CeNS Winter School 2007

Nanosystems: From Quantum Devices to Biological Engines

February 12 - 16, Burg Mauterndorf (Austria)

Program Committee:

Thomas Franosch, Sebastian Geiger, Don Lamb, Stefan Ludwig, Joachim Rädler

Invited Talks

Darwin meets Nano

Robert H. Austin

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It was said by Monod that the theory of evolution is "the most important scientific theory ever formulated, because of its general implications…and tremendous philosophical, ideological and political implications". Yet, in the US only 40% of the general public agree that the theory of evolution is probably right, and of that fraction 50% believe it is guided by a superior intelligence. One of the reasons for this skepticism is in fact the rather poorly understood quantitative foundations of the experimental aspects of evolution and neodarwinism. I will discuss recent experiments in my own lab that seek to develop an experimental approach to understanding evolution dynamics of cells in a world that we make by a combination of microfabrication and nanofabrication.

The Lateral Structure of Biological Membranes: Lessons from Model Systems

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The idea that lipids are simply randomly organized building blocks of membranes that form diffusion barriers between cytoplasm and the outside world changes since the coexistence of stable lipid domains in lipid bilayers was discovered, approximately three decades ago[1]. Conversely, the consequences of the non-random lateral organization of lipid membranes have not been acknowledged, particularly from the biology field, until the recent years where the "raft" hypothesis was postulated [2]. In the last 30 years, there has been extensive research to elucidate coexistence of lipid domains in membranous systems (mainly liposomes but also cell membranes) using an array of experimental techniques (fluorescence spectroscopy, differential scanning calorimetry, infrared spectroscopy, EPR, NMR to mention few), including theoretical treatments using computer simulations. In general, the above indicated experimental techniques produce mean parameters on the basis of data collected from bulk solution of many liposomes (or cells) and lack information about lipid lateral organization at the level of *single* vesicles, a quality that can be provided by fluorescence microscopy techniques [3]. This last (visual) information shown in Fig. 1 is presented as a new tool to correlate the lateral structure of compositionally complex mixtures with already well characterized artificial lipid model mixtures [3]. Comparative studies among the lateral structure of artificial lipid mixtures, natural lipid mixtures (both with and without membrane proteins) and membranes containing full composition under controlled environmental conditions will be presented. In addition, a short overview of the different experimental strategies utilized in the aforementioned studies will be discussed.

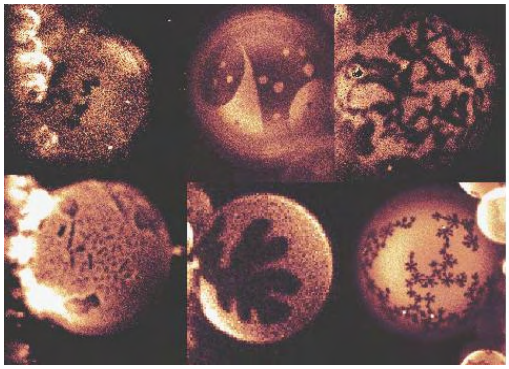

Fig. 1 *Giant liposomes displaying heterogeneity in the membrane lateral structure. The direct visualization is achieved using fluorescence microscopy related techniques.*

[1] C. Gebhardt, H. Gruler and E. Sackmann, Zeitschrift für Naturforschung, **32C**, 581 (1977).
[2] K. Simons and E. Ikonen, Nature **387**, 569 (1997).
[3] L. A. Bagatolli, Biochim. Biophys. Acta **1758**, 1541 (2006).

Single-Atom Nanoelectronics and Spintronics for Silicon-Based Qubits

Robert Clark

Director, Australian Research Council Centre of Excellence for Quantum Computer Technology, University of New South Wales, Sydney, Australia (www.qcaustralia.org)

The Australian Centre for Quantum Computer Technology has a focus on the demanding challenge of demonstrating silicon-based quantum computing at the few qubit level, in which the qubits are comprised of engineered phosphorus atoms embedded in a silicon host with quantum information encoded onto the electron charge or spin state of these atoms. This task involves the coordinated effort of research groups across six Australian universities, whose work will be described, and has required the development of single-atom-based fabrication strategies combined with aligned control gates and sensitive readout devices (electrometry).

Fully-configured qubit devices have been constructed in a top-down fabrication strategy, in which the phosphorus atoms are implanted individually at low energy into the high purity silicon substrate using nanoscale apertures and on-chip verification (atom counting), with qubit readout provided by radiofrequency single electron transistors. A high precision bottom-up approach, involving STM lithography and silicon MBE has been pursued in parallel.

Following a systematic development program from atom clusters down to single atoms, in which amongst other things we have demonstrated Si:P as a new (buried) double quantum dot system and quantum cellular automata, we have measured several 2-P-atom devices and a 4-P-atom device. RF-SET measurements of the 2-P-atom devices demonstrate an ability to controllably transfer a single electron between the two atoms in a P-P+ charge qubit configuration, and in pulsed gate voltage measurements of a device with exactly two P atoms prepared using apertures spaced by 50 nm, Fourier-transformed oscillatory structure in charge relaxation data between qubit levels is quantitatively consistent with acoustic-phonon-assisted tunneling with wavelength matched to a 52 nm donor separation.

Following the calibration of 0-40 GHz microwave spectroscopy on superconducting Cooper-pair-box charge qubit devices and single-Cooper-pair transistors (fabricated in-house) by observation of sideband structure (driven Rabi oscillation), we have carried out microwave spectroscopy on the 4-P-atom device. The frequency, power and magnetic field dependence of the data is striking, and the detailed energy level structure of this engineered multiple atom device can be extracted. Microwave spectroscopy measurements in progress on 2-P-atom devices with a close atom spacing are anticipated to provide charge qubit demonstration.

Finally, in the move from charge to spin qubits we describe the development of nano-Schottky 'reservoir' technology combined with single atom engineering for single spin readout and control, and a P-atom-rail 'bus' architecture (2D) for fast (nanosecond), coherent spin transport, namely Coherent Transport Adiabatic Passage (CTAP). A key target (6-P-atom) device (2 x CTAP3) will be described for the demonstration of the essential elements of a scaleable architecture for single-atom spin qubits in silicon. Here the qubit devices are combined with on-chip control electronics, for which we have designed and fabricated (at Peregrine Semiconductors) a RF-CMOS pulsed voltage source for mK operation.

This work has been funded by the Australian Research Council, the Australian Government and the US National Security Agency / US Army Research Office.

Biological Hydrodynamics

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The flow behavior of cells and vesicles is important in many applications in biology and medicine. For example, the flow properties of blood in micro-vessels is determined by the rheological properties of the red blood cells. Furthermore, microfluidic devices have been developed recently, which allow the manipulation of small amounts of suspensions of particles or cells.

While the membrane of vesicles just consists of a fluid lipid bilayer, red blood cells have a composite membrane which has in addition an anchored polymer network. This implies that the elastic properties of vesicles and red blood cells are very different.
Due to the large length- and time-scale gap between the atomic and the mesoscopic domain in soft matter systems, several mesoscale simulation techniques have been developed in recent years to study their hydrodynamic behavior. We have investigated one of these techniques, multi-particle-collision dynamics [1], in some detail. In particular, it has been shown that the method properly describes hydrodynamic interactions at low Reynolds numbers, if the parameters are in an appropriate range [2]. This method has then be applied to study the dynamical behavior of fluid vesicles and model red blood cells both in shear and capillary flows [3-6]. Several types of dynamical behaviors as well as shape transformations occur as a function of shear rate (or flow velocity), membrane viscosity and internal viscosity, which will be discussed in some detail.

[1] A. Malevanets and R. Kapral, J. Chem. Phys. **110**, 8605 (1999).
[2] M. Ripoll, K. Mussawisade, R.G. Winkler and G. Gompper, Europhys. Lett. **68**, 106 (2004).
[3] H. Noguchi and G. Gompper, Phys. Rev. Lett. **93**, 258102 (2004).
[4] H. Noguchi and G. Gompper, Phys. Rev. E **72**, 011901 (2005).
[5] H. Noguchi and G. Gompper, Proc. Natl. Acad. Sci. USA **102**, 14159 (2005).
[6] H. Noguchi and G. Gompper, preprint (2007).

Ex(e/o)rcising Demons: Quantum Brownian Motors

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Noise is usually thought of as the enemy of order rather than of a constructive influence. For the phenomena of Brownian motors [1-3], however, noise can play a beneficial role in enhancing and facilitating directed transport in absence of biasing forces. We identify variety of intriguing beneficial applications in physical, technological, and biomedical contexts.
In their modus operandi such quantum Brownian motors use the energy from the haphazard source of thermal quantum noise in order to perform work against external loads.
The basic principles that underpin directed quantum transport in quantum optical and solid-state based devices are elucidated for various nonlinear quantum systems. The very presence of non-equilibrium disturbances enables a Quantum Brownian motor to overcome the limiting laws imposed by thermal equilibrium, thereby rectifying quantum Brownian motion for shuttling efficiently quantum objects along *a priori* designed routes.

[1] R. D. Astumian and P. Hänggi, *Brownian motors*, Physics Today **55** (11), 33 (2002).
[2] H. Linke, editor, Special Issue on Brownian Motors, Applied Physics A **75**, No. 2 (2002).
[3] P. Hänggi, F. Marchesoni, F. Nori, *Brownian motors*, Ann. Physik (Berlin) **14**, 51 (2005).

Single-Molecule Fluorescence Studies of Gene Transcription

Achillefs Kapanidis[1], Konstantinos Lymperopoulos[1], Mike Heilemann[1], Emmanuel Margeat[2], Sam Ho[2], Ekaterine Kortkhonjia[3], Richard Ebright[3] and Shimon Weiss[2]

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[2] *Dept of Chemistry and Biochemistry and Dept of Physiology, UCLA, Los Angeles, California, USA*
[3] *HHMI, Dept of Chemistry and Waksman Institute, Rutgers University, Piscataway, New Jersey, USA*

The living cell is a microcosm comprising nanomachines that assemble, transport or process biomolecules. We are interested in machines and mechanisms in gene expression (the path that leads from genes on DNA to functioning proteins). A process central to gene expression is gene transcription by RNA polymerase; for example, much of the gene regulation occurs before and during transcription initiation, i.e., before RNAP breaks its initial contacts with promoter DNA (regions in the DNA that define the start of a gene).

Using single-molecule fluorescence resonance energy transfer (FRET) combined with alternating-laser excitation (ALEX) [1], we studied the mechanism of initial transcription, also known as abortive initiation (since it involves iterative synthesis and release of short RNA, 2-9 nucleotides in length). Specifically, we studied abortive initiation by monitoring the stoichiometry and conformation of transcription complexes in solution. We established that most complexes were active in abortive initiation and promoter escape [2]. Under the same conditions, we observed DNA compaction (as ''DNA scrunching'') during abortive-RNA synthesis. This compaction involved relative movement of downstream DNA towards RNAP, and no movement of upstream DNA relative to RNAP. Our results support a pure DNA-scrunching mechanism for abortive initiation, where downstream DNA is "reeled" in and out of the main RNAP channel during each cycle of abortive-RNA synthesis (see Fig. 1). Our results have important implications for the mechanism of promoter escape [3].

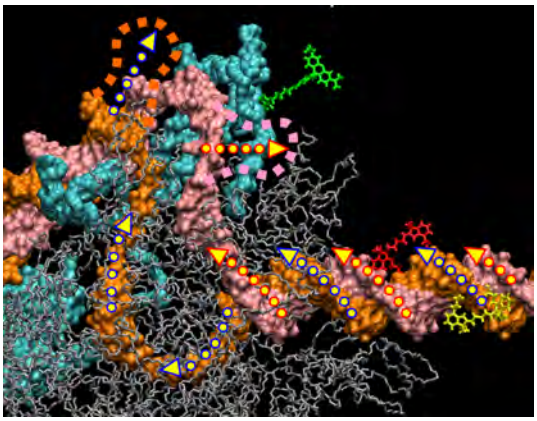

Fig. 1 *Initial transcription proceeds through "DNA-scrunching". Proposed movements of template and nontemplate DNA are indicated by arrows. Proposed positions for scrunched DNA are indicated by dashed lines. Positions of fluorophores used to analyze scrunching are in green (donor on polymerase), yellow (acceptor in absence of scrunching), and red (acceptor in presence of scrunching).*

We will also present recent progress in developing novel single-molecule fluorescence assays for the detection of proteins at low concentrations, which may be useful for detecting low-copy-number proteins in cells.

[1] Kapanidis AN, Laurence T, Lee NK, Margeat E, Kong X, Weiss S., Acc Chem Res. **38**, 523 (2005).
[2] Kapanidis AN, Margeat E, Laurence T, Doose S, Ho SO, Mukhopadhyay J, Kortkhonjia E, Ebright RH, Weiss S., Mol Cell **20**, 347 (2005).
[3] Kapanidis AN, Margeat E, Ho SO, Kortkhonjia E, Weiss S, Ebright RH, Science **314**, 1144 (2006).

Structure of Fungal Fatty Acid Synthase: A 2.6 MDa Molecular Assembly Line

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Fungal $\alpha_6\beta_6$ heterododecameric fatty acid synthase (FAS) harbors all catalytic domains required for *de novo* fatty acid synthesis. Recently, a 5Å resolution x-ray crystallographic electron density map of *Thermomyces lanuginosus* fatty acid synthase allowed fitting of homologous enzymes that catalyze the individual reaction steps [1]. The catalytic domains are embedded into a matrix which defines the architecture of the huge assembly. The synthesis is compartmentalized in two large reaction chambers, each containing three sets of active sites and three flexible acyl carrier proteins that transfer substrates between the catalytic domains (Fig. 1). This architectural solution differs considerably from the mammalian multienzyme [2], which catalyzes the same conserved reaction pathway but evolved as a homodimer.

