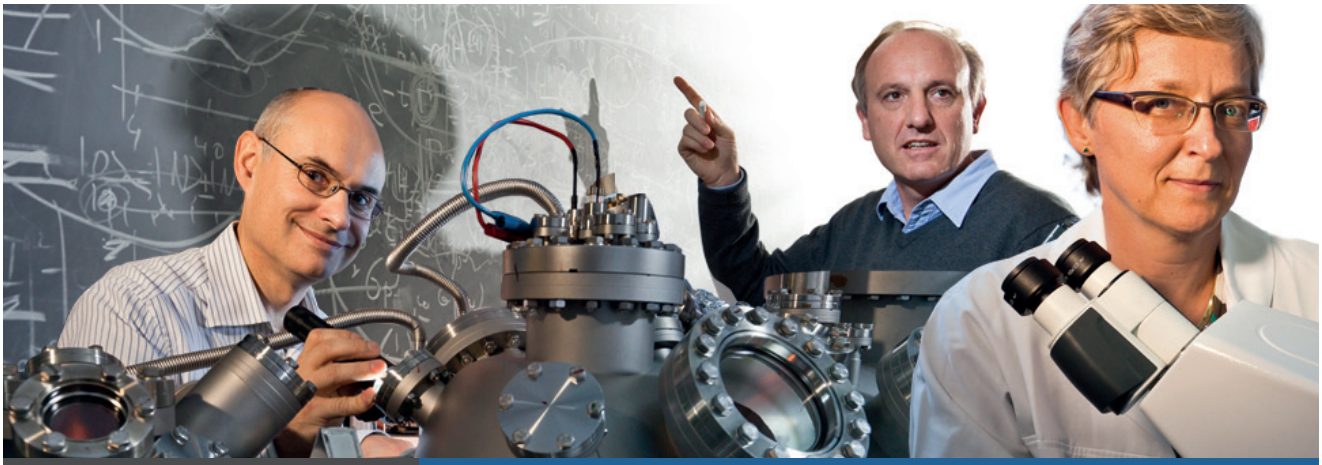


SNI
SWISS NANOSCIENCE INSTITUTE
EINE INITIATIVE DER UNIVERSITÄT BASEL UND DES KANTONS AARGAU

SNI update March 2012

Words from the Editor

Dear colleagues

The first three months of the year have already passed. It was a busy time. One of the projects we had to finalize was this years´s annual report. It clearly demonstrates that the NCCR Nano truly is a success story and that we have built up a strong nanocenter with excellent research. The smooth compilation of this year´s report also showed that we have not only achieved scientific excellence but that we also have improved organisationally. Many thanks to all, who have delivered their contributions in time, to Audrey Fischer, who collected the pieces and to Meret Hornstein, who took care about the layout and the production. Hot off the press we also have in our hands the latest Argovia report and our first SNI Competence Catalogue. With this compilation of competences and infrastructure gathered in the SNI we would like to raise even more interest among companies in our region. We hope that we have managed to present the services, which we can offer and - where possible - the collaborations we can build up.

Joint projects with companies are already routine business within the SNI. The new Argovia projects demonstrate how diverse these collaborations can be. In this issue of *SNI update* we will introduce the first four of these newly accepted projects of the Argovia program. In the cover story of this issue we will report on the project QUEST worth 2 Million Euro that was recently approved by the European Research Council. In an interview Dr. Dieter Scholer, member of the University Council, talked to Christel Möller and Tibor Gyalog about the position of the SNI and the outlook for nanoscale sciences in the future.

Finally, two of our colleagues who participated in the NCCR from the beginning, were honoured. In January, a festive farewell symposium was held to honour Ueli Aebi's achievements and in February, Christoph Gerber received the Bill Whelan Lifetime Achievement Award.

I hope you enjoy reading this spring issue of *SNI update* and I am looking forward to your feedback and suggestions.

