Issue March 2005

nanonews

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Contents	Page

Words from the Editor

Dear Colleagues,

The year 2005 has begun like 2004 has ended – pretty busy. In the past two months we had to shape the future of our NCCR. At the end of February, we submitted the full proposal for the NCCR continuation to the Swiss National Science Foundation (SNSF). We had to identify the most promising projects that will be continued in the next four years.

Additionally, all project and subproject leaders had to write their contributions for the Scientific Report, which was also submitted at the end of February. Into these two documents an enormous amount of administrative work and numerous discussions about the new project structure and budget were invested. However, it is not only hard work, it is also very exciting to see what our NCCR will look like in the near future and which fascinating research topics will be covered within the five projects. The positive side of the compilation of the Scientific Report is that we now hold in our hands the outcome of the past year, and again we can be proud of what we have achieved. Thank you all for your contributions! In particular, I would like to thank Christian Schönenberger, our current Deputy Director and my successor, who invested a lot of time and energy during the last weeks.

Some of the success stories of the past year are also covered in this issue of nanonews: Martin Hegner received the *Scientist of the Year Award* of the City of Basel. Reason enough to ask him to contribute the Cover Story on the Bio-Nanomechanics-Project for this issue of nanonews. Wolfgang Belzig was honored the *Walter-Schottky Prize 2005,* the most prestigious prize for solid-state physics awarded by the German Physical Society, and Christoph Gerber received several awards in recognition of his scientific achievements. Two of the NCCR spin-off companies, Concentris and Nanonis, received the CTI-Start-up Label that qualifies companies on the climb to sustainable growth.

As in the past the NCCR Nanoscale

Words from the editor

Science has contributed to and participated in numerous events and our scientists have published excellent scientific papers. Under the topic "We introduce …" we present this time a young women who has not published a scientific paper yet, but is already an expert in nanoscale science. She has recently presented her remarkable high school research diploma on nanotechnology to the public.

I wish all of you happy reading and a lot of success in the first months of the World Year of Physics.

Yours sincerely,

Hans-Joachim Güntherodt

Cover story

The Bio-Nanomechanics Project

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This article provides a brief overview of the ongoing life science projects within the Bio-Nanomechanics group of the University of Basel. A team of scientists of various research fields is working on the fundamentals of biological Nanoscience and on the development of the next generation of nano-biosensors. Driven by the interdisciplinary nature of the projects, the involved researchers managed to build during the last four years a group of closely collaborating experts in the various fields *(see http://monet.physik.unibas.ch/bio/index.html)*. **Such daily collaboration within the group is a solid foundation for both an efficient approach to research and comprehensive exchange of know-how.**

The projects we pursue involve two kinds of experiments. First, experiments on nano-systems involving single biomolecules in action investigated using biophysical tools (scanning probe microscopy, combined optical tweezers for force and optical spectroscopy) (1–3). Second, experiments performed on macro-systems involving novel tools for label free bio-sensing using cantilever array technology (4–6). The current projects pursued are only possible, because of a fruitful collaboration across research disciplines is occurring. In addition, without the support from the people from both the electronic and mechanical workshops, the high quality of our current instruments and tools would not be available as it is now.

Current Research Highlights

Optical Tweezers: At the Institute of Physics, a new type of combined optical tweezers instrument has been setup in our group (2, 3, 7). The implementation of confocal optical spectroscopy with single photon sensitivity allows combining force measurement in the sub-piconewton regime with optical detection of nanometer distances between single fluorophores (e.g. fluorescence resonance energy transfer, FRET) on interacting biomolecules or detection of local motion on a biomolecule. In figure 1 part of the current setup is shown.

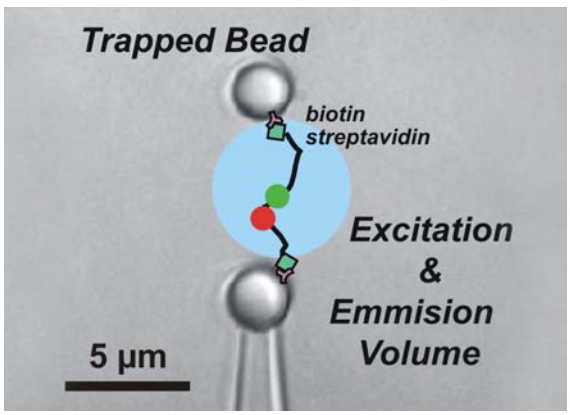


Figure 1: The biomolecule of interest is placed inbetween two polystyrene spheres (size ~2 µm diameter). The lower bead is held by a micropipette by suction and the top bead is held by laser tweezers that allow measuring sub-pN forces. On one end, the molecule is covalenty attached and on the other end, the molecule is bound via a strong biomolecular bond. Optical spectroscopy is performed by illuminating part of the field of view by an excitation laser (488 nm) and the optical response (fluorescence) is read out by EM-CCD or APDs.

By fluorescently labeling molecules (e.g. dsDNA with SYBR® green, or single fluorophores at specific sites) the mechanical response can be evaluated with pN precision and in parallel visual inspection can take place by single molecule fluorescence imaging (see figure 2). Our current measurements suggest that dsDNA undergoes a structural transition since the fluorescence response does not change during the transition at pulling forces between 65 and 75 pN.