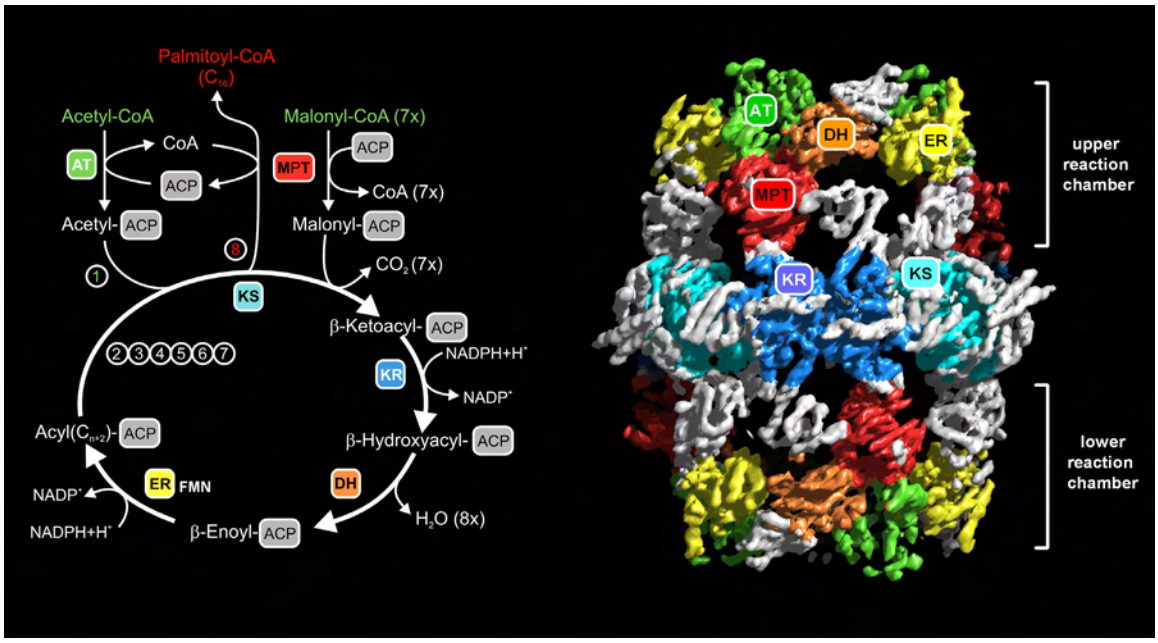

Fig. 1 *Enzymes involved in the cyclic biosynthesis of fatty acids and overview of the fungal fatty acid synthase particle. ACP, acyl carrier protein; AT, acetyltransferase; MPT, malonyl/palmitoyl transferase; KS, ketoacyl synthase; KR, ketoacyl reductase; DH, dehydratase; ER, enoyl reductase.*

Very recently, we were able to collect diffraction data to higher resolution which will allow us to build and refine an atomic model of the FAS particle. This new information can be used to analyze the catalytic centres of the enzymatic domains in detail, to understand the role of the additional structural elements and to gain further insights into the mechanism of substrate shuttling in the multifunctional molecular machine.

[1] S. Jenni, M. Leibundgut, T. Maier and N. Ban, Science **311**, 1263 (2006).
[2] T. Maier, S. Jenni and N. Ban, Science **311**, 1258 (2006).

Molecular Motors: Single Molecules, Cargo Transport, and Cooperative Behavior

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All directed movements of living organisms are based on molecular machines which perform mechanical work on the nanometer scale. Two different mechanisms for force generation have been identified: pulling forces generated by single motor proteins and pushing forces generated by the growth of single filaments. This article reviews recent work related to the pulling forces of molecular motors which give rise to a variety of active transport phenomena and structure formation processes.

Several aspects of the motor behavior will be discussed:

- Chemomechanical coupling and motor cycles of single molecules [1].
- Transport of cargo particles by several motors [2].
- Active diffusion of cargo particles in slab-like compartments [3].
- Molecular motor traffic in tube-like compartment [4,5].
- Immobilized motors interacting with gliding filaments [6].

For recent reviews covering these and additional processes, see [7] and [8].

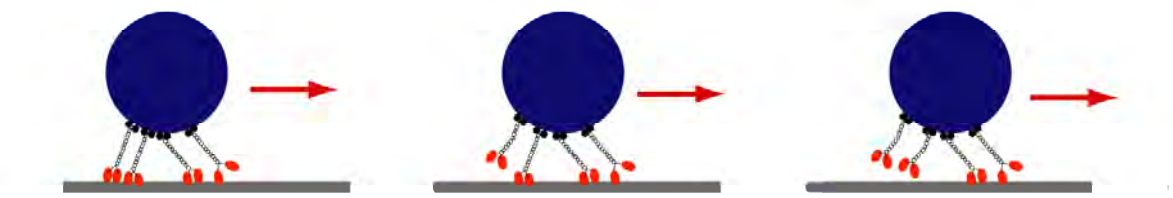

Fig. 1 *Three successive 'snapshots' for the cooperative transport of a cargo particle (blue) that is pulled by four molecular motors (red motor heads).*

[1] S. Liepelt and R. Lipowsky, Europhys. Lett (in press).
[2] S. Klumpp and R. Lipowsky, PNAS. **102**, 17284 (2005).
[3] S. Klumpp and R. Lipowsky, Phys. Rev. Lett. **95**, 268102 (2005).
[4] R. Lipowsky, S. Klumpp, and T. Nieuwenhuizen, Phys. Rev. Lett. **87**, 108101 (2001).
[5] M. J. I. Müller, S. Klumpp, and R. Lipowsky, J. Phys.: Cond. Mat. **17**, S3839 (2005).
[6] P. Kraikivski, R. Lipowsky, and J. Kierfeld, Phys. Rev. Lett. **96**, 258103 (2006).
[7] R. Lipowsky, Y. Chai, S. Klumpp, S. Liepelt, and M. Müller, Physica A **372,** 34 (2006).
[8] J. Kierfeld, P. Gutjahr, T. Kühne, P. Kraikivski, and R. Lipowsky, J. Comp. Theo. Nanosci. **3,** 898 (2006).

Multiple Scattering of Light: From Anderson Localization to the Brain

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Wave propagation in disordered media such as light propagation in clouds, snow, milk, paint or biological tissue can be roughly described by diffusive transport of the wave intensity. This description - which is well known from the Drude model for electronic transport - totally ignores the wave nature and hence fails to describe interference effects such as optical speckles which are fingerprints of the disorder.

One particular interference, that is the interference of waves traveling along reciprocal multiple scattering paths, is always constructive in the backscattering direction, even after averaging over many configurations of the disorder (i.e. speckles). It gives thus rise to enhanced backscattering and (weak) wave localization. P.W. Anderson predicted in 1958 a breakdown of the wave transport on macroscopic length scales which should occur when the scattering strength of the medium becomes very high, i.e. when the transport mean free path becomes smaller than the wavelength. In electronic transport this mechanism drives a metal-insulator transition. I discuss recent experiments which provide first clear evidence for the transition from weak to strong (Anderson-) localization of visible light [1] and allow a quantitative analysis of the localization transition [2]. There is also an optical analogue of universal conductance fluctuations in mesoscopic conductors [3].

Motions of scattering particles lead to temporal fluctuations of the speckle patterns which can be explored to detect very small particle displacements. This technique called Diffusing wave spectroscopy (DWS) has found many applications in soft matter and biophysics. A few examples will be discussed including near infrared DWS from human subjects which provide evidence that stimulus–evoked neural activity can be detected optically [4,5].

I acknowledge financial support by the Deutsche Forschungsgemeinschaft and the Center for Applied Optics at the University of Konstanz.

[1] Martin Störzer, Peter Gross, Christof Aegerter and Georg Maret, Observation of the critical regime near Anderson localization of light, Phys.Rev.Lett. **96**, 063904 (2006).
[2] C.M. Aegerter, M. Störzer and G. Maret, Experimental determination of critical exponents in Anderson localization of light, Europhys. Lett. **75**, 562 (2006).
[3] F. Scheffold and G. Maret, Universal Conductance Fluctuations of Light, Phys. Rev. Lett. **81**, 5800 (1998).
[4] J.Li, G.Dietsche, D.Iftime, S.E.Skipetrov, G.Maret, T.Elbert, B.Rockstroh and T.Gisler, Noninvasive detection of functional brain activity with near-infrared diffusing-wave spectroscopy, J. Biomed. Opt. **10**, 044002-1-12 (2005).
[5] J. Li, F. Jaillon, G. Dietsche, G. Maret and T. Gisler, Pulsation-resolved deep tissue dynamics measured with diffusing-wave spectroscopy, Opt. Express **14**, 7841-1-11 (2006).

Crystallography at the Frontiers

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During the past 50 years, X-ray crystallography has contributed importantly to the understanding of the molecular mechanisms of biological processes. Recent developments in the field of molecular biology, robotics, computation, and synchrotron radiation have not only enabled crystallographers to define atomic structures for an ever increasing number of soluble and membrane-bound proteins, but have also challenged them to elaborate ways to provide insights into the functional mechanisms of huge, multi-molecular machines with widely diverse functions, such as the ribosome (protein synthesis) or RNA polymerase II (mRNA synthesis) or photosystem I and II (light harvesting complexes). Excitedly, by using time-resolved approaches, we can now even watch single atoms moving during enzyme catalysis on a picosecond time scale.

Since all researchers working with biological material are confronted every now and then with the interpretation of results from X-ray diffraction experiments, this tutorial addresses those elements of the theory of crystallography which are essential to judge the significance and importance of such experimental results. In this respect, both the challenges and drawbacks of these experiments will be discussed. Several case studies will be presented and the biological as well as the technical aspects will be discussed. I will show how individual polypeptide chains or other organic compounds can be introduced into a given protein crystal by simple diffusion. This enables the production of a consecutive series of "pictures" of, for example, different enzymatic states that can later be concatenated to a "stroboscope movie" of a biological process. Furthermore, I will discuss recent exciting results obtained in studies of increasingly complex macromolecular machines and not only what, but also how biologically relevant information can be derived from these atomic models.

Single-Molecule Tracking of mRNA Exiting from RNA Polymerase II

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RNA Polymerase II (Pol II) is the sole enzyme responsible for producing all mRNA in eukaryotic cells. Understanding the molecular mechanism of Pol II transcription is therefore important for our understanding of gene expression and its regulation. Here, we use single molecule techniques to reveal details of the mechanism of this spectacular biological nano-machine.

The crystal structure of the elongation complex of the complete Pol II reveals incoming template and non-template DNA, a seven base pair DNA/RNA hybrid, and three nucleotides each of separating DNA and RNA [1]. Albeit, longer oligomers were used in preparation, the exit pathway of the nascent RNA could not be observed, presumably due to the inherent flexibility.

To determine the position of the nascent RNA, we have measured the distances between several known points on the Pol II elongation complex and the RNA using single pair fluorescence resonance energy transfer (sp-FRET). For a given position on the RNA we have measured three distances to known positions within the elongation complex, in order to map the unknown RNA position by triangulation. We have determined the position of the 5′ end of a 17-nt, 20-nt and 23-nt RNA thus mapping the exit pathway of the RNA product. As the RNA grows longer, we observe dynamical repositioning of the RNA. Our findings can be explained by models in which the RNA transiently interacts with the Rpb4/7 subunit, an interaction that could have implications in RNA modification as well as transcription initiation and termination.

Furthermore, we show that we can follow the transcription of a single Pol II molecule directly using single-molecule techniques.

[1] H. Kettenberger, K.-J. Armache and P. Cramer, Mol. Cell **16**, 955-965 (2004).

Observation of Electron Entanglement via Coulomb Interactions (Phase Recovery) and via Exchange Statistics (Two Particles AB Effect)

I. Neder, N. Ofek, Y. Chung, M. Heiblum, D. Mahalu, and V. Umansky

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We report on two different experiments, in which we orbital entangled a pair of electrons in two different methods.

In the first experiment, we employed a quantum 'which path' detector to perform accurate path determination in a two-path Mach-Zehnder electron-interferometer; leading to full suppression of the interference. Following the dephasing process we recovered the interference by measuring the cross-correlation between the interferometer and detector currents. Under our measurement conditions every interfering electron is dephased by approximately a single electron in the detector - leading to mutual entanglement of approximately single pairs of electrons.

In the second experiment, entanglement resulted with an unexpected interference between a pair of indistinguishable remote particles, coming from two, widely separated, independent and incoherent sources [2]. Via entangling this pairs of independent electrons, we measured a high visibility oscillatory dependence of the correlated arrival of two electrons at two drains. The periodicity of the oscillations corresponded to the Aharonov-Bohm flux enclosed by the combined two-electron trajectories (but not by those of a single electron); see Fig. 1. Since the measured currents are extremely weak, a long averaging process must be undertaken in order to overcome the unavoidable instrumental noise. This counterintuitive interference phenomenon between non-interacting and independent electrons is a direct result of Pauli's exclusion principle and the statistics of quantum particles.

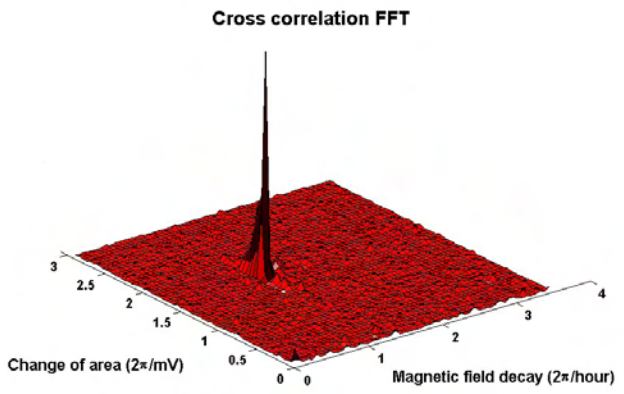

Fig. 1 *2-dimensional FFT of the cross-correlation signal between the two drains output shows clear AB oscillations peak at period corresponding to the Aharonov-Bohm flux enclosed by the combined two-electron trajectories.*

We are indebted to Y. Gefen, Y. Levinson, A. Stern and F. Marquardt for helpful discussions. The work was partly supported by the Israeli Science Foundation (ISF), the Minerva foundation, the German Israeli Foundation (GIF), the German Israeli Project cooperation (DIP), and the Ministry of Science - Korea Program.

[1] I. Neder, M. Heiblum, D. Mahalu, and V. Umansky, Phys. Rev. Lett. **98**, 036803 (2007).
[2] I. Neder, N. Ofek, Y. Chung, M. Heiblum, D. Mahalu, and V. Umansky, in preparation.

Tailoring the Material-Biology Interface

Christopher K. Ober[1], Rong Dong[1], Sitaraman Krishnan[1], Yi Yi[1], Barbara Baird[2], Manfred Lindau[3] and E. J. Kramer[4]

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The control of the physicochemical properties of surfaces in contact with biological systems represents a fundamental issue in many applications ranging from coatings to biotechnology and micro-electronics. In particular, advances in nanobiotechnology depend on the ability to fashion materials with precise control of feature size and functionality. This presentation focuses on issues of specific and non-specific binding and strategies being developed to control both.

Examples of specific binding that enable investigation of cell function will be presented. The broader issue of non-specific binding and how it relates to fouling release will also be discussed in terms of surface structure. Both polar and non-polar surfaces have been investigated and each type shows promise for release specific biological systems. In particular, polymer brushes grown from silicon surfaces have been shown to be especially effective [1]. The use of polymers brushes for control of cell-surface interactions will be discussed.