Best regards

Christian Schönenberger

Director of the Swiss Nanoscience Instituts, Universität Basel

UNI BASEL

Cover Story

QUEST – Hunt for entangled particles

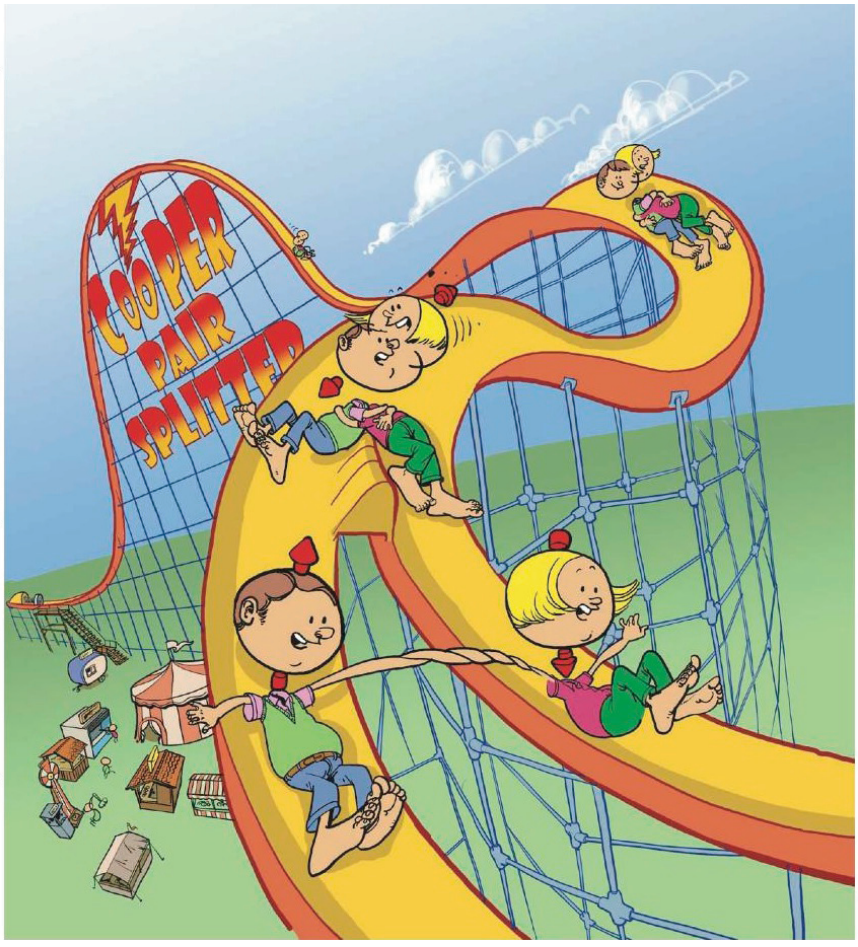
Professor Christian Schönenberger recently has received an "ERC Advanced Investigator Grant" from the European Research Council (ERC). Within the project worth 2 Million Euro, Christian Schönenberger investigates entangled electron pairs. In the next five years he plans to establish an efficient and continuous source for entangled electron pairs and to explore these pairs after their separation.

Spooky phenomenon

The entanglement of small particles like electrons or photons is a phenomenon that already concerned famous scientists like Albert Einstein. More than eighty years ago Einstein and his colleagues observed that the quantum theory that had been developed during those years, described strange phenomena. Such situations arise when more than one particle is described as a single unit. The smallest of these units is a pair of photons or electrons. Such a pair can be defined so that the condition of the single particle is not fixed but is dependent on his partner. A correlation between both particles exists, that persists even when the particles are separated. When the state of one particle is measured, the state of the other one is determined at exactly the same time. Einstein called these observations "spooky action at a distance" because he could not find a logical explanation. Nowadays, experts talk about entanglement when they describe the invisible connection between the particles. It is so difficult to understand for non-experts, because these properties are a specific characteristic of quantum theory and they are not manifested in our classical world. In our classical understanding of the world it is not imaginable that the state of the second particle is determined exactly when the state of the first particle is measured. This would require an information exchange between the particles that is faster than the transmission of light. Therefore, our world that builds on the quantum theory allows non-local connection by entanglement.