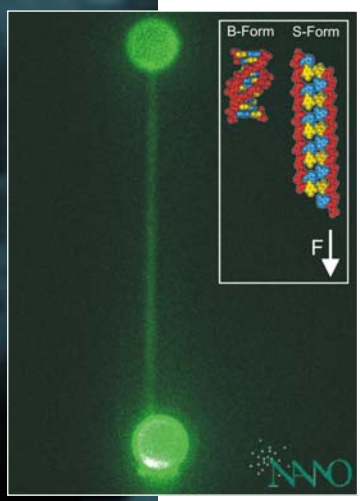


Figure 2: A single dsDNA molecule subjected to an external force of ~80 pN. The dsDNA molecule is clamped in between two polystyrene spheres and pulled by a piezo electric element. One question remaining is: Does the dsDNA dehybridize (dsDNA to two ssDNA) during the overstretch transition or does it undergo a structural transition into S-form (as shown in the inset: data from molecular modeling Lebrun A et al. NAR (1996)).

Additional projects are focused on the genetic transfer from bacteria to plant cells and at influences on DNA structure/mechanics of substances used for gene transfer in eukaryotes. Here, we study binding kinetics or mechanical changes induced by binding the molecules of interest to DNA molecules and then correlate our physical measurement to structure and function of the molecules involved in the process (collaborations with the Engel *www.mih.unibas.ch* and Giese group *www.chemie.unibas.ch/~giese/index.html*).

Dynamic force spectroscopy:
To get insights into the single molecule mechanics of the most prominent component of the M-band, the modular protein myomesin was expressed in vitro in the group of J.C. Perriard (ETHZ, *www.cell.biol.ethz.ch*) and was investigated on molecular scale using various methods (Circular Dichroism, Transmission Electron Microscopy and SPM). Imaging of single molecules was performed at the Maurice Müller Institute of the Biocenter (Group of U. Aebi) and mechanical manipulation was done at the Institute of Physics by dynamic force spectroscopy in our group (1, 8, 9). Figure 3 shows the sequential unfolding of protein monomers and the corresponding force vs. distance experimental data.

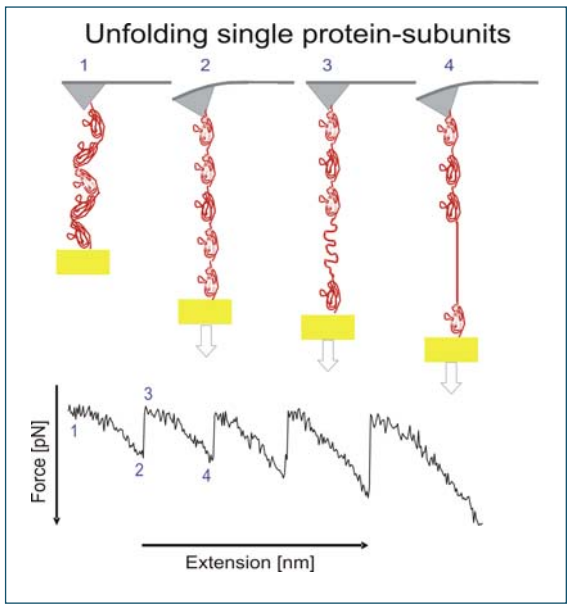


Figure 3: Dynamic force spectroscopy on myomesin muscle protein. The protein is cloned as a multimer and expressed in *E.coli.* The individual protein subunits are grafted onto an interface (gold or glass) and subjected to an external force. Individual sub-units unfold one by one by pulling with a atomic force cantilever in a physiological environment. Upper graph: Unfolding single subunits by pulling. Lower graph: Force versus distance plot. In collaboration with ETHZ (Group Perriard).

Our studies revealed that sarcomeric M-band component myomesin is an adaptable molecular spring. The Ig and Fn-like domains of myomesin demonstrate the high mechanical stability, comparable with the one of Ig-like domains of titin. The EH-myomesin isoform, expressed in some muscle types contains additional EH-fragment, shows no folding in EM and acts as an entropic spring similar to

Measurements on Microscopic and Macroscopic Systems in Biology

Macroscopic experiments yield time and population averages of the individual characteristics of each molecule. At the level of individual molecules, the picture is quite different: individual molecules are found in states far from population average, and their velocity dynamics are seemingly random. Whenever unusual states or rapid, random motions of a molecule are important, the macroscopic picture fails, and a microscopic description becomes necessary. Single-molecule experiments differ from macroscopic measurements in two fundamental ways: First, the fluctuations in both the system and in the measuring instrument are important, and second, in the relative importance of force and displacement as variables under experimental control and subject to direct experimental measurements. In single-molecule experiments using atomic force microscopy or optical tweezers the crucial parts of the measurement instruments themselves are small and subject to the same fluctuations as the system under study. Sensing at this experimental level thus, gives access to some of the microscopic dynamics that are hidden in macroscopic experiments.

*Label-free investigations on macro-systems require measurement tools which allow parallel assessment of various parameters. An important fact to be considered is the possibility to use an **in situ** reference probe which allows compensation for parasitic or convoluting effects, which influence the measurements on a small scale (e.g. temperature, chemical environment affecting the surface chemistry of the sensor, etc.). Cantilever array sensors are successfully applied in the field of genomics, gas-sensing, and proteomics and microorganism susceptibility testing. The elegance of these sensing methods is that the detection of an analyte does not require any labeling, as well as the various application fields only differ in the functional layers on the cantilever interface. The detection scheme remains common for all the different applications. Molecular recognition processes or mechanical changes taking place at a sensor interface are transduced into mechanical motion or induce shifts in physical parameters (e.g. resonance frequency), which are easily detected with nanometer – or in case of resonance-frequency shifts in Hz precision (in liquid).*

the PEVK domain of titin in our pulling experiments. Providing extra elasticity for the M-bands might be necessary during embryonic heart development, but could also be adaptation to pathogenic circumstances in adults. Again, an interdisciplinary collaborative effort was the key point to the completion of the project.