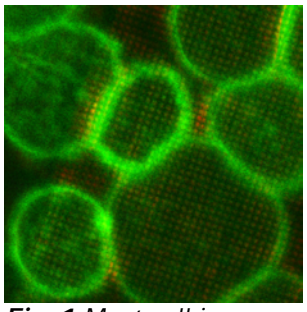

Fig. 1 *Mast cell in contact undergoing surface-induced degranulation.*

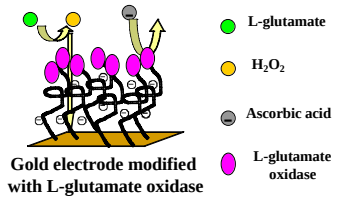

Fig. 2 *Scheme for successful screening of charged ascorbic acid using polymer brushes in glutamate sensor.*

Research that involves translating "bottle brush" architectures into simple polymer coatings will be discussed. The self-assembly of block copolymer thin films enables the creation of brush-like polymer surfaces [2]. The identification of a "universal" surface for release of all biological systems remains elusive. New coatings that make use of recent discoveries in improved fouling release based on dynamic surfaces will also be described [3]. These materials may form the basis of environmentally friendly fouling release coatings for marine and biomedical applications.

[1] W. Senaratne, L. Andruzzi and C. K. Ober, Biomacromolecules **6**, 2427 (2005).
[2] S. Krishnan, N. Wang, C. K. Ober, J. Finlay, M. E. Callow, J. A. Callow, A. Hexemer, E. J. Kramer, D. A. Fischer, Biomacromolecules **7**, 1449 (2006).
[3] S. Krishnan, R. Ayothi, A. Hexemer, J. Finlay, K. Sohn, R. Perry, C. K. Ober, E. J. Kramer, M. E. Callow, J. A. Callow, D. Fischer, Langmuir **22**, 5075 (2006).

The Two Channel Kondo Effect

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The breakdown of the Fermi liquid paradigm in quantum dots: Theory and Experiment.

Extending the Possibilities of Optical Manipulation

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In the basic form, laser tweezers are used to grab plastic beads that have a spherical of sphere. In this system, the location of the beads is determined but not the orientation. It would give additional control if the orientation, position of the grabbed particle could also be determined.

It is a very efficient possibility to use non spherical particles as test object. The anisotropy of the scattering by the non spherical body will have an orientational effect upon the particle. In addition, if the light forming the tweezers is also polarized, polarization effects can also be achieved.

I will discuss two basic approaches:

First, if we generate a helical shape, it will rotate in the optical tweezers. Such rotors, propellers can utilize different components of the momentum of light. They can be used to drive optomechanical systems.

Second, if the optical tweezers are formed by linearly polarized light, a flat object will be oriented in the trap. This effect can be used to order, orient particles. Torque can be measured and exerted by this system. I show application on single DNA molecules [1].
We studied these effects in detail on microscopic test particles of different shape generated by photopolymerisation. Structure building can be achieved by scanning a laser focus in a polymerisable resin, but more effective parallel photopolymerisation procedures were also developed using diffractive optical elements like kinoforms and SLMs.
Photopolymerisation offers a method to build complex integrated optomechanical systems that contain static movable mechanical parts, optical waveguides, etc. Complex microfluidic systems can be created this way. They can be operated by light.
For very complex systems, however, the power of light may not be sufficient to handle all tasks. To realize optical control of moving fluid in microchannels we developed the concept of optical control of electroosmosis: Fluid is moved by electroosmosis in the microchannels the walls of which are made of photoconductive material, and light can effectively switch the flow [2].
With the combination of these components complex optically controlled microfluidic devices can be built.

[1] L. Oroszi, P. Galajda, H. Kirei, S. Bottka and P. Ormos: Phys. Rev. Lett. **97** 058301 (2006).
[2] L. Oroszi, A. Dér, H. Kirei, V. Rakovics and P. Ormos: Appl. Phys. Lett. **89**, 263508 (2006).

Uptake of Artificial Viruses into Cells

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Curing diseases is of great challenge. This is especially true for diseases that are caused by gene alterations like cancer or hereditary diseases. The efficient treatment may require the incorporation or alteration of genes within cells of certain tissues in a living organism. Gene therapy aims to accomplish this task and uses gene shuttles to deliver DNA or RNA into cells. To date, two delivery systems (gene vectors) are mainly used: viral based vectors and non-viral vector systems. In this talk, I will give a short introduction into the cellular barriers that have to be resolved in order to deliver DNA into cells and present the non-viral based system we are currently using. Non-viral vector systems are mostly based on DNA complexed by cationic polymers like polyethyleneimide (PEI) which is used in our study. Systemic gene delivery for cancer gene therapy by non-viral vectors requires tissue-specific targeting. The epithelial growth factor receptor (EGFR) is overexpressed on a high percentage of human carcinomas and is therefore an attractive therapeutic target for tumor targeting. In this talk I will discuss the effect of EGF receptor targeting (EGF+) compared to untargeted PEI and untargeted, PEG (polyethyleneglycol) shielded (EGF-) polyplexes in respect to internalization into EGFR overexpressing HuH7 cells on single particle level. By using highly sensitive fluorescence wide-field microscopy, single particle tracking was performed to generate trajectories of the uptake dynamics. In addition, the internalization kinetics were evaluated and compared between the different polyplex formulations.

Lateral Nanostructures - From Quantum Point Contacts to Triple Quantum Dot Circuits

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The technique of using electrostatic gates to define lateral nanostructures is now more than two decades old. Historically many of the most significant physics that has been learnt in the nano-area has been obtained first using such devices. This is due to their unmatched tunability and versatility. Remarkably, such structures are still being used today at the very forefront of many areas of nano and quantum science, including potential applications in the rapidly expanding field of quantum information as well as fundamental studies of complex many-body physics such as the Kondo problem. In this talk I will provide a long introduction and emphasize the importance of these devices by illustrating some of the problems that they have been used to study historically. The talk will also focus on the relatively recent development which allows these devices to operate in the few electron limit. New effects and possibilities that arise from coupling such devices together will be shown. Important concepts and techniques such as charge detection spin to charge conversion and the stability diagram will be explained. An account will be also given of some of the most important experiments in the application of such devices to the field of qubits. Finally, an introduction to the new 'triple quantum dot system' will be given showing how the quantum cellular automata effects are unavoidable as one goes beyond the two quantum dot system.

Protein Crystal Structures in Biomedical Research: Molecular Players in Proprotein Activation

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Currently, protein crystallography is the most widely used methodology to obtain highly resolved three-dimensional structure of proteins, which are the key to understand their biological function and their biomolecular interactions at the atomic level. In addition, it provides the structural details crucial for the rational development of interacting molecules as drug candidates such as specific inhibitors.

We have used protein crystallographic methods to investigate the prohormone/proprotein convertase family of endoproteinases, most notably its best studied member furin. This protein family is essential for the maturation of a great variety of homeostatic but also of many pathogenic proteins within the secretory pathway, the endosomal pathway and at the cell surface. The 2.6 Å crystal structure of the decanoyl-Arg-Val-Lys-Arg-chloromethyl-ketone-inhibited mouse furin (Fig. 1) reveals an eight-stranded jelly-roll P-domain associated with the subtilisin related catalytic domain [1]. Various surface loops rendering the active-site cleft completely different from subtilisin explain furin's stringent requirement for Arg-P1+P4 and Lys-P2 by highly charge-complementary pockets and the preference of furin for basic P3+P5+P6 residues.

Similar to other members of the PC family, furin requires calcium for catalytic activity. We have determined the exact number and the three-dimensional localization of essential calcium ions in furin by collecting X-ray diffraction data on either side of the Ca *K* absorption edge and by calculating a novel type of double difference Fourier map from these anomalous scattering data [2]. Two calcium ions of different function were unambiguously identified.

Based on the structures of furin and its yeast homolog kexin, the potential structures of the entire PC-family were modeled, providing the experimental basis for a first understanding of the structural requirements also for the specificities of the other PCs [3]. Furthermore, these data as well as additional structural, biochemical and modeling analyses will aid in the rational design of anti-viral and anti-bacterial drugs [4].

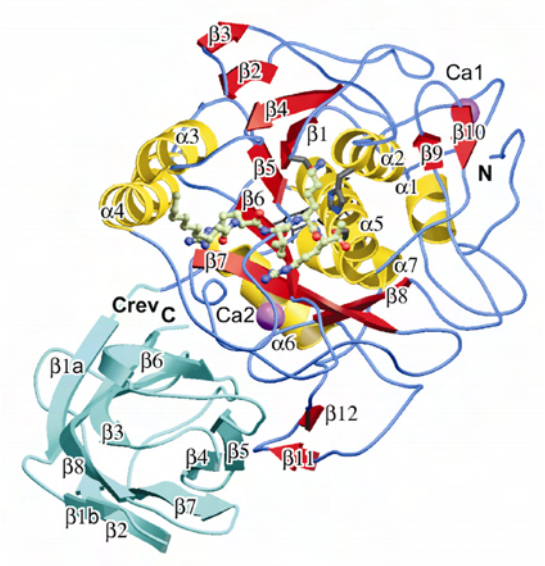

Fig. 1 *Ribbon plot of the mouse furin in standard orientation. The bound dec-RVKR-cmk inhibitor is shown with all atoms in ball-and-stick representation.*

[1] S. Henrich, A. Cameron, G. P. Bourenkov, R. Kiefersauer, R. Huber, I. Lindberg, W. Bode, and M. E. Than, Nature Struct. Biol. **10**, 520 (2003).
[2] M. E. Than, S. Henrich, G. P. Bourenkov, H. D. Bartunik, R. Huber, and W. Bode, Acta Crystallogr. **D61**, 505 (2005).
[3] S. Henrich, I. Lindberg, W. Bode, and M. E. Than, J. Mol. Biol. **345** 211 (2005).
[4] M. M. Kacprzak, J. R. Peinado, M. E. Than, J. Appel, S. Henrich, G. Lipkind, R. A. Houghten, W. Bode, and I. Lindberg J. Biol. Chem. **279**, 36788 (2004).

Mesoscopic to Universal Crossover of Transmission Phase of Multi-level Quantum Dots

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Transmission phase α measurements of many-electron quantum dots (small mean level spacing δ) revealed universal phase lapses by π between consecutive resonances. In contrast, for dots with only a few electrons (large δ) the appearance or not of a phase lapse depends on the dot parameters. We show that a model of a multi-level quantum dot with local Coulomb correlations and arbitrary level-lead couplings reproduces the generic features of the observed behavior.

At small δ, correlations generate renormalized single-particle levels of which one is generically much broader than the others, producing Fano-type antiresonances that lead to universal behavior for α.

Poster Contributions

Quantum Telegraph Noise

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We analyze the effect of quantum telegraph noise, produced by a single electronic defect level, on the decoherence of a charge qubit. In contrast to earlier works, [1-3], we describe the full time-evolution of the coherence factor even at short and intermediate times. In striking contrast to the well-known case of decoherence by a bath of harmonic oscillators, the coherence factor displays oscillations as a function of time and other parameters. We analyze these in detail using a numerical evaluation of the exact solution for the density matrix of the qubit.

[1] Y. Makhlin and A. Shnirman, Phys. Rev. Lett. **92**, 178301 (2004).
[2] Alex Grishin, Igor V. Yurkevich, and Igor V. Lerner, Phys. Rev. B **72**, 060509(R) (2005).
[3] Y. M. Galperin, B. L. Altshuler, and D. V. Shantsev, Phys. Rev. Lett. **96**, 097009 (2006).

Drug Release from Controlled Diameter Mesoporous Silica Incorporated In a Bioactive Porous Scaffold

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Ordered mesoporous silicas, where mesopores are arranged in a periodic array showing uniform size, have been proposed for hosting and further delivering drug molecules [1]. The possibility of modulating the pore size in a range from 2 to 10 nm makes conceivable the control of drug diffusion and release. Ordered mesoporous silicas may be combined as drug carriers within bioactive glass-ceramic scaffold used to fabricate bone implant, so to obtain a multifunctional system able not only to promote successful integration of the implanted prosthesis, but also to deliver locally species of pharmaceutical interest in a controlled manner.
This can be achieved by precipitating via sol-gel an ordered mesoporous silica inside the macroporous structure of a bioactive scaffold [2].

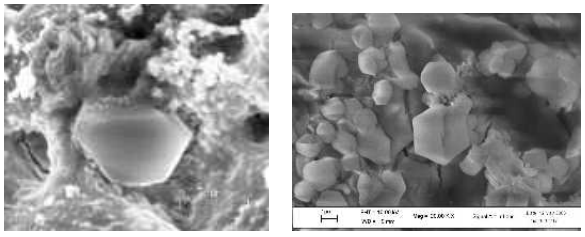

Fig. 1 *Micrographs for SAMPLE-1 (a) and 2 (b).*

Two kinds of ordered mesoporous silica (herein denoted as OMS), both with hexagonal symmetry of pore array but different pore size, have been incorporated inside a ceramic scaffold with the molar composition 50%SiO_2, 44%CaO, 6%K_2O (named SCK) [3], so obtaining two OMS-scaffold composites. One (SAMPLE-1) was obtained in strong acidic conditions starting from a solution of triblock copolymer (Pluronic 123) [2], the other (SAMPLE-2) was prepared following a recipe similar to that used to synthesize SBA-3 [4]. In both cases the scaffold has been soaked in the silica synthesis batch and then aged at 60°C. Then scaffold-OMS composites have been calcined to remove the surfactant.
The X-ray diffraction patterns of OMS-SCK composites show the typical peaks ascribable to the hexagonal mesophase. Nitrogen adsorption isotherms are of type IV, with a hysteresis

loop around 0.7 p/p_0 in the case of SAMPLE-1. Pore size results 8.6 nm and 2 nm for SAMPLE-1 and SAMPLE-2, respectively.
SEM-EDS analysis reveals the presence of silica grains with hexagonal symmetry incorporated in the internal macropores of the scaffold (Fig. 1).

Adsorption of ibuprofen from solution shows that scaffold as such adsorbs only 0,8% w/w of ibuprofen, SAMPLE-1 5% w/w, about six times higher, and SAMPLE-2 1,4% w/w, about two times higher, due to the presence of OMS.
Drug delivery *in vitro* has been performed by soaking the samples in a stirred simulated body fluid (SBF) at 37°C. The delivery of ibuprofen from SAMPLE-2, characterized by smaller mesopores, is slower than from SAMPLE-1 (Fig. 2), indicating an effect of the mesostructure on the delivery kinetics. The assessment of *in vitro* bioactivity was carried out following the formation of hydroxyapatite in SBF at 37°C during 1 month. The scaffold-OMS composite maintains similar bioactivity features of SCK.