Platform for experiments

Within the QUEST project Christian Schönenberger and his team first plan to establish a continuous, highly efficient source for entangled electron pairs. The quantum information for electrons refers to their spin. The spin can be +1/2 or -1/2, which can also be called "spin up" or "spin down". Two electrons can be combined so that their joint spin is zero, i.e. if one electron is spin up then the other is spin down or vice versa. It is not predictable which electron is facing in which direction. But as soon as one spin is measured the spin of the partner is



First together, then separated.

immediately fixed even if the partners are separated over long distances. Recently, scientists were able to produce entangled electron pairs experimentally. Christian Schönenberger and his team plan to move one step further. His goal is to realize a model system in which a solid-state source generates a continuous stream of entangled electron pairs. Subsequently, the pairs shall be separated and studied experimentally. With these studies, the scientists are breaking new ground: although there are some theoretical investigations covering this topic, as yet, no comparable experimental set-up exists.

Separated pairs

As a source for electron pairs with entangled spin the researchers realize a so-called "Cooper-pair splitter" that is built out of tiny conductive structures on the nanometer scale (nanostructures). The term Cooper-pair refers to the scientist Leon Cooper, who first recognized that electrons in a superconductor form pairs with a total spin of zero. A source of entangled electrons is now easy to realize when electron pairs from a superconductor are injected into the nanostructure. The nanostructure then separates the pairs. This is achieved by using a crossing. If quantum dots are deposited in the arms of the crossing, various interactions lead to the separation of the electron pair. These crossings can be assembled with carbon nanotubes or with wires made of semiconductor materials.
To prove the entanglement, Christian Schönenberger's group will determine the non-local correlation by measuring the spin direction of both partners. Alternatively, they will reunite the pairs by a collision. The path that they will take after the encounter provides information about their entanglement.

New applications

Why does Christian Schönenberger study these phenomena? Why do he and his team invest so much time and effort to experiment with single electrons, to entangle them and finally separate them again?

These experiments on entanglement provide basic knowledge for innovative applications like safe decoding or quantum computation. Professor Schönenberger's group has a long-standing experience in research with nanoelectronic devices and in the production of tiny instruments used to manipulate single molecules and based on novel materials like carbon nanotubes and graphene. It suggests itself, that they make use of the knowhow to investigate this innovative research approach. Additionally, the close collaboration with colleagues from the research team of Professor Daniel Loss at the SNI, who investigated the theoretical principles for this experimental approach, offers ideal working conditions for this research topic.

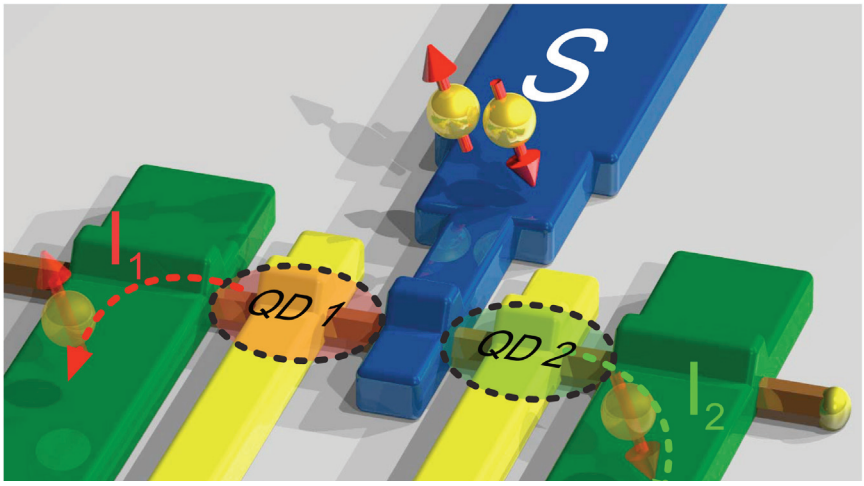


Illustration of a Cooper-pais splitter with two quantum dots (QD).

Excellent starting position for nanotechnology

Interview with Dieter Scholer

Dr. Dieter Scholer is a medical doctor. He held leading positions at Ciba and Novartis Pharma over two decades, contributed fundamentally to building-up the pharmaceutical start-up company Speedel AG and today is member of several boards and commissions including the University Council of the University of Basel. According to Dr. Scholer Northwestern Switzerland offers excellent starting conditions to build up **the** internationally renowned nanocenter of Switzerland. Now it is important to strengthen the good position, to build up the infrastructure that is essential for sustainable success, to further expand alliances and networks, and very importantly, to transfer scientific success into valuable technical applications.