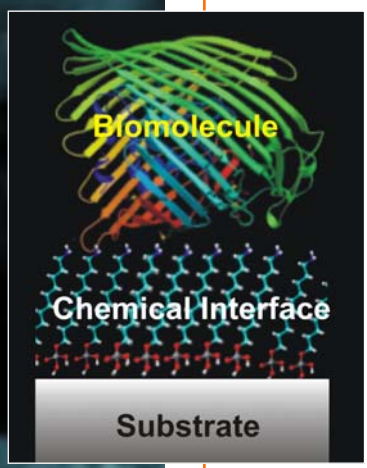
Multifunctional cantilever arrays:
In our group we currently use multifunctional cantilever array technology to measure with eight sensors in parallel (see *http://monet.physik.unibas.ch/~hegner/functionalNOSE.html* or *www.zurich.ibm.com/st/nanoscience/cantilever.html*). The experiments we performed are all label-free and provide high-sensitivity results on molecules which are involved in cellular processes

Nanomechanical Sensors and Tools

In our experiments the design of individual sensor interfaces is common in all three approaches: scanning probe microscopy/spectroscopy, optical tweezers and cantilever array sensors. All techniques require the following issues to be fulfilled:

- *Immobilization of the molecule under investigation in a native manner on a sensor interface using various chemical approaches (see figure)*
- *Determination of forces of a few pico-Newton (pN) and position deflection readout with nanometer accuracy*
- *Ability to detect conformational changes with nanometer accuracy*

We explore and develop new schemes of direct chemical modification of single molecules or native immobilization of the biomolecule of interest via chemical cross-linkers onto the substrate a. Most of our experiments require covalent attachment of biomolecules on the interface or chemical modification of the molecules of interest. The main reason for this is that in some experiments we actively pull on a single molecule. Release of the biomolecule off the interface is not within the scope of the experiments. In other cases we regenerate receptor molecules bound to the interface by rinsing the interfaces with chemicals which release all bound ligand molecules interacting with their receptor sites. If physisorption were the 'attachment' mechanism for the receptor molecules, then some of the receptor molecules on the sensors surface would be stripped off during such processes and the functionality of the sensors would be hampered. Ref: [a] M. Hegner, Single Mol. 1, 139 (2000)



Biomolecules are grafted in a native manner onto the underlying substrate by specific chemistry (e.g. self assembled monolayers) or direct chemical modification of a molecular site.

(5, 10–12). In genomic analysis we can now detect within a complete RNA sample whether a gene is present or not. Single nucleotide polymorphism (SNP) detection has been demonstrated earlier (10) and we can now also measure whether a gene has been turned on (i.e. production of increased amounts of specific mRNA) upon extracellular interactions of small molecules with cell membrane receptors. Such measurements characterize a cellular system, which is first in a 'normal' state, and thereafter in a transiently perturbed state. Triggering of the gene is only enabled during the time the small molecule is present in the supernatant of the investigated cells. The induced RNA signal corresponds to a differential nanometer deflection signal with respect to a reference cantilever placed *in situ*. We could show that the measured surface stress upon hybridization of specifically bound nucleic acids correlates in a linear manner with the concentration of the molecules present in the environment to be probed (11). The sensitivity of our sensors currently equals that of current gene chip technology, but our key advantage is that there is no need for amplification of the material nor for optical labeling of the molecules involved. These studies have been conducted in collaboration with U. Certa of the Roche Medical Center of Genomics at Basel. Figure 4 shows a scheme of the multifunctional cantilever arrays. We also measure tran-

scription activation nanomechanically by binding transcription factors to DNA targets at the interface of our cantilever sensors. In the field of proteomics (12) our sensors were considerably improved during the last year by using special receptor fragments such as single chain variable antibody fragments or ankyrins (13) in collaboration with group A. Plückthun at the University of Zürich *(www.biochem.unizh.ch/plueckthun/).*

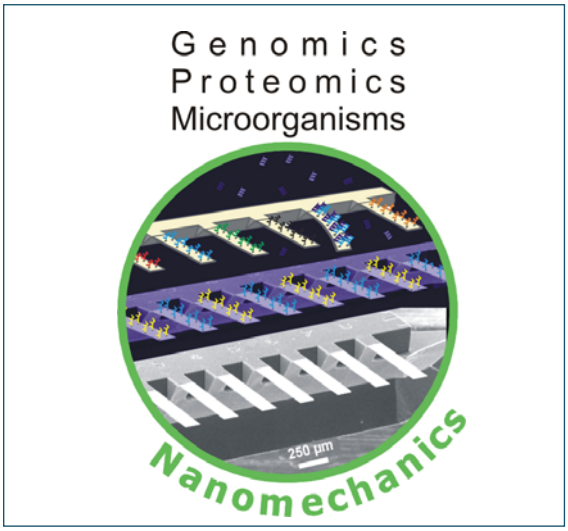


Figure 4: Multifunctional cantilever allow differential label free detection of transcribed RNA fragments within total RNA. The binding detection of transcription factors to dsDNA, soluble protein binding to antigen activated interfaces and tracking conformational changes in membrane proteins. Such sensors – operated in dynamic mode – are able to follow microorganism growth in real time and to investigate antibiotic susceptibility within a couple of hours.

The sensitivity of our new sensors is enhanced by a factor of 100 as compared to previously published results [13] and lies now in a regime comparable to current surface plasmon resonance technology. By using ankyrin receptor molecules we shall be able to screen libraries of precursors and optimize our receptors for soluble proteins. Analysis on the cellular level will also involve interactions on the cell membrane. Our membrane protein sensitized cantilevers are able to convert interactions on the cell membrane into nanomechanically measurable signals. The beauty of nano-mechanical sensors is that these sensors are transducing conformational changes in the membrane protein upon ligand binding into a mechanical deflection. Furthermore, the binding of the ligand (e.g. mass change) can be tracked by measuring the shift in resonance frequency *in situ.* These features are not available in parallel using competing techniques. The only parameter that changes when investigating genomics or proteomics applications is the receptors placed on our sensor interfaces (e.g. DNA sequences, protein epitops).