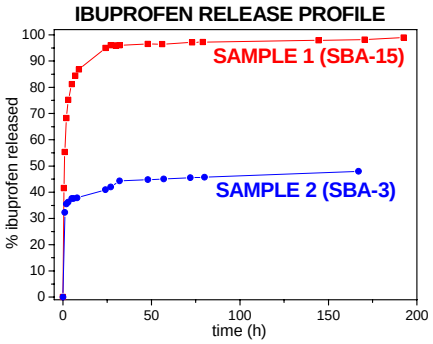

Fig. 2 *Ibuprofen release in SBF at 37 °C*

[1] M. Vallet-Regí, et al., Chem. Mater. **13**, 308 (2001). [2] B. Onida, et al., Stud. Surf. Sci. Catal. **158 b**, 2027 (2005). [3] C.Vitale, et al., J Mat. Sci. Mat. Med. **15**, 209 (2004). [4] G. Stucky et al., Chem. Mater. **6**, 1176 (1994).

Chain Geometry Controls Electronic Coherence in Conjugated Polymers

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[2]*Department of Physics, University of Utah, Salt Lake City, USA*

The performances of optoelectronic devices based on conjugated polymers depend on the influence of morphology on the electronic structure. Within this context, we correlate the photophysics and the chain morphology of a model fluorene polymer, poly-(9,9-dioctylfluorene) (PFO), at the single molecule level.

PFO shows different phases that can be identified by photoluminescence spectroscopy. Well resolved and red-shifted emission bands are observed for the planarized beta phase while a less structured blue emission is characteristic of the glassy one. The identification of these spectroscopic features at the single molecule level, with a remarkable photo stability of the beta phase [1], has raised the question of how to control intramolecular chain conformation and consequently photophysics.

Here we use a vapour swelling procedure [2] to increase the relative percentage of beta phase chains with respect to glassy ones in thin film of dispersed PFO. By low temperature single molecule polarization anisotropy we probe the conformation of isolated chains in both phases. The results demonstrate that beta phase molecules are characterized by higher polarization values than the glassy ones, reflecting an elongated character of the chain. Contrary to that, the random values of the dihedral angle between repeat units in the glassy phase lead to a decrease in the overall chain stiffness and reduce the anisotropy.

Additionally, we observe single chains with both types of emission, indicating only a partial conversion of the initial glassy segments to planarized beta segments. Our results show a strong correlation between the zero phonon line width and the anisotropy in the emission of beta phase molecules. Extremely narrow lines (0.5 meV) are observed for completely polarized emission. This indicates that beta phase constitutes a 1D crystalline polymer where the exciton can reach coherent dephasing times of 2 ps. The truly 1D nature of this material promises outstanding exciton and charge carrier mobility previously only found in polydiacetylenes [3].

[1] K. Becker, J. M. Lupton, J. Am. Chem. Soc. **127**, 7306 (2005). [2] M. Grell et al., Macromolecules **32**, 5810 (1999). [3] F. Dubin et al., Nat. Phys. **2**, 32 (2006).

How Does RNA Polymerase II Respond to DNA Damage?

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DNA damage can cause harm to all organisms, including humans. DNA can be damaged by several reasons, for example by exposure to sunlight. In the cell DNA is transferred into RNA by a protein named RNA polymerase, this process is named transcription. Later on this RNA is translated into a protein. If the DNA is damaged, RNA polymerase can misincorporate leading to damaged RNA, which in turn can lead to a mutant protein (see Fig. 1). This mechanism is called transcriptional mutagenesis (TM) [1].
TM is expected to play a role in human cancer development. For example, mutant proteins might cause a pre-cancerous cell to become cancerous by escaping growth inhibitory signals [1].

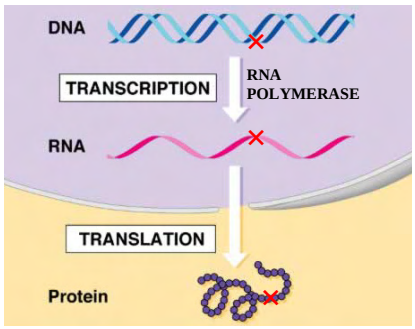

Fig. 1 *From DNA to protein. In this scheme a defect in DNA (red cross) is transferred to RNA resulting in a mutant protein.*

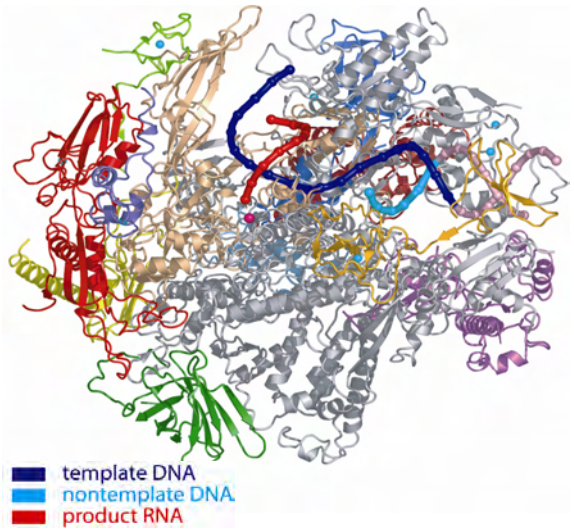

Fig. 2 *Structure of RNA polymerase II containing (undamaged) DNA and RNA strands. [2]*

The exact mechanism of TM is not known. In particular, it is generally unclear how specific DNA lesions are recognized and processed by the RNA polymerase. To be able to prevent or cure the harmful effects caused by mutant proteins, a better insight into the mechanism is needed. Therefore, this mechanism is studied using two approaches. The first approach provides information about the (mis)incorporation of the complementary base pair opposite to the DNA damage. In addition, the kinetics of (mis)incorporation can be investigated. Secondly, the structure of RNA polymerase at the point of misincorporation is determined using X-ray scattering (see Fig. 2). The combination of these results should elucidate the mechanism of damage recognition and processing.

[1] T. T. Saxowsky and P.W. Doetsch, Chem. Rev. **106**, 474 (2006).
[2] H. Kettenberger, K. J. Armache and P. Cramer, Mol. Cell. **16**, 955 (2004).

Uptake Kinetics and Dynamics of Functionalized and Non-Functionalized Polyplexes in HuH7 Cells

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Nonviral vectors are an important candidate for gene therapy, however they are still less efficient than viral vectors. One reason is the lacking cell specificity of nonviral vectors compared to viral vectors. For this reason PEI (polyethyleneimine) polyplexes with a PEG (polyethyleneglycol) shield were functionalized with EGF (epidermal growth factor) for specific binding to the EGF receptor on the cell surface.
Differences in uptake dynamics and kinetics of PEI, PEI-PEG and PEI-PEG-EGF particles were characterized on a single particle level.
Using highly sensitive fluorescence wide-field microscopy HuH7 wild type cells were transfected with Cy-3 labeled PEI, PEI-PEG or PEI-PEG-EGF particles.
By means of single particle tracking, trajectories of the uptake dynamics were obtained. Usually, particles showed three kinds of motion: firstly a phase of drift with very small step lengths, which could be assigned to membrane-related movement; secondly, a (confined) diffusive movement characterized by a larger step length that was independent of membrane movement; thirdly, directed motion along microtubules. No diffusive or directed motion was observed before particles entered the cell, entry took place in the first phase.
To evaluate the uptake kinetics, quenching experiments were performed in which the fluorescence of the extracellular particles was quenched with trypan blue. By comparing the amount of particles before and after quenching, the percentage of particles internalized by the cell was determined.
91% of PEI-PEG-EGF particles were internalized within 10 minutes. For PEI-PEG particles in contrast the internalized fraction was reduced to 19 % and for PEI particles to 22 % within 20 minutes.
Thus, functionalization of PEI polyplexes with a PEG-EGF ligand results in accelerated and increased internalization.

The New 300 kV Transmission Electron Microscope in Großhadern - a Powerful Tool for Determining Structure, Morphology and Chemical Maps of Nanostructures

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Presently, a new Transmission Electron Microscope (TEM), the Titan^{TM} 80-300 is being installed at LMU in Großhadern. Working at 300 kV and equipped with a field emission electron gun the new microscope features various attachments making it a flexible tool for materials characterisation at the sub-nanoscale. This contribution aims at informing members about the available characterisation methods and their potential applications to scientific problems within CeNS.

After briefly introducing the instrument and basic techniques such as diffraction and imaging, the special capabilities of the new TEM and related applications will be discussed. In high resolution mode (HRTEM) the instrument has an information limit of around 1Å allowing structural characterisation at the atomic scale. In addition, atomic number specific high-resolution imaging can be performed in scanning mode. Using image mapping of larger sample areas, spatial information from light optical methods can be correlated with TEM images obtained at higher resolution. In both scanning and conventional imaging modes tomograms can be constructed from a tilt series to recover 3D images of nanostructures. In order to facilitate imaging of electron-sensitive materials such as polymers or biological samples, a cryo-holder and low-dose software is available.

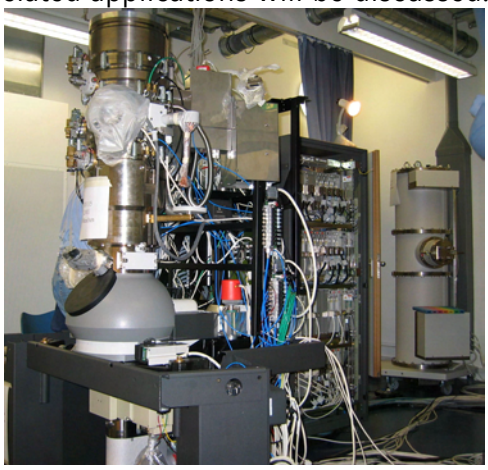

Fig. 1 *Status of the new TEM on 03/01/07*

Elemental mapping and point analysis can be performed with both characteristic X-ray spectroscopy and electron energy loss spectroscopy (EELS). In the case of EELS the lateral resolution is approaching the atomic scale.

In summary, the combination of several techniques including diffraction, imaging, spectroscopy, and tomography at very high resolution makes the new TEM a versatile tool for the comprehensive characterisation of nanoscale materials.

Atomic Force Microscope: Lithography and Synthesis of Nano Objects

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Why nano objects are so interesting for us? Nano objects like nanoparticles, nanotubes can be used to build many different types of nanodevices for magnetic, electrical, biomedical and optical application. Due to the small size (smaller than 100 nm) of the objects their properties (mechanical, electrical and magnetic) differ from the properties of the same material in bulk.

For example iron nanoparticles can be placed on the modified substrates [1]. These iron nanoparticles can be used as (patterned) catalyst arrangements for the site-selective assembly of carbon nanotubes (CNT). Therefore specific problems have to be mastered. Nearly all well-known techniques of carbon nanotube production require extreme conditions (pressure, high temperature etc.). There are many substrates that will suffer under these conditions. However, a new approach in carbon nanotube growth was proposed [2]. The idea is to use a microwave as an alternative source of heating and alcohol as a carbon source [3]. The main advantage of the microwave is the capability of selective heating. Depending on the conductivity of different material, some of them heat faster than the others. Especially metallic iron nanoparticles are beneficial because of their small size and microwave radiation is selectively absorbed. Characterization of CNTs (size, conductivity, etc.) can be performed using TEM, SEM, Raman spectroscopy and SFM.

[1] S. Hoeppener, R. Maoz, S. Cohen, L. Chi, H. Fuchs, J. Sagiv, Adv. Materials **14**, 1036 (2002).
[2] E. H. Hong, K. - H. Lee, S. H. Oh, C. G. Park, Adv. Materials **14**, 676 (2002).
[3] S. Maruyama, R. Kojima, Y. Miyauchi, S. Chiashi, M. Kohmo, Chem. Phys. Lett. **360**, 229 (2002).

Methods to Measure Gene Expression by Numbers

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Gene expression is observed in living cells using fluorescent proteins. Usually the techniques applied to detect the expressed proteins provide information about the fluorescence intensity but not about the number of proteins expressed. We present various approaches to calibrate fluorescence microscopy measurements. Combining fluorescence-correlation-spectroscopy and microscopy we measure the number of proteins in a solution of a known number of lysed cells and out of it determine GFP concentrations from fluorescence intensity time-lapse measurements of *E.coli* bacteria.

Quantum Cellular Automata Frustration by Spin Blockade in a Lateral Triple Quantum Dot

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Some of the quantum information schemes proposed in solid state physics require the manipulation of single electrons. Quantum dots are used for single electron manipulation and it has been shown that it is possible to couple two and three quantum dots. The lateral triple quantum dot system is created by confinement of 2D electrons by means of electrostatic gates placed on top of a GaAs/AlGaAs heterostructure. The number of electrons in each quantum dot can be controlled individually down to the (0,0,0) configuration in which each quantum dot is empty. The different electrostatic couplings between each pair of dots give rise to cellular automata effects, where the addition of an electron into one of the dots forces the redistribution of electrons already in the system to minimize the electrostatic energy. We present experimental evidence showing that these cellular automata effects are also governed by quantum mechanics and can be suppressed by spin blockade mechanisms, in other words, redistribution of electrons can only take place if their spin configuration allows it.

Structural Studies on RNA Polymerase I

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RNA polymerase I (Pol I) transcribes ribosomal DNA (rDNA) units, which are found in multiple clustered copies in every eukaryotic cell. After processing of the ribosomal RNA (rRNA) precursor, the mature RNA is subsequently incorporated into nascent ribosomes. Pol I consists of 14 polypeptides, 5 of them are shared with RNA polymerase II and III, 7 peptides show homology based on the primary sequence and 2 of them (A49 and A34.5) are unique subunits of Pol I. The A49/A34.5 subcomplex together with A43 and A14 are responsible for the enzymatic specificity of rRNA transcription by Pol I.

In order to understand the specific transcription mechanism of Pol I, more structural information is needed. The aim of our work is to establish the 3-D structure of Pol I. For this purpose two complementary strategies are pursued. First the endogenous protein complex (approx. 600 kDa) from yeast was purified and we try to elucidate the total structure at medium resolution. The second approach is the recombinant expression, purification and crystallization of the A49/A34.5 and A43/A14 subcomplexes of Pol I. The results obtained will give more detailed structural information, which will lead to a better understanding of the specific transcription process of Pol I.