Which role do the nanosciences play nowadays?

I am personally convinced that nanosciences and nanotechnologies are key technologies of our current times. They are interdisciplinary technologies that will crucially influence and fertilize other areas.

Which areas would you highlight?

For me as a medical doctor, there are especially the life sciences and within these mainly applications of nanotechnology in medicine that interest me most. These are also topics that are very well represented here in Basel. I think that in diagnostics, nanotechnologies will set new standards with respect to sensitivity and specificity. Furthermore, we will get to know new approaches in therapy and diagnostics. Already now, we have gained new insight into the molecular and submolecular understanding of biological structures, for example tissue surfaces, membranes and ion channels. New imaging techniques have been developed so that we can detect morphological modifications before clinical symptoms appear. Furthermore, there are possibilities for new developments like novel (bio)materials, biosensors, and medicinal tools. We can also break new ground in the area of drug application. Thanks to new carrier molecules drugs can be transported to the target more specifically and with less side effects. In the future, nanorobots will probably lead to new insights and option for therapies.

Could you please elaborate on the role of the SNI in respect to the development of nanosciences?

The SNI and its predecessor organization, the NCCR Nanoscale Sciences at the University of Basel, have gained an excellent position in the field of nanoscale sciences. Already years ago the Departement of Physics has built up the base for a competence center in nanoscale sciences. Based on this experience the SNI has by now acquired an excellent scientific reputation and has launched numerous interdisciplinary collaborations. Additionally, the SNI is embedded in a widely branched network of local and national research organizations. The SNI network also expands across national borders.

In summary, the nanoscale sciences are now a well-established focus-point of the University of Basel. In this context, we explicitly thank the canton Aargau that underlines its engagement in nanoscale sciences with the support of two Argovia professors and several research projects. That the SNI takes a key role in nanoscale sciences is additionally shown by the nano curriculum. Basel was the first university in Switzerland that established the nano studies.

With special nanotech events the SNI aims to contribute to the interaction between academia and industry that you are requesting. What do you think about the events that help bringing together scientists and representatives from industry?

I really like the events I have visited so far. The program was tailor-made for the audience and everything was professionally presented. I especially appre-

ciated that we could experience the enthusiasm of the researchers. They were able to bring across their curiosity for novel findings and offered new perspectives combined with critical judgments. For the future, the coordination with events organized by i-net BASEL Nano and the European Foundation for Clinical Nanomedicine (CLINAM) could be optimized.

You mentioned that knowhow transfer between universities and industry is essential. In this respect, what is the main duty of universities? Should they concentrate on basic research or invest more time in applied science?

For me it is clear that universities should concentrate on basic research. Nowadays, this needs to be done internationally and interdisciplinary. However, all scientists should keep an eye open for possible applications. They should observe their field, evaluate and stay open for development perspectives and possible collaborations with industry.

Generally, universities have to invest more effort in the funding of first class research than in years past. They are forced to fight for the funding of projects from the Nationalfond or European Research Organizations, they have to position themselves in an international comparison by originality, quality and critical resources.

From my point of view, we have to put special emphasis on optimal collaborations between the University of Basel, other research institutions (like Friedrich Miescher Institute and Systems Biology), the University of Applied Sciences and industrial partners. In Basel, we have the privilege to be part of an almost unique Life Sciences location with potential synergies between basic science, targeted research and development. If we clearly define interests and expertise while keeping institutional and individual independence, all partners can benefit from cooperative work. We will gain new insights and will be able to speed up the implementation of new findings into applications. This relationship between industry and the University of Basel has a long-standing tradition. However, because of the globalization of companies these bonds have to be taken care of. In the past, many managers and researchers had connections to the University of Basel and collaborations with the university came naturally. Nowadays, this is no longer the case and the university has to strive for the funding of interesting research cooperations.

You mentioned the word "interdisciplinarity". This leads us to the nanocurriculum at the University in Basel. What do you think about the nanostudies?

From my point of view, the University of Basel has achieved something very special and excellent by establishing the nano studies. I cannot evaluate career opportunities of nano students, but nowadays it is essential to learn, think and work in an interdisciplinary way. The depth of each branch needs be retained but it is helpful when studies at universities have an interdisciplinary approach.