A rapid-response biosensor for the detection of microorganism growth was developed using micromechanical oscillators coated by common nutritive layers ("shrinkage of a centimeter-sized Petri dish down to micron-sized cantilevers"). The change in resonance frequency as a function of increasing mass on a cantilever array represents the basis of the detection scheme. The sensor is able to detect active growth of *E. coli* cells within 1 hour (14) or the growth of microfungi in ~ 4 hours (15), which is considerably faster than in conventional assay where such tests take ~ 8–12 hours *(E. coli)* or up to weeks (microfungi). Furthermore, this method allows detection of selective growth of *E. coli* within only two hours by adding antibiotics to the nutritive layers (16). This new sensing method for the detection of selective bacterial growth allows future applications in e.g. rapid antibiotic susceptibility testing.

As obvious from the above mentioned examples pursued in our group, the cantilever array technology could provide a new approach for a new handheld label-free nano-mechanical cantilever-diagnostics devices for rapid parallel diagnosis of multiple pathogens causing diseases (e.g. measurement of gene activation, binding of antigens to selected multiple target-specific synthetic ankyrin repeat proteins as sensors and

selective susceptibility detection of microorganisms). Such a novel device could provide a tool for the comprehensive and fast disease management at the point of care. Just from the diversity of the projects pursued in our group it is obvious that without an interdisciplinary approach such tasks could never be tackled.

The long-term scope of our future projects will focus on merging single molecule sensitivity (achieved in the first two types of experiments conducted in our group) with parallel measurements and multifunctional cantilever array technology by downscaling of measurement sensors and periphery and other adaptations. Additional information upon our activities can be found in ref (17).

Acknowledgment

First of all, we would like to thank our colleagues from Basel and Rüschlikon for the great collaborative effort and for their valuable contributions to make progress in the field of "BIO-NANO-MECHANICS" (actual members: N. Backmann, T. Braun, A. Bredekamp, M. Ghatkesar, W. Grange, F. Huber, S. Husale, P. Shagaldian; former members: V. Aranyos, V. Barvich, P. Bertoncini, A. Bietsch, K. Gfeller, N. Nugaeva, E. Rebourt, J. Zhang). We are grateful to Hans-Joachim Güntherodt, Ernst Meyer, and Wilfried Grange. We also thank in particular our hard working technicians and the Micro/Nanomechanics Group@IBM Res. Lab Zürich, for their excellent contribution in cantilever array microfabrication (U. Drechsler, M. Despont).

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(see *www.nccr-nano.org*),
CTI (Technology Oriented Program TOP NANO21), EUCOR Learning and Teaching and Mobility (ELTEM) Nanotechnology project
(see *www.eucor-nanoscience.org)* and the IBM Research Laboratory Zürich.

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Martin Hegner

receives Science Award

At the end of 2004, the City Council of Basel has awarded PD Dr Martin Hegner of the University of Basel with the Science Award. Martin Hegner received the prize for his research in the field of nanobiology. As a member of the NCCR Nanoscale Science and other national and international co-operations Hegner developed new nanomechanic biosensors that help to better understand basic processes of molecular recognition of single molecules. More at: *www.nccr-nano.org/nccr/nccr_network/awards/hegner_stadt_basel* and in the Cover Story of this issue of nanonews.

Wolfgang Belzig

receives Walter-Schottky Prize

PD Dr Wolfgang Belzig received the Walter-Schottky Prize 2005, the most prestigious prize for solid-state physics awarded by the German Physical Society. Wolfgang Belzig got the prize for his theoretical work on quantum transport in nanostructures. The prize consists of 15,000 Euro and a certificate. It is named in memory of Walter Schottky, a theoretical physicist and pioneer of solid-state physics and electronics. More at: *www.nccr-nano.org/nccr/nccr_network/awards/walter_schottky_prize_belzig/*.

Christoph Gerber

receives Economist No Boundaries Innovation Award

Professor Dr Christoph Gerber, now Director of Scientific Communication of the NCCR Nanoscale Science, together with Professor Dr Gerd Binnig and Dr Heinrich Rohrer, has been awarded the Economist "No Boundaries" Innovation Award 2004 in San Francisco. The prize was given to them in recognition of the invention and development of the scanning tunneling microscope (STM), which marked the birth of nanoscience and nanotechnology. The Economist Annual Innovation Summit & Awards honors the individuals and best practices that drive the most successful innovations that transform global economy. Among the award recipients 2004 are Linus Torvalds, creator of the Linux computer operating system, David Goeddel, pioneer in the field of gene cloning and expression of human proteins, and Vic Hayes for the development of wireless LANs. More at: *www.nccr-nano.org/nccr/nccr-_network/awards*

Additionally, Christoph Gerber was elected Fellow of the Institute of Physics, UK in November 2004 by the Council.

András Kis

received the prize Latis Internationale 2004

In November 2004 Dr András Kis received the Prize Latsis Internationale for his achievement in nanomechanics of mesoscopic objects like carbon nanotubes, disulfide nanowires and protein polymers. This work had been done when András Kis was postdoctoral fellow at the Laboratory of Nanotubes (LNNME-IPMC) with Professor Forró (EPFL).