Confocal Raman Imaging of the Distribution of Mechanical Stress in Bent Cantilevers

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Raman spectroscopy is based on the inelastic scattering of photons by matter. Thus, in a scanning confocal microscope, one can use Raman spectroscopy to depict the chemical composition of surfaces with a high lateral resolution. The resolution limit is given by the diffraction limited spot-size of the focused laser beam (here: approximately 250 nm using a 532 nm laser). For crystalline materials such as silicon, the fingerprint spectrum by the Raman scattering is also dependent on the phonon band-structure. This, however, is changing under external stress or strain.
In atomic force microscopy, most probes are made out of silicon and are subjected to stress by the mechanical interaction of the AFM tip and the sample surface. In order to design the dynamic behavior of AFM cantilevers it is necessary to know the stress distribution in the material.

Electron Transfer Processes in the Electrochemical Solar Cell – Comparison of Dye and Dot Sensitized Titania

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The electrochemical solar cell (ECS), also known as the Grätzel cell, is a promising alternative to the standard polycrystalline silicon solar cell showing an efficiency of up to 12% in diffuse daylight [1]. The electron transfer processes at the sensitizer-titania heterojunction are of great importance for the overall efficiency of this solar cell. It is the task of this work to build up an experimental setup to characterize the transfer processes in the nanosecond to millisecond time domain and to compare heterojunctions of different photosensitizers linked to various types of crystalline titania nanoparticles with high surface areas.

The ECS (see Fig.1) consists of crystalline TiO_2 as a wide bandgap semiconductor sandwiched between two transparent conducting oxides. The titania is functionalized with a photoactive material – a dye or a semiconducting nanocrystal. An electron is excited by an incoming photon to the LUMO of the sensitizer and immediately transferred to the conduction band (CB) of the titania (10-50 ps [2]). Ideally the electron is transferred to the anode, then *via* a load, dissipating its energy to the cathode and finally it is recovering the hole at the HOMO of the sensitizer *via* an ion conductor (or redox couple). The efficiency of the cell is lowered by the back transfer of the electrons from the TiO_2 CB to the photosensitizer and the leakage of the electrons from the titania CB to the ion conductor. These loss-processes in the millisecond time domain [3] are influenced by the exact formation of the heterojunction between the sensitizer and titania.

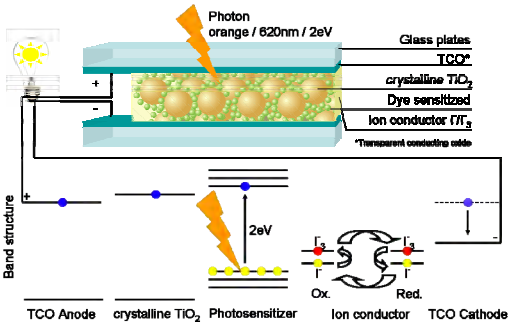

Fig. 1 *Schematic overview of the electro-chemical solar cell: Main components and corresponding band structure.*

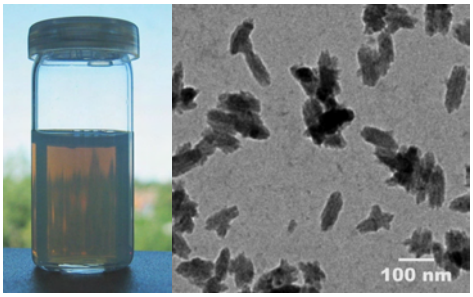

Fig. 2 *Colloidal suspension of titania nanoparticles and TEM-micrograph.*

In this project, different nanoscale titania morphologies with high surface areas are synthesized (see Fig. 2) and compared to commercially available titania nanoparticles.
We characterize the heterojunction formed with dyes or differently functionalized quantum dots with a pump-probe spectroscopy setup suitable for the nanosecond to millisecond time domain and a broad energy range.

The authors acknowledge funding from the Advanced Materials Science (AMS) program and from the Cluster NIM at the LMU. We thank Professor Riedle for his support.

[1] B. O'Regan and M. Gratzel, Nature **353**, 737 (1991).
[2] J. L. Blackburn, D. C. Selmarten, and A. J. Nozik, J. Phys. Chem. B **107**, 14154 (2003).
[3] C. Bauer, G. Boschloo, E. Mukhtar, and A. Hagfeldt, J. Phys. Chem. B **106**, 12693 (2002).

Quantum Mechanical Switching of Ballistic Electrons

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We aim towards the realization of a magnetic field free Mach-Zehnder Interferometer as a current qubit. As a first step we realized a junction of two one-dimensional (1D) channels as a beamsplitter for ballistic electrons.

For the desired application as a current qubit quantum mechanical switching between the 1D channels is required.

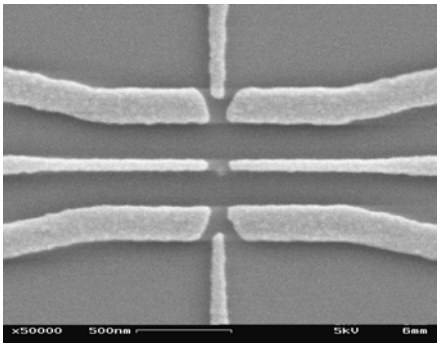

Fig. 1 *SEM picture of the sample. The bright structures are gates that can define 1D channels when negative voltage is applied.*

Theoretical predictions suggest quantum mechanical switching behaviour only for a suitable geometry and very clean 1D channels. Following numerical calculations with NextNano performed specifically for our hetereostructure we have lithographically fabricated gate defined channels in a GaAs/AlGaAs-heterostructure (Fig. 1). We observe switching between two 1D channels that is strongly temperature (and magnetic field) dependent and dissapears for T > 700 mK. Comparison of our experimental results with theoretical predictions suggests that we indeed observed quantum mechanical switching.

We would like to thank Tobias Zibold and Peter Vogl from Walther Schottky Institut at the TUM for their numerical simulations with NextNano and the good collaboration.

On-Chip Detection of Single Microwave Photons in Super-Conducting Circuit QED

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We propose and analyze a scheme for detecting single microwave photons traveling along a superconducting transmission line on a chip. The setup exploits a nonlinear coupling between different modes in a transmission line resonator, brought about by the interaction with a superconducting qubit (as demonstrated in recent experiments). Remarkably, the backaction produced by the measurement device may produce a fundamental limit for the fidelity of photon detection in any such scheme. This is a consequence of the Quantum Zeno effect, and we discuss both analytical estimates and quantum trajectory simulations of the measurement process.

Microfluidic Systems for Biophysical Analysis

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Microfluidic systems have gained importance in many fields of biology, chemistry, and biophysics over the last few years. Applications of such systems range from the analysis of the dynamic behavior of fluids, over highly sensitive DNA recognition to chambers for cell culture. Nowadays, most microfluidic devices are processed in polymers, mainly SU8.
Our project concentrates on the integration of different microfluidic devices in SU8 and their chemical and biological surface functionalization. The applications of our systems range from different mixing setups combined with colloidal probes for the rheological analysis of liquids and mixtures to customized structures for biological use.
For all kinds of applications, surface functionalization plays an important role. Especially for biological applications, recent studies have shown, that SU8 is not fully biocompatible [1]. Thus, functionalization of the surface is of special importance. Surface activation methods include oxygen plasma treatment and wet chemical approaches to achieve an improved wetability. In a different approach, we use biopolymer coatings to enhance biocompatibility.

[1] F. Walther, P. Davidovskaya, S. Zürcher, M. Kaiser, H. Herberg, AM. Gigler and RW. Stark, Journal of Micromech Microeng. in press.

DNA- and Lipid Raft Manipulation on Microstructured Lipid Membranes

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We aim at manipulating macromolecules and membrane domains using supported and cantilever membranes on microstructured surfaces. DNA on shaped supported cationic membranes serves as a 2D-confined polymer following biased reptation dynamics whereas the influence of curvature on lipid rafts is tested. Possible applications are novel electrophoresis devices, gene mapping and protein positioning in membranes.

Dynamics of Rod-Like Macromolecules

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Nature as well as modern technology presents us a variety of heterogeneous materials ranging from porous rock over gels to the inner structure of eukaryotic cells. Macromolecules being immersed in such materials exhibit a host of phenomena including Brownian motion, anomalous diffusion, fractal dynamics and a curious zig-zag motion.

Using a minimal model, the emergence of anomalous transport can be understood as a consequence of spatial heterogeneities and excluded volume [1]. We have extended this model to capture essential properties of the dynamics of a rod moving between randomly distributed, fixed rods. For simplicity, the motion is restricted to a plane. For long rods, strong entanglement effects lead to a suppression of rotational diffusion, while at the same time, they enhance center-of-mass diffusion [2].

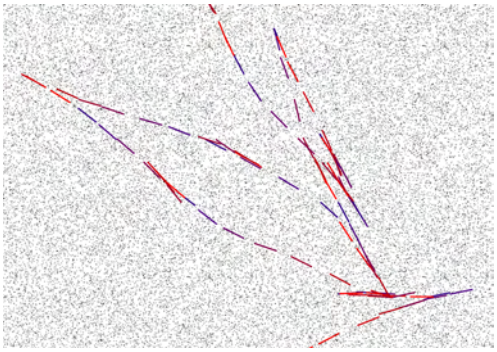

Fig. 1 *The zig-zag motion of a long, thin rod between randomly distributed obstacles leads to an increase of the diffusion coefficient.*

Our results from Molecular Dynamics simulations allow for a detailed comparison with the tube model by Doi and Edwards. Further, they give insight into the origin of the zig-zag motion and the effect of enhanced diffusion. The analysis is complemented by Brownian Dynamics simulations, mimicking the microscopic dynamics of a macromolecule in solution in a more realistic way.

[1] F. Höfling, T. Franosch, E. Frey, Phys. Rev. Lett. **96**, 165901 (2006).
[2] F. Höfling, Ph.D. thesis, Ludwig-Maximilians-Universität München (2006).

Combinatorial and Chemical Structuring on Surfaces

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Self-assembled monolayers (SAM) of functionalized trichlorosilyl- and trimethoxyalkyl chains evolved as materials for surface modification with exciting prospects for application. There are several promising approaches in microfabrication which are using SAMs for surface patterning. Electro-oxidative nanolithography is a method for patterning of octadecyltrichlorosilane (OTS) surfaces in which CH_3 groups transform to COOH groups. Surface patterm in the nanometer to millimeter regime can be fabricated with this technique.[1] Another method for patterning surfaces is the patterning of benzaldimine monolayer by low-energy electron beam irradiation.[2] Here amine groups are generated and can be used for further modifications. These methods are inherently limited to the generation of only one functional group. Therefore, alternative approaches have to be used if multifunctional surface patterns are addressed.
Here we describe a route to pattern SAMs in a range of micrometer to millimeter by partly removal of the OTS from the surface. Patterned OTS monolayers are filled with reactive functional groups (e.g. bromo-functionalized trichlorosilanes, …) to provide binding capabilities for nanoparticles or for subsequent chemical reactions. We are interested to have thiol[3,4] and also azide functional groups on the surface. These topics have potential valuable input to sensor array systems and combinatorial research.

[1] S. Hoeppener, R. Maoz, J. Sagiv, Nano Letters **3**, 761 (2003).
[2] Y.J. Jung, Y.-H. La, H.J. Kim, T.H. Kang, K. Ihm, K.-J Kim, B. Kim, J.W. Park, Langmuir **19**, 4512 (2003).
[3] N. Balachander, C.N. Sukenik, Langmuir **6**, 1621 (1990).
[4] M.R. De Guire, J.-J. Shyue, Langmuir **20**, 8693 (2004).

Drift Mobility of Long-Living Excitons in Coupled GaAs Quantum Wells

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Photo-generated electron-hole pairs in quantum well devices can be manipulated in lifetime and position via a mesoscopic voltage-controlled electrostatic landscape. Whereas exciton ionization and spatial separation of electron-hole pairs by large in-plane electric fields enable us to store and release optical images at will [1,2], the quantum-confined Stark effect allows us to create long-living excitons and study their dynamics on mesoscopic length scales [3,4]. Here we employ the quantum confined Stark effect in a coupled double quantum well to generate spatially indirect excitons with lifetimes exceeding 1 sec and to study their motion induced by a controlled spatial variation of the out-of-plane electric field. The confinement of such long-living excitons into artificial traps aims at observing Bose-Einstein condensation of excitons [5,6].

With spatially and time-resolved photoluminescence we study the dynamics of spatially indirect excitons generated in a GaAs-AlGaAs double quantum well at low temperatures.

Temporal variation of the gate voltages applied to interdigitated gate electrodes induces excitonic motion in the quantum well plane, perpendicular to the narrow gate electrodes via the spatial variation of the quantum-confined Stark effect [3]. Thus we can establish long lifetimes of mobile excitons. Macroscopic drift of excitons is studied employing a laterally graded electrostatic potential induced via a current-carrying resistive gate [4]. This allows us to determine the drift mobilities of such long-living excitons. Across several hundreds of microns a drift mobility of $>10^5$ cm^2/eVs is observed for temperatures below 10 K. With increasing temperature the excitonic mobility decreases due to exciton-phonon scattering. Artificial stressors prepared on top of the double quantum well induce an additional variation of the excitonic potential and cause trapping of excitons, e. g. to narrow ring-like regions around the stressor perimeter. Suitable combinations of these trapping schemes will be discussed that create the potential for possible exciton condensation.

We acknowledge financial support by the Center for NanoScience (CeNS) in Munich and the DFG Projekt KO 416/17-1.

[1] J. Krauß et al., Phys. Rev. Lett. **88**, 036803 (2002).
[2] J. Krauß et al., Appl. Phys. Lett. **85**, 5830 (2004).
[3] A. Gärtner, D. Schuh, J. P. Kotthaus, Physica E **32**, 195-198 (2006).
[4] A. Gärtner, A. W. Holleitner, J. P. Kotthaus, D. Schuh, Appl. Phys. Lett. **89**, 052108 (2006).
[5] L. S. Levitov et al., Phys. Rev. Lett. **94**, 176404 (2005).
[6] Z. Vörös et al., Phys. Rev. Lett. **94**, 226401 (2005).

Asymmetric Partitioning of G_{M1} Ganglioside into Fluid and Heterogeneous Single Lipid Bilayers

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The ganglioside G_{M1} is the cell membrane receptor that binds to the protein cholera toxin. A complex comprising five G_{M1} molecules per protein forms to enable cholera toxin to cross the membrane and enter the cell. To gain physical insight into receptor-ligand binding and complexation events in cell membranes, we study how G_{M1} influences lipid molecular density and arrangement in single lipid bilayers using X-ray reflectivity and fluorescence microscopy.