Personally, I decided to start a career in the pharmaceutical industry because in the 70's interdisciplinarity was practiced there. It is a success of the

SNI at the MUBA

After the great success of SNI workshops at traditional Swiss fairs like OLMA and MUBA in 2010, the SNI again takes part at the TuN Basel, a special exhibition at the MUBA 2012. At the TuN Basel a broad audience, especially children and families, can experience technology and natural sciences in interactive workshops.

Estimations assume that more than 300´000 visitors will come to the MUBA. For the first time, special technology and natural science days will be held for high school students. During these events the SNI communications team will promote the nano curriculum at the University of Basel with a special ambitious program. Planned are talks by Prof. Dr. Dominik Zumbühl, Meret Hornstein and Dr. Tibor Gyalog.

More information at:
www.tunbasel.ch/

Meret Hornstein (alias Lieutenant Uhura) and Tibor Gyalog (alias Captain Kirk) are preparing their workshop for the TuN Basel focusing on the young audience.

universities that barriers between departments and faculties are now breaking and that interdisciplinary work is increasing.

How do you see the further development of nanotechnologies?
The prerequisites for the development of nanotechnologies in Northwestern Switzerland are excellent. However, it is now important for nanoscale sciences to further evolve. Conditions need to be created so that we can fully exploit the potential of nanosciences here in the region and in the whole of Switzerland. The transfer of findings in basic science into industrial applications – this is the major challenge I see. Knowhow and technology transfer organization like i-net BASEL Nano (a platform that was founded to bring forward innovation in nanoscale sciences) will play a major role. Additionally, the Comission for Technology and Innovation (KTI) is a key player for knowhow and technology transfer. However, the financial support for transfer projects is still an issue.

Besides the good starting position, vision and leadership are required for sustainable success. The position of Basel is positive in this respect as well. In recent years, the important role of nanoscale sciences at the University of Basel and within the Life Sciences Cluster Basel was emphasized in several strategic documents. In the area of medicine, the European Foundation for Clinical Nanomedicine, which was founded in Basel, is very active and evaluates the state of knowledge in yearly congresses with international researchers.

In the end, it is crucial that the Basel region attracts talented and creative researchers and that strength of the different players are combined. We have to focus on relevant topics and projects and we have to compete with national and international players in the field.

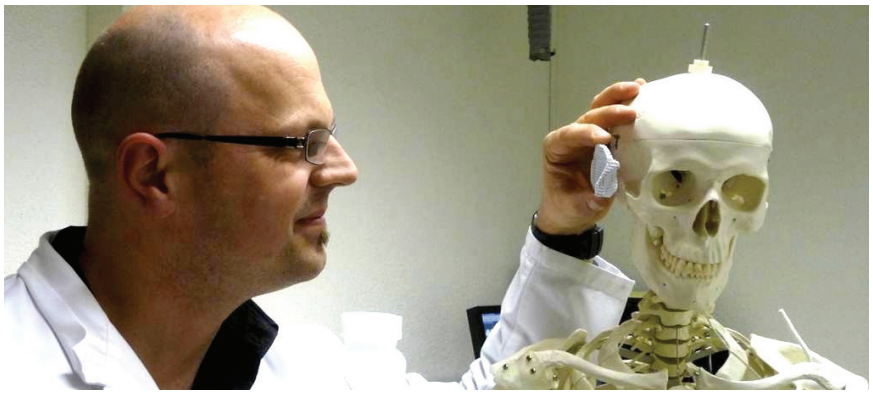
New Argovia projects

End of last year the Argovia board approved eight new Argovia projects. Now the projects have started and we introduce BIOPRINT, FILTRELEC, NANOCURE and nanoFACTs.

BIOPRINT

Within the project BIOPRINT, scientists under the leadership of Dipl.-Ing. Ralf Schumacher from the University of Applied Sciences Northwestern Switzerland work on tailored patient-specific bone-replacing implants that mimic characteristics of natural bone tissue. For an ideal implant, biocompatibility and biomechanical properties as well as chemistry and structure of the surface play a crucial role. The surface structure and the chemical composition have to enable optimal adherence of human cells so that rapid osteointegration is possible. On the other hand, chemical functionalization of the material and of the implant surface should prevent that inflammations occur.