CTI-Start-up Label for NCCR start-ups

Concentris and Nanonis, two start-up companies of the NCCR Nanoscale Science, were awarded the CTI Start-up Label in September 2004. The CTI Start-up Label qualifies start-up companies as being ready for sustainable growth. It gives credibility, provides integration into networks, and helps to access venture capital. More at:
www.ctistartup.ch/index.html?-&page_id=21&node=4&level=0&l=1

Ribbon Award

During the MRS Fall 2004 Symposium "Scanning Probe and Other Novel Microscopies of Local Phenomena in Nanostructured Materials" Dr Terunobu Akiyama, Kaspar Suter, Professor Dr Urs Staufer, and Professor Dr Nico de Rooij have won the Ribbon Award for their Poster "Novel Dynamic Scanning Microscope Probe and its Application to Local Electrical Measurement in an Ion Sensitive Field Effect Transistor". Full text at:
www.nccr-nano.org/nccr/research/publications

Congratulations to the award winners!

We introduce . . .

Issue by issue we introduce members of the NCCR Nanoscale Science. This time we interviewed a young women who is still at school but would like to become a NCCR member in the future. Natascha Kappeler, is in her last year at high school and chose nanotechnology as topic of her high school research paper (Maturandenarbeit). She produced a remarkable report, organized an exhibition, gave a talk, and excellently demonstrated the fascination of nanoscale science.

Natascha Kappeler

Natascha, why did you choose nanotechnology as topic for your work?
For me the fascination of the nanocosmos began on October 29th, 2002 during an information event at the Kantonsschule Alpenquai Luzern. The event was announced in a brochure and focused on the new NanoCurriculum in Basel, previously unknown to me. After the talk of Professor Dr Andreas Engel I was fascinated about this world of „dwarfs“ and in August 2003 I began my research work with the topic “Nanotechnology – door to the 21st century”.

What exactly was the goal of the work?
One of the goals was to find out and to explain what we understand by nanotechnology. Additionally, I wanted to learn more about the future of nanotechnology and I planned to evaluate the chances and risks of these new technologies. Finally, I wanted to present my findings in an exhibition to the public.

Nanotechnology is a very broad topic. How did you start your research?
In the beginning, I read several books and searched the Internet. I sent out letters and emails to numerous companies and laboratories that deal with nano. Resulting from this I received information from all over Europe. Based on the immense amount of material I concentrated my research on biology and medicine.

How did the scientists that you contacted react?
Everybody I asked was very helpful and supported me with information and material.

Please summarize the outcome of your research in three sentences
All students and scientists I interviewed agreed that nanotechnology has a great future. For the current leading role of Switzerland it is essential that governmental and private financial support be guaranteed. Regarding risks, nanotechnology is like any other technology; as dangerous as the human being that uses it.

We introduce . . .

What did you personally learn from your work?
This research work has further confirmed my desire to study nanoscale science and the topic has more and more cast a spell over me. Additionally, I was able to get to know some personalities in the nano field.

How did your colleagues from school react? Were they as enthusiastic as you are?
Most of my colleagues were fully occupied with their own work. However, among the younger pupils and also among teachers there was considerable interest.

What are your plans for the future?
It is my greatest wish to start my studies nanoscale science in October 2005 in Basel after I have finalized my Matura.

Thanks a lot, Natascha for this interview and all the best for the future!

Interviews with NCCR PhD students at: *www.nccr-nano.org/nccr/nccr_network/introducing*

New in the NCCR

Daniel Klauser	Doctoral Student in Project Quantum Computing
Seyed Alireza Ghasemi	Doctoral Student in Project Quantum Computing
Michel Calame	Senior Scientist in Project Molecular Electronics
Meike Cordes	Doctoral Student in Project Functional Materials
Olivier Jacques	Postdoctoral Fellow in Project Functional Materials
Mario Kaiser	Doctoral Student in Project Nanoethics

A warm welcome to all new NCCR scientists. We wish you success in your studies and research and a good time in our NCCR.

Press releases

An important communication tool

As a National Center of Competence in Research we have to fulfill a role as interface between science and the society. Therefore, we should continuously communicate our scientific findings to the public. Important tools to achieve this are press releases. Among others we have issued a press release on a scientific publication:

New principle for data storage and molecular switches

Scientists within the NCCR Nanoscale Science have explored a new process to produce complex two-dimensional structures from single molecules. Those could be the basis for data storage elements with incomparable storage density and for molecular switches. A paper on this research was recently published in the science journal "Angewandte Chemie". The researchers show in their work how molecules self-organize at room temperature to chains and pairs on a surface. The molecules organize so complex and precise to physically and chemically identical building blocks made of several hundred atoms as not yet possible with technological production processes.

Full press release (in German) at:
www.nccr-nano.org/nccr/media/press_releases/press_release_paper_jung.pdf

Media Coverage (in German) at:
www.nccr-nano.org/nccr/media/in_the_media

Events

Nanotechnology – a topic in schools

Nanotechnology is an interesting topic also for young people. That became obvious in a high school diploma research paper (Maturandenarbeit) on nanotechnology produced by Natascha Kappeler. Natascha began her studies on nanotechnology in August 2003. She interviewed scientists and students, participated in several conferences, read and planned. With the results, in October 2004, she opened a public exhibition under the title "Nanotechnology – the door to the 21st century". The exhibition took place in the auditorium of the Academic High School Obwalden and attracted about a hundred people. The NCCR Nanoscale Science supported her in the preparation process and provided microscopes for the exhibition. Natascha Kappeler was interviewed for this issue of nanonews (see above) and will start her studies in Nanoscale Science with the coming winter semester.