When incorporated asymmetrically into a lipid bilayer, G_{M1} stretches the lipid leaflet distal to the substrate and increases the lipid headgroup density, as demonstrated by X-ray reflectivity (Fig. 1). Reflectivity measurements also verify the asymmetric distribution of G_{M1} in the bilayer. Furthermore, binding of the B subunit of cholera toxin to G_{M1} does not change the reflectivity or the molecular rearrangement of the lipid bilayer. We also investigate G_{M1} in heterogeneous membranes of cholesterol, sphingomyelin and DOPC. This ternary lipid mixture can phase separate, to approximate lipid rafts in the plasma membrane. Determining the structure and dynamics of heterogeneous membranes containing G_{M1} can help us to better understand if G_{M1} prefers certain lipid phases in cell membranes. Incorporation of G_{M1} into

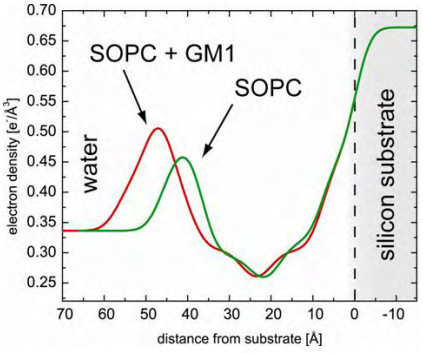
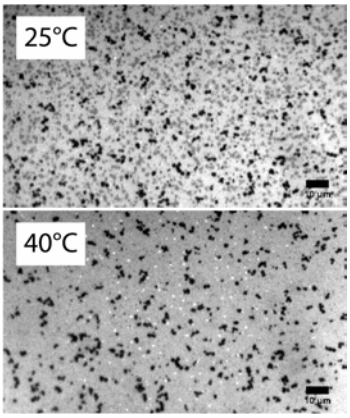


Fig. 1 *Electron density profiles extracted from the reflectivity of a homogeneous lipid bilayer membrane of SOPC before and after G_{M1} is incorporated into upper leaflet.*



heterogeneous bilayers with lipid rafts results in black and gray domains (Fig. 2). We demonstrate that the gray domains exhibit reversible temperature-dependent phase behavior. G_{M1} may have a condensing effect on lipid bilayers containing cholesterol, resulting in the formation of black defects and the reduction in lipid diffusion that we measure with continuous bleaching experiments.

Fig. 2 *Fluorescence micro-graphs of lipid bilayer of 1:2:2 molar ratio of cholesterol/ sphingomyelin/DOPC after G_{M1} incorporation. Gray domains disappear upon heating.*

Phosphorescence Quenching in the Vicinity of Gold Nanoparticles

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Gold nanoparticles alter the radiative and nonradiative decay rates of nearby dye molecules, resulting either in decreased or increased luminescence intensity. While the effects of gold nanoparticles on surrounding fluorophores have been investigated thoroughly, there are no corresponding studies dealing with the influence of gold nanoparticles on the luminescent properties of phosphors. Especially for applications in biosensing, phosphors are particularly suitable, as they allow to cut off autofluorescence.

We have investigated the influence of gold nanoparticles on the radiative and nonradiative decay rates of two different phosphorescent dyes. The phosphors are attached to the nanoparticles via a biomolecular recognition reaction. Time-resolved luminescence spectroscopy reveals an increase of the radiative as well as the nonradiative rate in all regarded phosphor/gold nanoparticle hybrid systems. The increase in the radiative rate is outweighed by the more prominent enhancement in the nonradiatve rate, thus a luminescence quenching occurs.

Membrane Deposition on Pentacene Thin Films

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Molecular beam deposition of crystalline thin films of pentacene is currently the most effective way to fabricate organic field effect transistors with charge carrier mobilities in the order of 1 cm^2/Vs. Here, we employ the possibility to coat such devices with a phospholipid membrane. Experiments are performed by combining fluorescence microscopy and synchrotron reflectivity to access the structure and fluidity of such coatings in water. This work is part of an EU-initiative (Biodot).

HIV-1 Gag Assembly Studied by TIR FRAP

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HIV Gag is a protein, which is sufficient and required for formation of viral particles. Gag assembly occurs mostly at the plasma membrane. During this process recruitment of various cellular proteins (like Tsg101 [1]) promoting viral budding takes place. Total internal reflection microscopy allows exciting and bleaching of a thin layer of around 100 nm near the coverslip surface. We have built a combined TIRF/wide-field setup that is capable of switching between the two excitation regimes on a millisecond timescale. This allows us to achieve rapid change of the imaging depth when required. Bleaching in TIRF arrangement allowed us to observe accumulation and clustering of GFP-labeled Gag at the bottom of the cellular membrane prior to budding at different stages of infection. Moreover, by utilizing multicolor labeling of different viral and cellular proteins it is possible to determine their recruitment kinetics to the budding site.

We would like to thank SPP 1175 and CeNS for financial support.

[1] J. Martin-Serrano, T. Zang, P. Bieniasz, Journal of Virology **77**, 4794 (2003).

Numerical Simulations of Oligonucleotides

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This work proposes a theoretical analysis using molecular modeling to predict the three-dimensional structure of the synthetic oligonucleotide CpG-A, identified as the first synthetic stimulus to trigger large amounts of type I interferon in human plasmacytoid dendritic cells. After the construction of the CpG-A duplex model, both molecular dynamics simulation and structural analysis were carried out. The results demonstrate the stability of the CpG-A duplex structure and that a G-quadruplex can be formed by duplex dimerization, resulting in a unit for the nanoparticle formation. Properties of the CpG motifs were also analyzed and a Hoogsteen base pair appearance could be considered in the CpG-A recognition process involving the Toll-like receptor 9.

Template Removal by Uncatalyzed Oxidation with Hydrogen Peroxide – Optimizing the Reaction Conditions for Mesoporous Silica Nanoparticles and MCM-41

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Template removal is an essential step in the creation of porous materials. In the case of ordered mesoporous silicates this is normally performed by oxidation of the organic template at high temperatures. However, this classic method of calcination has major disadvantages in the case of colloidal systems of mesoporous silica nanoparticles (Figure 1), which irreversibly aggregate during the drying and heating steps. In such systems the cationic cetyltrimethylammonium template is therefore usually extracted with ethanolic solutions of ammonium nitrate and hydrochloric acid, leading to an incomplete template exchange. In order to completely remove the organic template from the mesopores of colloidal silica systems without causing particle agglomeration, the oxidation with hydrogen peroxide was investigated [1,2].

The influence of various parameters including the application of different catalysts (Fe^{3+} or nitric acid), reaction temperatures and reaction times on the remaining template content in mesoporous silica was determined. It was found that a combination of uncatalyzed oxidation by H_2O_2 at 95 °C for 3 h followed by acid extraction yields the best results. The obtained mesoporous silica nanoparticles reveal high surface areas and pore volumes with a significantly decreased template content in comparison to extracted material. The stability of different functional groups incorporated into the mesoporous materials during the oxidation treatment will also be discussed.

[1] Y. Xia, R. Mokaya, J. Phys. Chem. B **110**, 9122 (2006).
[2] L. M. Yang, Y. J. Wang, G. S. Luo, Y. Y. Dai, Micropor. Mesopor. Mater. **81**, 107 (2005).

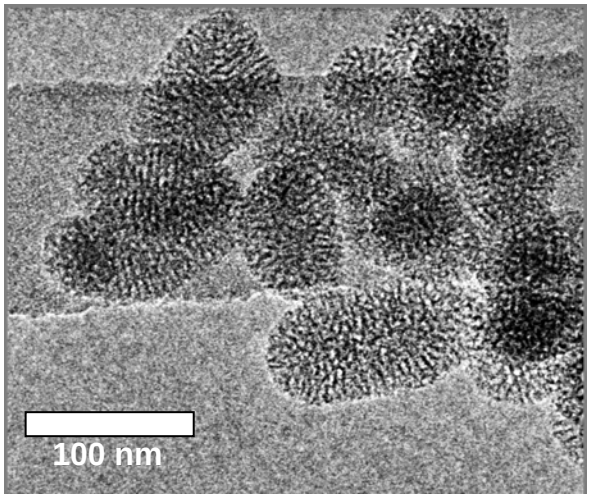

Fig. 1 *TEM micrograph of mesoporous silica nanoparticles.*

Periodic Mesoporous Organosilicates Confined within an Anodic Alumina Membrane

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Department of Chemistry and Biochemistry, University of Munich, Munich/Germany

Periodic mesoporous silica (PMO) materials can be synthesized from bis(alkoxysilyl) precursors $(RO)_3Si\text{-}R'\text{-}Si(OR)_3$ in the presence of surfactants such as tetraalkylammonium halides or nonionic triblock-copolymers. This way it is possible to produce materials with both high loading of organic functional groups, homogeneously distributed throughout a silica matrix, and highly ordered mesoporous structures. Previously PMO materials have been synthesized in the form of powders and thin films. Here we report the synthesis of PMO materials within a porous anodic alumina membrane (AAM) host system, thus

combining the advantages of thin films with the orientation and high aspect ratios featured by the anodic alumina channels.
The PMO mesophases were prepared using an approach similar to evaporation-induced self assembly (EISA). Successful template removal could be achieved by applying a stepwise calcination of both phases with several tempering steps.

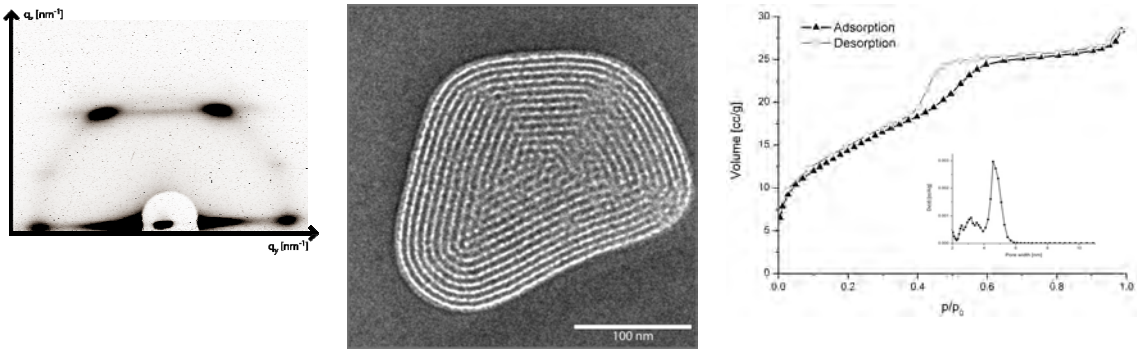

Fig. 1 *a) 2D SAXS diffraction pattern, b) TEM micrograph and c) Nitrogen sorption isotherm of calcined ethylene bridged PMO in porous alumina.*

Acknowledgement: The authors thank the DFG (SFB 486) for supporting this work.

Mapping the Diffusional Landscape of a Porous Nanostructure

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Single Molecule Spectroscopy (SMS) is used in combination with Transmission Electron Microscopy (TEM) to trace out the internal structure of mesoporous thin films and to gain insight into the diffusion dynamics with respect to the underlying structure of the host. Individual dye molecules acting as molecular beacons are incorporated into the pores and their diffusion pathway through the pore system is observed by optical widefield microscopy [1,2].

However, structural features on the nanometer scale cannot be observed by optical methods. To resolve the pore structure in detail TEM measurements are needed. Usually, the sample preparation for TEM is either time-consuming, when it involves the preparation of cross-sections, or it lifts the film off its substrate by scratching. With such methods it is thus not possible to directly correlate the nanopore structure of the film and the trajectories of the dye molecules obtained by fluorescence spectroscopy.
Here, we present the synthesis of thin mesoporous films loaded with fluorescent dye molecules that can be successively investigated by optical Wide-field Microscopy and TEM. We developed a method to overlay the images obtained by the two methods (Fig. 1). This is the first time that dynamical information from single particle diffusion can be directly correlated with the structural details of the porous host obtained by TEM.

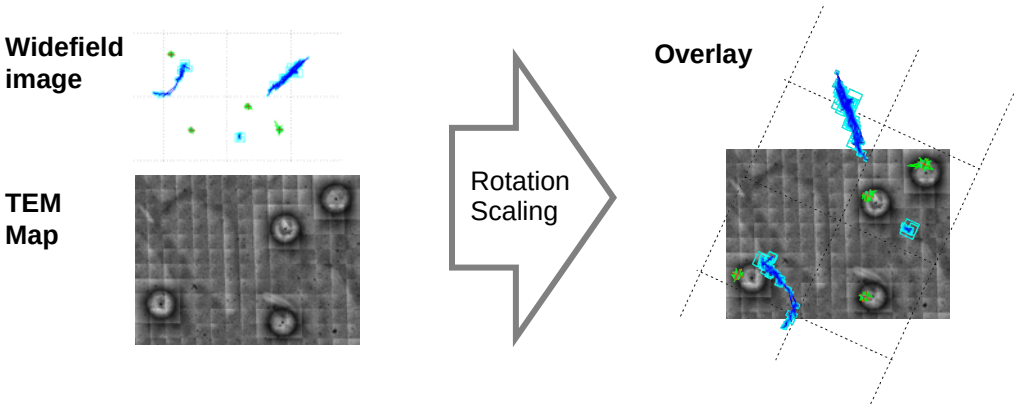

Fig. 1: *Overlay of single particle tracks obtained by widefield microscopy with transmission electron micrographs of the pore structure. The positions of polystyrene beads that are added to the synthesis solution are used to calculate the rotation angle and scaling factor.*

[1] C. Hellriegel, J. Kirstein, R. Brown, C. Bräuchle *et al.*, J. Phys. Chem. B **108**, 14699 (2004).
[2] C. Hellriegel, J. Kirstein, C. Bräuchle, New Journal of Physics **7**, 23 (2005).

Control of Organized Growth of Zincophosphate and Aluminophosphate Crystals on Modified Gold Substrates

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The effect of a ZP layer on the surface growth of $AlPO_4$-5 and zincophosphate analogue of zeolite X (FAU) has been investigated [1,2]. The ZP-containing layers exhibit efficient growth with high bonding strength - crystalline phases were still present after sonication. In contrast, the non-ZP pre-treated gold substrates did not exhibit any crystal-growth at the surface. The influence of several parameters such as nature of template (DABCO, TEAOH, TrEA), the presence of fluoride anions, as well as the nature of the initial reactants on the orientation of the crystal layers on the gold substrate were investigated. For example, the use of DABCO as template leads to growth of AFI-type crystals having prismatic faces (along the c axis) partially perpendicular to the gold surface (Fig. 1A, B), while the use of TEAOH as template and in the presence of fluoride anions results in AFI-type crystals on the surface with the prismatic faces parallel to the surface (Fig. 1C).