The project team of BIOPRINT aims to tailor the macroscopic 3D shape and inner nano and microscopic structure of the 3D implant scaffolds. Using a technique called “Rapid Prototyping” they will produce specific, individual implants out of synthetic analogues of natural occurring substances. The biofunctionality will be achieved by focusing on synthetized nano-porous ceramic powder carrying chemical and/or biochemical additives; through post processing of the manufactured scaffolds or by layered deposition of additives with specific functions like antimicrobial activity. Additionally, the different implants will be strengthened by tiny collagen fibrils to build up stable and reinforced biomimetic implants. Applying different mechanical, analytical and biological tests systems



Dipl.-Ing. Ralf Schumacher is project leader of BIOPRINT.

the project team will be able to evaluate their results in order to define the best combination of methods.

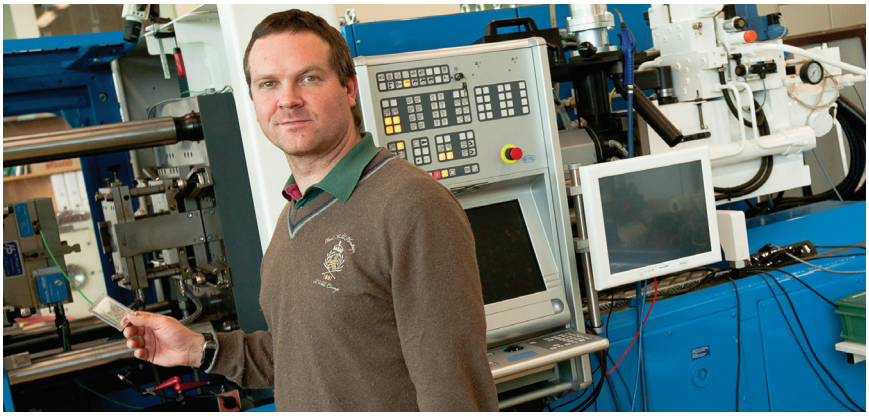
Partners within the project BIOPRINT are: Dipl.-Ing Ralf Schumacher, Institute for Medical and Analytical Technologies (University of Applied Sciences Northwestern Switzerland (FHNW)); Professor Dr. Uwe Pieles, Laboratory for Nanotechnology (FHNW), Dr. Olivier Braissant, LOB2 Laboratory of Biomechanics & Biocalorimetry (University of Basel) and Dipl.-Ing. Philipp Gruner, Medicoat AG in Mägenwil.

FILTRELEC

More than 70% of the running costs for air filter systems are caused by their energy consumption. The filter medium itself is only a small cost factor, but it is responsible for the energy efficiency of the systems. In the new Argovia project FILTRELEC, scientists from the University of Applied Science Northwestern Switzerland (FHNW) work together with colleagues from the Paul Scherrer Institute and the two companies Jakob Härdi AG and Chematest. Together they want to increase the efficiency of filters for ambient air.

Different mechanisms are responsible for filtering particles of different sizes in particle filters. Large particles are filtered through collision with a three-dimensional network of fibres. Very small particles adhere to the fibres. For particles of medium size those two mechanisms are not working efficiently. However, by using so called Elektret additives the efficiency for medium sized particles can be increased. These nanoadditives induce a permanent electrostatic charging of the fibres and herewith a virtual increase of the fibre´s diameter. Different substances that exist in the environment discharge the fibres and therefore cause a decrease in filter efficiency. In the project FILTRELEC scientists examine if a special modification of the nanoadditives and a multilayered functional filter structure can reduce the vulnerability against discharge.

In FILTRELEC researchers from the teams of Prof. Dr. Per Magnus Kristiansen (FHNW) and Prof. Dr. Jens Gobrecht (PSI) work closely together with members of the two companies Jakob Härdi AG and Chematest.



Prof. Dr. Per Magnus Kristiansen is leading FILTRELEC.

NANOCURE

Within the project NANOCURE the project team around the scientists Prof. Dr. Uwe Pieles (FHNW), Prof. Dr. Bert Müller (University of Basel) and Michael Hug (credentis ag) examine a novel approach for the treatment of dental caries.

