journal "Chemical Communications".

University of Basel at the Hannover Messer 2012

Basel, 23.04.2012. The Department of Chemistry of the University of Basel presented a sensor and detoxification system that recognizes and detoxifies free radicals using nanoreactors at the world's most important technology fair.

Discover today, develop tomorrow: The University of Basel at the MUBA

Basel, 12.04.2012. The Biocenter, the Departments of Mathematics and Informatics, Physics as well as the Swiss Nanoscience Institute actively participated in an interactive show at the MUBA 2012. The goal was to raise interest for natural sciences and technology among children and young adults.

Nanotechnology: Molecules make quantum waves

Basel, 26.03.2012. Quantum physics describe a wavelike behavior also for heavy objects, which is difficult to align with our experience in daily life. An international team of scientists succeeded in filming the interference pattern of single dye molecules, which were synthesized by the team of Prof. Marcel Mayor from the University of Basel. The movie was published recently on the website of "Nature Nanotechnology".

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

i-net innovation networks: New support for innovation of the Northwestern cantons in Switzerland

Liestal, 23 04.2012. With the new association i-net innovation networks the Northwestern cantons Basel-Stadt, Basel-Land and Jura plan to cooperate in respect to supporting innovation. The canton Aargau is engaged in i-net from the beginning and a membership is planned in 2012. The goal of i-net innovations networks is to further improve conditions for local technology enterprises and to continue the efforts that more companies of technology industries are founded or located in Northwestern Switzerland.

Full press releases at: www.inet-innovation.ch/?L=1

Please contribute

We are looking forward to your feedback, ideas, success stories and news that might be of interest for the SNI community.

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