BioNano Workshop

In January 2005, 38 scientists from the NCCR Nanoscale Science and the UK met for a Bio Nano workshop in Lenzerheide, Switzerland. They exchanged their experience and thoughts on:

- structure and nanomechanics of biological molecules
- biological mechanical sensors
- chemical and biological cantilever sensors
- biosensors and bioelectronics
- growth, patterning and probing of biomolecules
- theory and modeling of tip-sample interactions

During the three-day meeting all participants enjoyed the open and stimulating atmosphere, the lively discussions on science, the perfect weather and some fast ski-runs.

Nanofair

With the participation of numerous NCCR members the second nanofair took place from 14th to 16th September, 2004, in St. Gallen, Switzerland. During the three-day trade show, more than 150 exhibitors showed product innovations and commercialized applications from the fields of nano and microtechnology and attracted more than 4500 visitors. There was also a huge response to the Nano Conference and the other new conferences and seminars. The 3rd Nanofair in 2005 will be held from the 13th to the 15th September.
More at: *www.nanofair.ch*

Biovalley Science Days

From 13th until 22nd October 2004, the third Biovalley Science Week took place in Lörrach, Freiburg, Strasbourg, Colmar, and Basel. One afternoon during the event was basically carried out by the NCCR Nanoscale Science (19th October). During six lectures NCCR members presented their research topics ranging from nanomechanics over nanotools for systems biology to nanomedicine, nanoparticles and nanocontainers and the impressive nano-network of the scientists in Basel. About 120 participants used this excellent opportunity to inform themselves about various aspects of nanoscale research in Basel. More about the Biovalley at: *www.biovalley.com*

Science and business in dialogue

Following the Biovalley Science Day on 19th October 2004, the Basel Chamber of Commerce organized their tenth meeting, "Science and Business in dialogue", this time focusing on nanoscale science. Professor Güntherodt (NCCR Nanoscale Science) introduced about 400 interested participants to the fascinating nano-world. Professor Aebi (NCCR Nanoscale Science) presented with the scanning-force microscope for diagnosis of cartilage diseases a concrete example of a nanoscale science application and Professor Certa (Roche Basel) explained the role of nano and micro-technologies in today's medicinal research. The relation between science and business became very obvious in the second half of the event when three young entrepreneurs presented their spin-off companies (Concentris GmbH, Nansurf AG and Zeptosens AG) that all have their roots in nanoscale science. During the cocktails following the event it became very obvious how important and stimulating events are where science meets public. More about the Basel Chamber of Commerce at: *www.hkbb.ch*

From a single lens to scanning probe microscopy – Science Days at Rust

During this year's Science Days in October 2004 at the Europa Park Rust (Germany), the NCCR Nanoscale Science presented the development of microscopy to the 15,000 visiting pupils. Since the first microscopic observations from van Leeuwenhoek in the 17th century until the discovery of the Scanning Tunneling Microscope in 1981 by IBM researchers, microscopy has led to novel technological breakthroughs.

During the exhibition the visitors could explore feathers and the spikes of stinging nettles under the light microscope and they could learn by interactive experiments how an atomic force microscope functions. Additionally, everybody got to know more about current research topics in nanoscale science. Thanks to a generous loan of Zeiss, the NCCR could also present antique microscopes of the last four centuries. An illustrated brochure helped to guide children through the exhibition. It supported teachers not only during the event, but will also be used in their lessons at school. More about the Science Days at: *www.science-days.de/sdays/*.
Further images of the NCCR stand at: *www.nano-world.org/Events/sciencedays2004*

Physics for Tomorrow

Members of the NCCR Nanoscale Science joined a group of students from the Gymnasium Liestal to the launch conference of the World Year of Physics in Paris in January 2005. The conference Physics for Tomorrow was the first in a large series of events during the International Year of Physics declared by the General Assembly of the UNO. Over 1000 participants joined the meeting under the aegis of the UNESCO including many Nobel Prize winners, other eminent scientific personalities, and around 500 young students from over 80 countries. The students from Liestal and the NCCR scientists highly appreciated this unique chance for exchange between world-leading scientists and students and are now enthusiastically starting into the World Year of Physics. More about the World Year of Physics at:
www.wyp2005.ch

Web corner

About us: Know-how and technology transfer page:
www.nccr-nano.org/nccr/about_us/transfer

Protected part of the Internet accessible only by NCCR members contains forms and guidelines, full papers and much more: accessible via "Login" on the top navigation bar

Short overview presentation on nanoscale science and the NCCR (in German):
www.nccr-nano.org/nccr/media/overview_presentation

Questions and Answers document on safety and risks in nanoscale science:
www.nccr-nano.org/nccr/research/safety_and_risks_in_nanoscale_science

Dates to remember

Internal

Review Panel Site Visit 2005
19th–20th April 2005 in Basel, CH

Nanoconference
31st July– 4th August 2006 in Basel, CH

Nanofair
13th–15th September 2005, St. Gallen, CH

External

"MEMS/Nanotechnology Platform" at SEMICON Europa 2005
11th–15th April 2005, New Munich Trade Fair Centre. More at:
http://wps2a.semi.org/wps/portal/_pagr/128/_pa.128/463.

Niels Bohr Summer Institute 2005, Transport in mesoscopic and single-molecule systems
15th–26th August 2005, Copenhagen, Denmark. More at:
www.nbi.ku.dk/side27927.htm

"Trends in Nanoscience: Structure and Functions"
October 8th–12th, 2005, Kloster Irsee, Germany, More at:
www.uni-ulm.de/sfb569/Irsee/index.htm.