The human body possesses a huge potential for self-healing. In many processes tissue is regularly formed and removed. Our teeth as well are constantly demineralized and remineralized when we ingest. If this equilibrium comes out of balance, the tooth cannot be remineralized and dental caries is the consequence. This process depends on the oral hygiene, preferred type of food, and oral microflora of each individual. In a first step, bacterial acids cause a demineralisation at the weakest point of the tooth. Initial lesions or “white spots” develop. These rarely remineralize spontaneously and normally cannot be regenerated. If caries proceeds, the pseudointact surface breaks down forming a carious cavity. Standard treatment since more than 100 years is to mechanically open the carious area and to fill it with a biocompatible material.

Credentis ag has now launched an innovative treatment method that regenerates the affected enamel. Scientists of the University of Leeds have developed a self-assembling peptide that, applied to the carious lesion, diffuses into the initial lesion and forms a supramolecular network inside the carious lesion. As soon as this 3D network exists, the crystallisation of nanocrystals is initated and the regeneration of the white spots is induced. Nowadays, initial lesions can be treated

successfully applying this method. For larger cavities the product does not function yet.

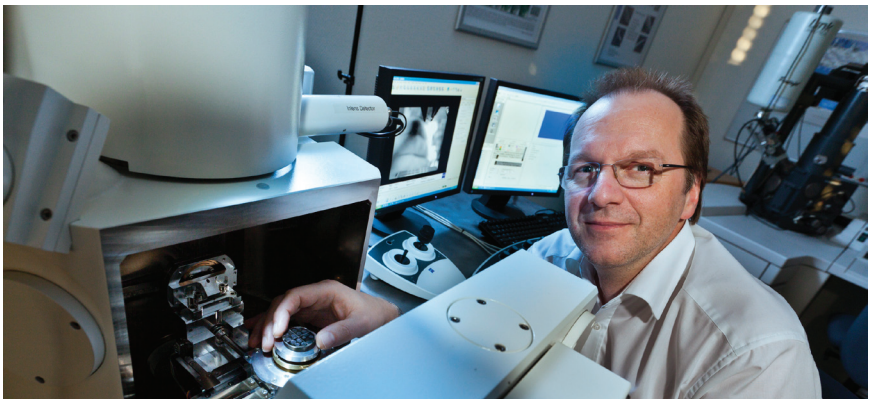
The whole process, especially the diffusion of the peptide through the enamel, is poorly understood. Within the Nano-Argovia project NANOCURE researchers will jointly develop *in vitro* models to better understand the course of the treatment und to optimize treatment concepts. Initially, natural teeth with artificially induced carious lesions will be used. In a further step, scientists will establish a tailor-made, synthetic model that comes close to natural teeth thanks to its special sequential composition. With the help of these models, the team will later analyze and optimize the artificial healing process. Their results will help to improve the treatment and to synthesize the next generation of self-assembling peptides that enable regeneration even with advanced carious lesions.

nanoFACTs

The Argovia project nanoFACTS shall considerably contribute to develop innovative textiles with active cooling mechanism. Functional textiles like this could be worn by firefighters under insulating protective clothing. Cooling underwear would be a considerable relief during their hard work and would increase their safety.

We cannot imagine a closet without functional clothes anymore. However, not only for recreational textiles but also for protective working gear innovative technologies offer novel possibilities to equip clothes with special functions. One method to add functionality to textiles is to encapsule an active material and apply the capsules to the textile surface. However, the capsules need to have the right size. They should not be too large, otherwise they get washed off too easily. On the other side, they need to have a minimal size so that sufficient active material is captured. Studies have shown that the optimal capsules vary between 100 and 10´000 nanometer. Currently, existing encapsulation methods are not very suited to produce capsules in this range.

Within the project nanoFACTS scientists from the University of Applied Sciences Northwestern Switzerland (Prof. Dr. Uwe Pieles, Dr. Olfa Glaid, Dr. Johann Grognoux), of the University of Basel (Prof. Dr. Wolfgang Meier, Dr. Nico Bruns, Dr. Cornelia Pailvan, Dr. Olivier Braissant) and HeiQ Materials (Dr. Murray Height, Dr. Christoph Bradbury) strive to establish two encapsulation methods to tailor the capsule size between 100 and 10´000 nanometer. On one hand, they are pushing the emulsion technologies to smaller sizes (top-down approach). On the other hand they investigate new technologies (e.g. vesicles) in a bottom-up approach. First they will focus on the idea of developing functional capsules for thermal regulation of clothing. However, when the method is established it can be applied to various active ingredients and target functions.