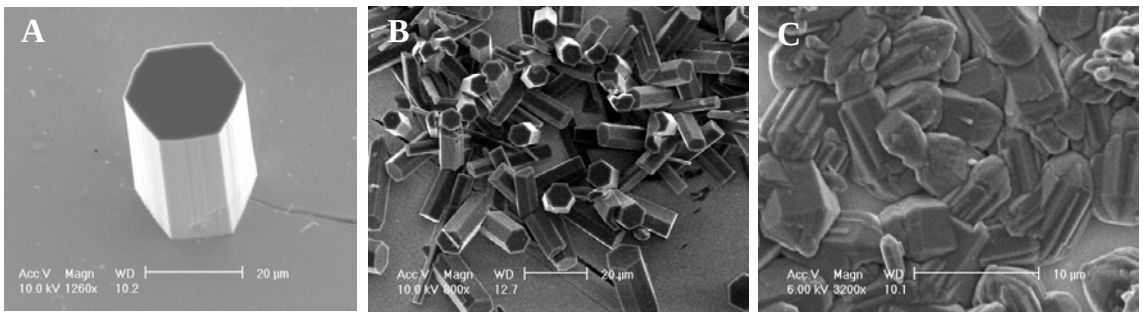

Fig. 1. *SEM images of AlPO4-5: A, B- DABCO as SDA. C- TEAOH as SDA and HF.*

[1] S. Feng and T. Bein, Science **265,** 1839 (1994).
[2] S. Feng and T. Bein, Nature **368,** 834 (1994).

Room-Temperature Storage of Excitons in Elongated Semiconductor Nanocrystals

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The excited state of colloidal nanostructures consisting of a spherical CdSe core overgrown with a rod-like CdS shell can be perturbed effectively by electric fields.[1-3] Field-induced fluorescence quenching coincides with a suppression of radiative rate without increasing ionization. After turning off the electric field, a significant fraction of quenched - and therefore stored - excitons recombines radiatively, even for a duration of the electric field pulse of up to 100 µs. Application of an electric field not only promotes the separation of electron and hole wave function but also influences the depopulation dynamics of localised states on the surface of the nanocrystal. This leads to a significant change in the exponent of the characteristic power law decay of the delayed luminescence. Furthermore, exciton storage selects the most polarizable particles. Consequently, a significant quantum confined Stark effect spectral shift of ~15 meV along with a correlated broadening of the spectrum is visible in the time-resolved emission of the ensemble at room temperature.

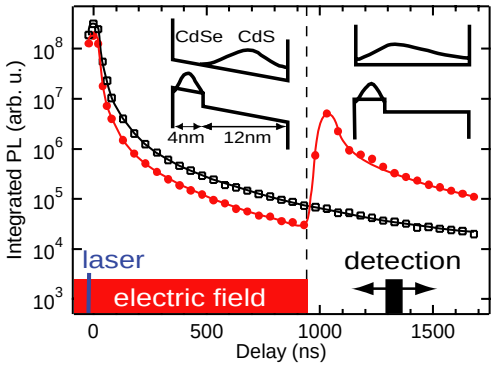

Fig. 1 *Time resolved PL decay with (solid dots) and without (open squares) an electric field pulse of 1 µs duration. The sketches indicate the separation of electron and hole wave functions during and after the field.*

[1] J. Müller et al., Phys. Rev. Lett. **93**, 167402 (2004). [2] R. M. Kraus et al., Phys. Rev. Lett. **98**, 017401 (2007). [3] J. Müller et al., Nano Lett. **5**, 2044 (2005).

Spin-Selective Optical Initialization of Single Electron in a Quantum Dot

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Recent works on spin dependent optical properties of a single, resident electron in a self-assembled quantum dot [1,2,3], demonstrated coherent spin manipulation on a single electron. This represents an important milestone in quantum information processing.
Quantum dots can be stably charged with a single electron [4]. We showed that the spin orientation of this resident electron can be read out by resonant high resolution laser spectroscopy [3,5]. Furthermore the spin orientation can be initialized by optical means through an electrical control of the tunnel coupling between the quantum dot and a reservoir of electrons. To achieve spin initialization we exploited forbidden, but in reality weak optical transitions of the exciton. The origin of the violation of the forbidden selection

rules was systematically investigated and allowed us to obtain a direct optical measurement of the resident electron g-factor.
A precise knowledge of the resident electron g-factor as well as the deterministic spin initialization allowed us to perform the first microwave electron spin resonance experiment on a single quantum dot.

[1] Kroutvar et al., Nature **432**, 81 (2004). [2] Atatüre et al., Science **312**, 551 (2006).
[3] Högele et al., Appl. Phys. Lett. **86**, 221905 (2005). [4] Warburton et al., Nature **405**, 926 (2000).
[5] Högele et al., Phys. Rev. Lett **93**, 217401 (2004).

DFT Study of Metal-Molecule-Metal Interfaces: Investigation of Au(111) - Self Assembled 4-Mercaptopyridine - Pd Junction

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The various methods (DFT, MP2) and models (periodic, cluster) of modern quantum chemistry have been applied to investigate the structure effects as well as electronic effects participating in the metal–organic molecule-metal system.
Recently an electrochemical approach combining elements of currentless and electrodeposition was used to deposit a self-assembled monolayer (SAM) of 4-mercaptopyridine on a (111)-oriented Au single crystal [1, 2].

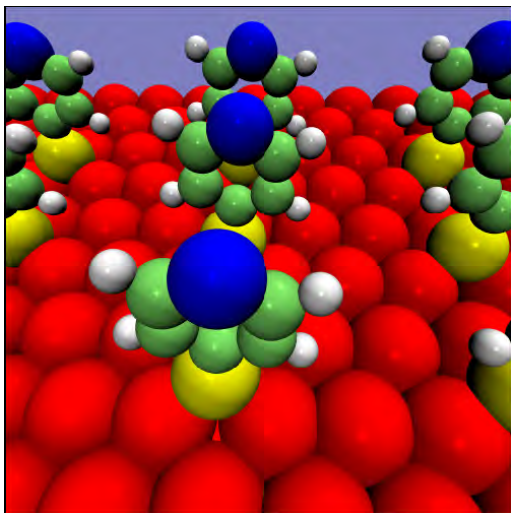

Fig. 1 *Example of the structure of 4-mercaptopyridine molecules on Au(111) studied by DFT calculations.*

In a second step, two-dimensional Pd islands were prepared on top of the SAM thus creating a molecular device consisting of a metal-molecule metal junction. A main goal of the present study is to extend our understanding of these systems in order to interpret various experimental features (*e.g.* UPS spectra or STM images) at the atomic scale level.
The calculations show 4-mercaptopyridine at low coverage can occupy several interaction sites on Au(111). The molecule is significantly tilted from the surface normal in all the sites. The most stable site bridge-hollow is about 0.2 eV more stable than the hollow and on top sites. A denser packing leads to more upright configurations and a lowering of relative energy differences between particular site types (Fig. 1 shows one of the structures addressed in the calculation).
DFT calculations indicate in agreement with the experiment that there is a strong interaction between the molecules and the Pd islands. The DOS spectra show significant reduction of DOS close to Fermi level due to the one-folded Pd...N interaction. The qualitative agreement was achieved between the experimental and calculated DOS spectra of Pd layers interacting with 4-mercaptopyridine self-assembled on Au(111) crystal.

This work has been supported by the Deutsche Forschungsgemeinschaft (DFG) within SFB 569.

[1] V. Ivanova, T. Baunach, and D. M. Kolb, Electrochim. Acta **50**, 4283 (2005).
[2] H.-G. Boyen, P. Ziemann, U. Wiedwald, V. Ivanova, D. M. Kolb, S. Sakong, A. Groß, A. Romanyuk, M. Büttner, and P. Oelhafen, Nature Mater. **5**, 394 (2006).

Transfection Statistics from EGFP-Fluorescence Data

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We report on the stochastic nature of artificial gene transfer based on high content analysis of single cell fluorescence time courses *in vitro*. Using enhanced green fluorescence protein (EGFP), expression of typically 500-2000 individual cells was monitored. A wide range of expression values was found with typically 10^6–10^7 EGFP molecules per fluorescent cell. In general, steady state expression is well described by a linear chemical rate-model, predicting a total expression factor of $3{\cdot}10^6$ EGFPs per plasmid. Use of destabilized EGFP, which has a shorter half-life, scales the distribution of expression levels as expected. The variance in maximal expression arises from rare events of successful transfection. Assuming a Poisson process for transfection, we find typically 1.3–1.4 plasmids per fluorescent cell. Consistently, cotransfection of equal amounts of EYFP and ECFP encoding plasmids yields mostly EYFP- or ECFP-only expression and a minority of cells with mixed color. Hence, we identified variability in protein numbers to arise from the stochastic nature of the delivery process rather than from cell-to-cell variability in gene expression.

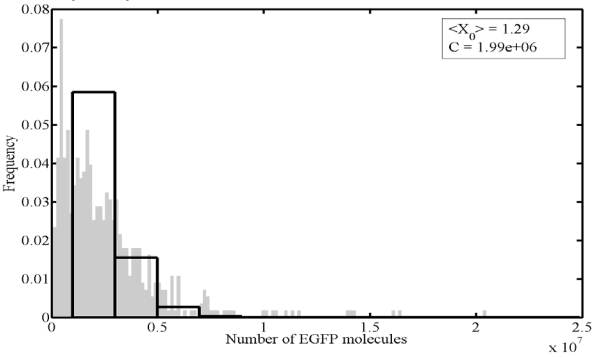

Fig. 1 *Histogram of expressed EGFP molecules are plotted in greyscale. The corresponding distribution of plasmids is drawn in black bold lines. Mean plasmid number in fluorescent cells and expression factor are given in insert.*

Physical and Chemical Parameters Controlling the Size and the Morphology of Nanosized Zeolite BEA

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Zeolite BEA is a tridimensional channel system zeolite, usually obtained with Si/Al ratios in the range from 9 to infinity. The zeolite is highly interesting for various applications in the classical field of catalysis, due to the possible strong acidity of the material, but also for adsorption of hydrophobic molecules. This zeolite can also be used for emerging applications, for instance to prepare low-k dielectric constant material. Among the properties needed to design an appropriate material used for low-k dielectric constant applications, the hydrophobicity character is probably the most important. The hydrophobicity-hydrophilicity balance of zeolites can be controled by varying the Si/Al ratio in the framework. Hence, the more siliceous the framework, the less the water amount adsorbed, the more hydrophobic the zeolite. Therefore, nanosized BEA is an excellent candidate for the preparation of low-k dielectric constant layers and films. Unfortunately, the size of the zeolite particles decreases with the increase of the aluminum content [1,2],

and as consequence, the smallest particles have low Si/Al ratio, which is not suitable for low-k dielectric constant materials.
The aim of this work is to investigate the influence of the physical and chemical parameters on the evolution of the particle size of zeolite BEA, the morphology, and the chemical composition of the materials.
Several parameters have been investigated such as the influence of alumina source (Al isoprpoxide or Al tri,sec-butoxide), the silica source (Cab-O-Sil or tetraethoxysilane), and the temperature (100 or 140°C). It turned out that, keeping the composition of the precursor gel constant, the smallest particle size distribution has been obtained with Al tri,sec–BuO as alumina source and with Cab-O-Sil as silica source as can be seen using DLS (Fig. 1).

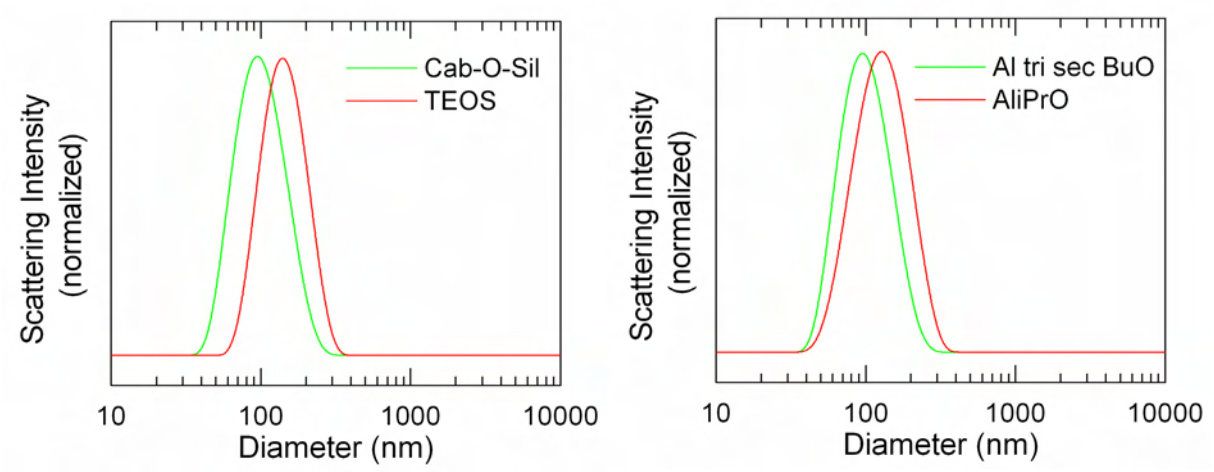

Fig. 1 *Dynamic Light Scattering (DLS) of the colloidal particles obtained by varying the silica source (working with Al tri,sec-BuO as alumina source) (left), and by varying the Alumina source (working with Cab-O-Sil as silica source) (right).*

[1] M.A. Camblor, A. Corma, S. Valencia: Microporous Mesoporous Mater., **25**, 59 (1998).
[2] M.A. Camblor, A. Corma, A. Mifsud, J. Perez-Pariente, S. Valencia, in: H. Chon, S.-K. Ihm, Y.S. Uh (Eds.), Progress in Zeolite and Microporous Materials, Stud. Surf. (1996) Sci. Catal. **105**, 341 (1997).

A Serial Triple Quantum Dot in the Few Electron Regime

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A serial triple quantum dot (TQD) has been laterally defined by means of metal split gates on an AlGaAs/GaAs-heterostructure. We discuss charge stability diagrams of the TQD in the few electron regime measured at low temperatures with a nearby quantum point contact as charge detector. In addition, we investigate electronic transport properties of the TQD. A variety of co-tunnelling processes, including quantum cellular automata switching are observed in the vicinity of quadruple- points of resonant single electron tunnelling.