More external events under: *www.nccr-nano.org/nccr/events/external_events/*

Recent Publications

Project 1 – Nanobiology and Nanomedicine

Development of insulated conductive probes with platinum silicide tips for atomic force microscopy in cell biology
Terunobu Akiyama, Maurizio R. Gullo, Nicolaas F. de Rooij, Andreas Tonin, Hans-Rudolf Hidber, Patrick L. T. M. Frederix, Andreas Engel and Urs Staufer
Japanese Journal of Applied Physics 43, 3865–3867 (2004)

Pacemaker channels in mouse thalamocortical neurones are regulated by distinct pathways of cAMP synthesis
Samuel G. A. Frère and Anita Lüthi
J Physiol 554.1 pp 111–125

Temperature dependence of the force sensitivity of silicon cantilevers
U. Gysin, S. Rast, P. Ruff, E. Meyer, D. W. Lee, P. Vettiger, and C. Gerber
Phys. Rev. B 69, 045403 (2004)

Ultra-small single-crystal silicon cantilevers for scanning force microscopes
Yang, J.L.; Despont, M.; Hoogenboom, B.W.; Drechsler, U.; Frederix, P.L.T.M.; Martin, S.; Hug, H.J.; Vettiger, P.; Engel, A.
Micro Electro Mechanical Systems, (2004). 17th IEEE International Conference. (MEMS)

Electron and atomic force microscopy of the trimeric ammonium transporter AmtB
Matthew J Conroy, Stuart J Jamieson, Daniel Blakey, Thomas Kaufmann, Andreas Engel, Dimitrios Fotiadis, Mike Merrick, Per A Bullough
EMBO reports 5, 12, 1153–1158 (2004)

A concept for G protein activation by G protein-coupled receptor dimers: the transducin/rhodopsin interface
Slawomir Filipek, Krystiana A. Krzysko, Dimitrios Fotiadis, Yan Liang, David A. Saperstein, Andreas Engel, Krzysztof Palczewski
Photochem. Photobiol. Sci., 3, 628–38, (2004)

Atomic force microscopy of biological samples
P.L.T.M. Frederix, B.W. Hoogenboom, D. Fotiadis, D.J. Müller, and A. Engel
MRS Bulletin, 29, 449-455, July (2004)

Cell targeting by a generic receptor-targeted polymer nanocontainer platform
Pavel Broz, Samantha M. Benito, CheeLoong Saw, Peter Burger, Harald Heider, Matthias Pfisterer, Stephan Marsch, Wolfgang Meier, Patrick Hunziker
Journal of Controlled Release 102 (2005) 475–488

Modeling and optimization of high-sensitivity, low-volume microfluidic-based surface immunoassays
Martin Zimmermann, Emmanuel Delamarche, Marc Wolf, Patrick Hunziker
Biomedical Microdevices 7:2 (2005)

Project 2 – Quantum Computing and Quantum Coherence

Solid-State quantum communication with Josephson arrays
Alessandro Romito, Rosario Fazio, C. Bruder
quant-ph/0408057

Spin transport in diffusive superconductors
Jan Petter Morten, Arne Brataas, Wolfgang Belzig
Phys. Rev. B 70, 212508 (2004)

Publications

DC-transport in superconducting point contacts: a full counting statistics view
J.C. Cuevas, W. Belzig
Phys. Rev. B 70, 214512 (2004)

Molecular spintronics: Coherent spin transfer in coupled quantum dots
Florian Meier, Veronica Cerletti, Oliver Gywat, Daniel Loss, D. D. Awschalom
Phys. Rev. B 69, 195315 (2004)

Phonon-induced decay of the electron spin in quantum dots
Vitaly N. Golovach, Alexander Khaetskii, Daniel Loss
Phys. Rev. Lett. 93, 016601 (2004)

Measurement efficiency and n-shot readout of spin qubits
Hans-Andreas Engel, Vitaly Golovach, Daniel Loss, L.M.K. Vandersypen, J.M. Elzerman, R. Hanson, L.P. Kouwenhoven
Phys. Rev. Lett. 93, 106804 (2004)

Asymmetric quantum shot noise in quantum dots
Hans-Andreas Engel, Daniel Loss
Phys. Rev. Lett. 93, 136602 (2004)

Controlling spin qubits in quantum dots
Hans-Andreas Engel, L. P. Kouwenhoven, Daniel Loss, C. M. Marcus
Quantum Information Processing, Vol 3, Numbers 1-5, 115–132 (2004)

Electron spins in dots and rings: coherence, read out, and transport
Hans-Andreas Engel
ISBN 3-8322-2770-9, (2004)

Coulomb scattering in a 2D interacting electron gas and production of EPR pairs
D. S. Saraga, B. L. Altshuler, Daniel Loss, and R. M. Westervelt
Phys. Rev. Lett. 92, 246803 (2004)

Influence of dephasing on shot noise in an electronic Mach-Zehnder interferometer
Florian Marquardt and C. Bruder
Phys. Rev. Lett. 92, 056805 (2004)

Kondo effect in a many-electron quantum ring
A. Fuhrer, T. Ihn, K. Ensslin, W. Wegscheider, and M. Bichler
Phys. Rev. Lett. 93, 176803 (2004)

Positive cross-correlations due to dynamical channel blockade in a three-terminal quantum dot
A. Cottet, W. Belzig, C. Bruder
Phys. Rev. B 70, 115315 (2004)

Relaxation and dephasing in a many-fermion generalization of the Caldeira-Leggett Model
Florian Marquardt and D. S. Golubev
Phys. Rev. Lett. 93, 130404 (2004)

Project 3 – Atomic and Molecular Nanosystems

Sublattice identification in scanning force microscopy on alkali halide surfaces
R. Hoffmann, L. N. Kantorovich, A. Baratoff H. J. Hug and H.-J. Güntherodt
Phys. Rev. Lett. 92, 146103 (2004)