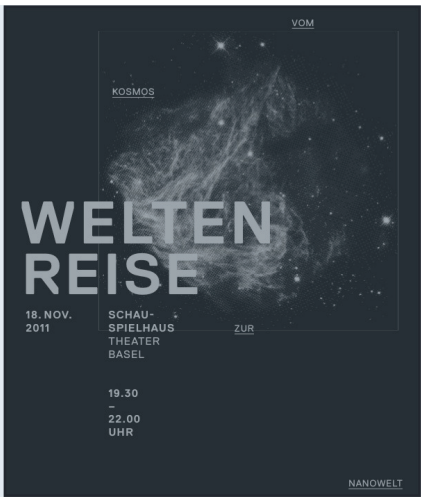


Prof. Dr. Uwe Pieles is project leader of the two Argovia projects NANOCURE and nanoFACTs.

Did you miss “Weltenreise”?

The film is now available. Just have a look under **http://weltenreise.unibas.ch.**

The first “Weltenreise”, a trip from the cosmos to the nanoworld, took place on November 18th 2011 in the Schauspielhaus in Basel. Talks and impressions were recorded by the New Media Center of the University of Basel under the direction of Thomas Lehmann.



Awards

Bill Whelan Lifetime Achievement Award for Christoph Gerber

On February 26th, during the Miami Winter Symposium 2012 – a "Nature" Conference - Professor Dr. Christoph Gerber received the Bill Whelan Lifetime Achievement Award.

He was honoured for his groundbreaking research in scanning probe microscopy and for the development of biochemical sensors based on Atomic Force Microscopy. Christoph Gerber received the award during the conference "Nanotechnology in Biomedicine", which was visited by numerous internationally distinguished scientists. His research has considerably contributed to the development of certain areas in nanomedicine.

More information at:
www.nanoscience.ch/nccr/people/awards/award_000002/award_long

Farewell to Ueli Aebi

On Thursday 26th January, many internationally distinguished scientists came together to participate in the farewell symposium honouring Prof. Dr. Ueli Aebi, Professor of Structural Biology at the Biozentrum, University of Basel and former Director of the Maurice E. Müller Institute for Structural Biology. Amongst the guest speakers were the Nobel Laureate Prof. Werner Arber (Biozentrum, University of Basel), Prof. Tom Pollard (Yale University), Prof. Wolfgang Baumeister (Max Planck Institute for Biochemistry), and Prof. Hans-Joachim Güntherodt (Swiss Nanoscience Institute).
More information at:
www.biozentrum.unibas.ch/symposium-aebi/index.html und unter: **www.nanoscience.ch/nccr/knowhow_and_tecTransfer/events/**

Recent Press Releases

EU grant for Christian Schönenberger

Basel, 27.01.2012. Prof. Dr. Christian Schönenberger, Director of the Swiss Nanoscience Institute at the University of Basel, received an „ERC Advanced Investigator Grant" from the European Research Council (ERC) worth 2 Million Euro. In the planned project the physicist and his team will examine entangled electron pairs – an experimentally not very well researched area of quantum mechanics. His research aims to deliver important fundamentals for the development of quantum computers and new, secure encoding methods.

Election of the endowed Georg-H.-Endress professor for experimental physics

Basel, 21.12.2011. The endowed Georg-H.-Endress professorship for experimental physics at the University of Basel will be filled with the Swiss physicist Patrick Maletinsky, currently working at Harvard University. The professorship is directed to nano sensor technology. It bears the name of the founder of the internationally acting Endress+Hauser group, Dr.h.c. Georg H. Endress, who passed away in 2008. The professorship is financed by the Georg-H.-Endress Foundation in Reinach, BL with a contribution of 3.2. Million Swiss Francs over ten years.

Full press releases in German at:
www.nccr-nano.org/nccr/media/recent_press_releases