Friction and wear on the atomic scale
E. Gnecco, R. Bennewitz, O. Pfeiffer, A. Socoliuc, and E. Meyer
Springer Handbook of Nanotechnology, 631, ISBN: 3-540-01218-4

Temperature dependence of the force sensitivity of silicon cantilevers
U. Gysin, S. Rast, P. Ruff, E. Meyer, D. W. Lee, P. Vettiger, and C. Gerber
Phys. Rev. B 69, 045403 (2004)

Publications

Frictionless sliding on the atomic scale
E. Gnecco, A. Socoliuc, E. Meyer
Imaging & Microscopy, Ausgabe 2, (2004), pg. 44

Nanodispenser for attoliter volume deposition using atomic force microscopy probes modified by focused-ion-beam milling
A. Meister, M. Liley, J. Brugger, R. Pugin, and H. Heinzelmann
Applied Physics Letters, December 20, 2004, Volume 85, Issue 25, pp. 6260–6262

Project 4 – Molecular Electronics

Observation of Fano resonances in single-wall carbon nanotubes
Bakir Babic, Christian Schönenberger
Phys. Rev. B 70, 195408 (2004)

Kondo effect in carbon nanotubes at half filling
B. Babic, T. Kontos, C. Schoenenberger
Phys. Rev. B 70, 235419 (2004)

Conductance properties of nanotubes coupled to superconducting leads: signatures of Andreev states dynamics
E. Vecino, M. R. Buitelaar, 1, A. Martín-Rodero, C. Schönenberger and A. Levy Yeyati
Solid State Communications Vol 131, Issues 9-10, 625-630 (2004)

Conductance of atomic contacts in liquid environment
L. Grüter, M.T. González, R. Huber, M. Calame, C. Schönenberger
cond-mat/0410666

Suitability of carbon nanotubes grown by chemical vapor deposition for electrical devices
B. Babic, J. Furer, M. Iqbal, C. Schönenberger
AIP Conf. Proc. 723, 574 (2004), cond-mat/0406638

Shot-noise and conductance measurements of transparent superconductor/two-dimensional electron gas junctions
B.-R. Choi, A. E. Hansen, T. Kontos, C. Hoffmann, S. Oberholzer, W. Belzig, C. Schoenenberger, T. Akazaki, H. Takayanagi
cond-mat/0410621, submitted to Phys. Rev. B

Project 5 – Functional Materials by Hierachical Self Assembly

Supramolecular patterned surfaces driven by cooperative assembly of C60 and porphyrins on metal substrates
Davide Bonifazi, Hannes Spillmann, Andreas Kiebele, Michael de Wild, Paul Seiler, Fuyong Cheng, Hans-Joachim Güntherodt,Thomas Jung, and François Diederich
Angewandte Chemie Int. Ed. (2004), Volume 116, Issue 36, Pages 4863–4867

Self-assembly of reactive amphiphilic block copolymers as mimetics for biological membranes
Andreas Taubert, Alessandro Napoli and Wolfgang Meier
Current Opinion in Chemical Biology, Volume 8, Issue 6, December 2004, Pages 598–603

Water-in-water mesophases for templating inorganics
Andreas Taubert , Ernst Furrer and Wolfgang Meier
Chem. Commun., (2004), (19), 2170–2171

Publications

Asymmetric ABC-triblock copolymer membranes induce a directed insertion of membrane proteins
Roxana Stoenescu, Alexandra Graff, Wolfgang Meier
Macromolecular Bioscience (2004), Volume 4, Issue 10, Pages 930–935

Polymer nanocontainers for drug delivery
M. Sauer, A. Graff, and W. Meier
Carrier-Based Drug Delivery, pp 224–237, Oxford University Press,

Colloidal nanoreactors and nanocontainers
Marc Sauer and Wolfgang Meier
Colloids and Colloid Assemblies, Wiley-VCH, ISBN 3-527-30660-9

Reinforcement of single-walled carbon nanotube bundles by intertube bridging
A. Kis, G. Csányi, J.-P. Salvetat, Thien-Nga Lee, E. Couteau, A. J. Kulik, W. Benoit, J. Brugger and L. Forró
Nature Materials 3, 153–157 (2004)

Behaviour of transition metals catalysts over laser-treated vanadium support surfaces in the decomposition of acetylene
Jin Won Seo , Klara Hernadi , Csilla Mikó and László Forró
Applied Catalysis A, Vol. 260, Issue 1, 87–91

Synthesis and magnetic characterization of Cu(OH)[sub 2] nanoribbons
P. Umek, J. W. Seo, L. Fórró, P. Cevc, Z. Jaglicic, M. Skarabot, A. Zorko, and D. Arcon
AIP Conference Proceedings, Volume 723, Issue 1, pp. 427–430

Effect of irradiation on aligned carbon nanotube fibers
Cs. Mikó, M. Milas, J. W. Seo, E. Couteau, N. Barisic, R. Gaál, and L. Forró
AIP Conference Proceedings, Volume 723, Issue 1, pp. 107–110

Mass production of multiwalled carbon nanotubes by chemical vapor deposition
A. Magrez, Cs. Mikó, J. W. Seo, R. Gaál, and L. Forró
AIP Conference Proceedings, Volume 723, Issue 1, pp. 61–64

Amphiphilic dendrimers with heteroleptic bis ([2,2′:6′,2″]terpyridine)-ruthenium(II) cores
Derk Joester, Volker Gramlich, François Diederich
Helvetica Chimica Acta, Volume 87, Issue 11, Pages 2896–2918

All NCCR publications are available at:
www.nccr-nano.org/nccr/research/publications

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