Interfacial Self-Assembly of the Binary System PTCDI and Melamine on Graphite

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Scanning Tunneling Microscopy (STM) was utilized to investigate self-assembly of perylene tetra-carboxylic di-imide (PTCDI) and 1,3,5-triazine-2,4,6-triamine (melamine) at the liquid-solid interface at room temperature. In order to reveal the role of the solvent for the formation of interfacial supramolecular structures, we compared two different solvents, namely hexanoic ($C_6H_{12}O_2$) and nonanoic ($C_9H_{18}O_2$) acid. In addition the relative concentrations of both compounds in binary solutions were varied.
A distinct morphology of the supramolecular structures was found for the two solvents used: Hexanoic acid resulted in irregular, small unconnected patches. In contrast to hexanoic acid, the structures appear more regular and exhibit less defects when prepared with nonanoic acid as solvent. In both solvents binary solutions precipitate six-fold honeycomb structures. The internal structure, however, deviates considerably for the two solvents. In hexanoic acid a periodic arrangement of putatively empty cavities was found, whereas in the case of nonanoic acid explicit patterns inside the cavities were reproducibly observed. A model which explains the difference by a distinct influence of the solvent is presented.

Observation of Chaperonin-Mediated Protein Folding by Single-Molecule FRET

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Chaperonins can modulate the rate and yield of protein folding by binding and encapsulating substrate proteins. Using single molecule Fluorescence Resonance Energy Transfer and Pulsed Interleaved Excitation (PIE), we have investigated the conformations and dynamics of these substrates both unbound and bound to the *E. coli* chaperonin GroEL. A slow folding mutant of the maltose binding protein (MBP(DM)) was selected as a model system for investigating the conformations as it interacts with GroEL and transits through the folding cycle. In our study, we observe two conformations of MBP(DM) when bound to GroEL in the nucleotide-free state, one of which is even more expanded than the unfolded protein. This unfolding process though in principle can remove kinetic traps, is shown not to be a necessary event for rate acceleration of refolding. We also demonstrate that nucleotide and GroES binding to the GroEL-MBP(DM) complex leads to progressive collapse of the unfolded protein in agreement with the decrease in hydrophobic surface area of GroEL.

Organic Thin Film Transistors: Molecular Structure and Response to Excitation by Light

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Field effect transistors based on crystalline thin films of small organic molecules are an emerging technique for applications such as large area displays. Presently, the molecular arrangement is not known in detail and the physical mechanism of charge transport in such devices is still under debate. Here, we present the molecular structure of the pentacene unit cell in thin film transistors as determined from x-ray diffraction experiments. Furthermore, spatially resolved photoresponse has been measured on pentacene thin film transistors. The technique allows for the investigation of the response to illumination with a spatial resolution in the submicron regime. Enhanced photoresponse was observed close to the negatively biased electrode. We have modelled the experiment using drift-diffusion simulations and a photo doping mechanism. In this model holes in pentacene can drift, while electrons remain almost fixed at their site of generation until they recombine.

How Does a Straight Polymer Relax?

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Although the relaxation dynamics of semiflexible polymers from an initially straight conformation has been discussed extensively in the recent literature, this seemingly simple problem involves nontrivial physics that is not yet completely understood. This is partly due to the ambiguous meaning of "initially straight", for which various realizations are conceivable. The filament could be stretched (by optical tweezers, electric fields, elongational flows, ...), but it could also be quenched, i.e., prepared in an initial low-temperature environment. In all cases, the longitudinal contraction is driven by the same purely stochastic forces, yet the resulting deterministic growth laws for pertinent observables reflect for short times fundamental differences in the underlying relaxation processes. We present a comprehensive explanation how these differences emanate from the various realizations and how they give rise to universal long-time relaxation. Further, we compare our theoretical results to recent experiments and simulations.

Picosecond Waveguide Spectroscopy

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[2] *Institut für Angewandte und Experimentelle Physik, Universität Regensburg, D-93040, Regensburg, Germany*

We perform time-of-flight experiments on propagating electromagnetic pulses within a waveguide circuit exploiting Auston-switches. Generally, Auston-switches consist of two voltage-biased metal electrodes fabricated on top of a photoconductive substrate [1]. The electrodes are short-cut as soon as a laser pulse excites charge carriers within the substrate. The response time of such a chip-integrated photo-switch depends both on the temporal duration of the laser pulse and the recombination lifetime of the optically induced charge carriers within the substrate. In our experiment we utilize low-temperature grown GaAs as a substrate material in combination with femtosecond laser pulses of a titanium:sapphire laser. We achieve response times in the range of a few picoseconds.

As depicted in Figure 1, Auston-switches can be easily incorporated into lateral waveguide circuits. An optical pump-pulse excites an electromagnetic pulse in the voltage-biased coplanar waveguide. In turn, the electromagnetic pulse starts to travel along the coplanar waveguide. A probe-finger senses the transient electric field of the traveling pulse as soon as an optical probe-pulse excites charge carriers within the second Auston-switch at the probe-finger-position. The time-delay between the pump- and the probe-pulse is set with a delay-stage, which allows tracing the propagation of the electromagnetic pulse in the time domain.

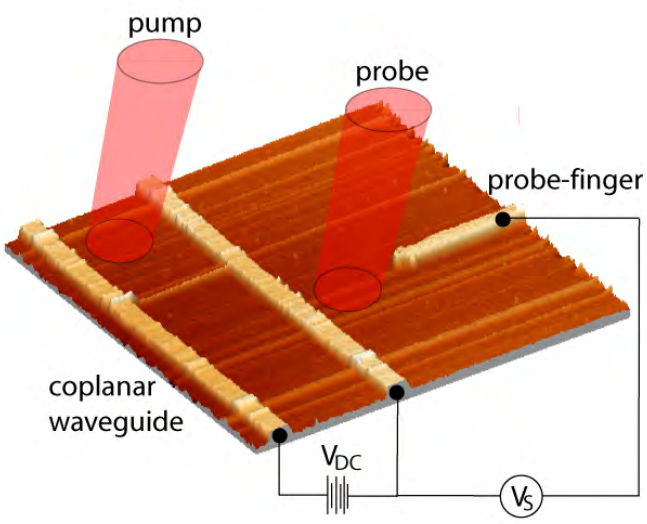

Fig. 1 *A pump-pulse initiates the propagation of a transient electromagnetic pulse within a voltage-biased waveguide. The propagating pulse is detected by focusing a second short optical probe-pulse between the probe finger and the waveguide. The voltage V_S as a function of the time-delay between the pump- and the probe-pulse gives insights into the dispersion of the propagating electromagnetic pulse.*

In the presentation we will show time-of-flight experiments on picosecond electromagnetic pulses propagating in waveguides with varying geometries. In particular, we show the dependence of the propagating pulses on the bias-voltage V_{DC}, the optical intensity, the propagation distance, and the photon wavelength. The results are compared to theory and finite element simulations [2].

[1] D.H. Auston, IEEE J-QE **19**, 639 (1983).
[2] G. Hasnain, K. Goossen, and W. Knox, Appl. Phys. Lett. **56**, 515 (1990).

Nanoscale Optical Imaging of Single Carbon Nanotubes

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[2]*The Institute of Optics, University of Rochester, Rochester NY, USA*

Single-walled carbon nanotubes (SWCNTs) attracted great attention as model systems for quasi-one-dimensional quantum wires with great promise for applications in photonics, opto- and nanoelectronics. SWCNTs are unique since both photoluminescence (PL) and Raman scattering can be observed simutaneously under the same experimental condition [1] (see Fig.1). We use PL and Raman scattering spectroscopy to study electronic and vibrational properties of semiconducting nanotubes.

Optical techniques with nanoscale spatial resolution are essential for resolving inhomogeneities along individual SWCNTs. Our method is based on the local field enhancement effect at a laser illuminated metal tip, giving a spatial resolution down to 10nm. We observed non-uniform Raman scattering and PL along the same individual nanotube [2,3]. The variation of emission energies is attributed to the fluctuations in dielectric constant of the local environment. This technique is ideally suited to study hybrid nanoscale systems such as DNA-wrapped SWNTs and QD-SWNTs. We report on our first result on these systems.

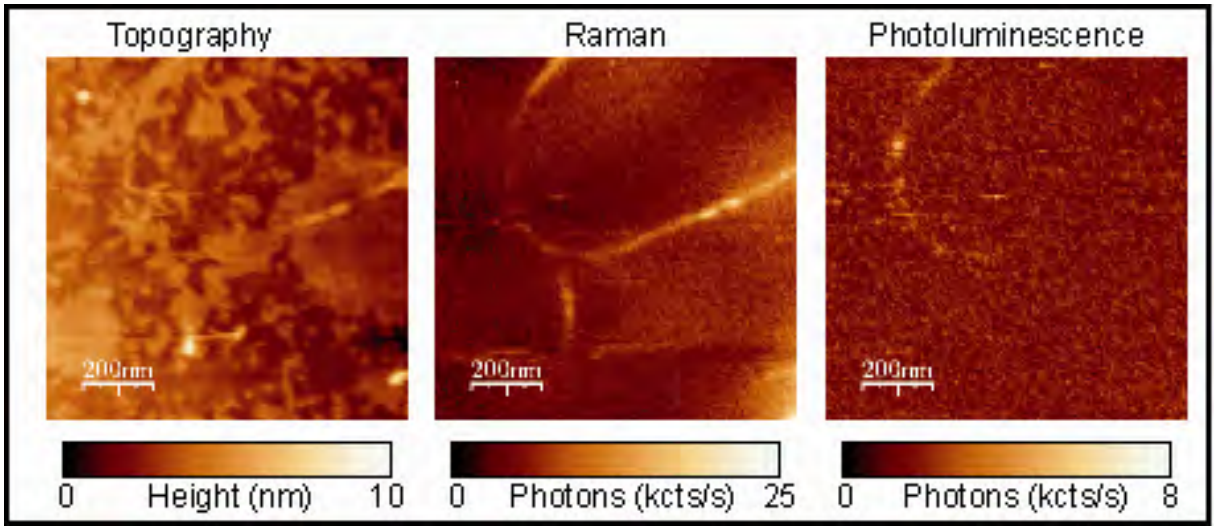

Fig. 1 *Topography of DNA wrapped single nanotube (a), near-field Raman scattering (b) and photoluminescence (c) images of the same nanotube.*

[1] A. Hartschuh et al., Science **301**, 1354 (2003).
[2] A. Hartschuh et al., Phys. Rev. Lett. **90**, 095503 (2003).
[3] A. Hartschuh et al., Nano Lett. **5**, 2310 (2005).

Electron Transport in Carbon Nanotubes induced by Surface Acoustic Waves

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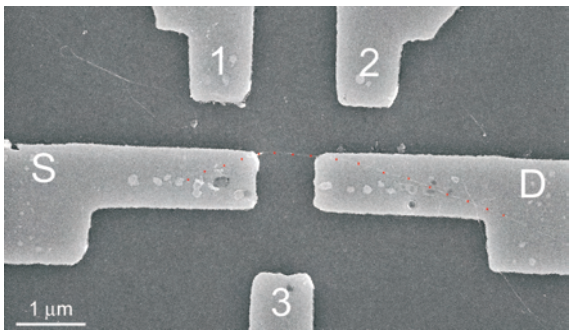
Charge transport through carbon nanotubes (CNT) is investigated since their discovery in 1991. They show one-dimensional conducting properties as well as quantum dot behaviour in certain cases.
A new approach for current transport is the application of surface acoustic waves to drive electrons through CNT quantum dots.
Therefore contact structures electrodes (Ti/Au, Ti/Pd) are processed on a piezoelectric $LiNbO_3$-substrate and dissolved CNT are aligned between source (S) and drain (D) electrodes (tube-on-metal). Contact barriers are arising between metal leads and CNT leading to formation of a quantum dot in the CNT. Additional prepared gate electrodes (1, 2 and 3) allow a manipulation of the energy levels in the quantum dot.



The height of these barriers can be influenced by the electric potential attended to the SAW. Choosing the wavelength of the SAW double the size of the electrode distance the barriers are modulated alternately. That means the source barrier is lowered and can be passed by an electron while the drain barrier is raised preventing the electron from leaving the dot directly. Half a wavelength later the influence is inverted and the electron can leave the quantum dot.
Thus one electron per wave cycle is transported through the CNT resulting in quantized current which can be calculated as I = e·f, (e: elementary charge, f: frequency of the SAW).

Structure and Dynamics of Crystalline Protein Layers Bound to Supported Lipid Bilayers

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We model peripheral membrane proteins at the surface of cell membranes using streptavidin and avidin bound to biotinylated lipids in a supported lipid bilayer (SLB) at the solid-liquid interface. Using X-ray reflectivity and simultaneous fluorescence microscopy [1], we characterize the structure and fluidity of a protein layer containing two-dimensional streptavidin crystals bound to a SLB (see Fig.1). Single lipid bilayers provide a biologically-relevant environment for *in-situ* investigation of membrane-associated proteins interacting with lipids.

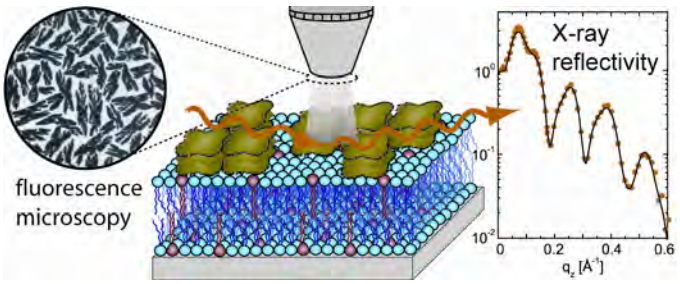
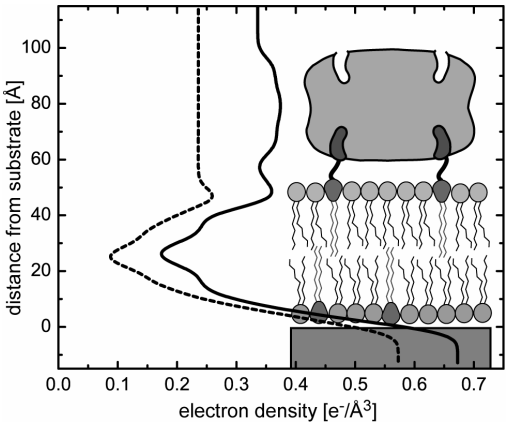


Fig. 1 *Sketch of a protein layer adhered on top of a solid supported lipid bilayer. The 2D structure and fluidity is investigated via fluorescence microscopy. X-ray reflectivity provides the nanoscale density profile.*

Our model membranes are single bilayers of 90% SOPC and 10% biotin-X-DPPE on silicon oxide substrates with average roughness of ~ 3 Å. Using continuous bleaching [2, 3], we measure a 10-15% decrease in the fluidity of the SLB after protein layer formation. We propose that this reduction in lipid mobility is due to a small fraction (~ 4%) of immobilized lipids bound to the protein layer that create obstacles to membrane diffusion [2].



Fits to our X-ray reflectivity data show a ~ 40 Å thick layer of protein and we resolve the ~ 8 Å layer separating the protein from the bilayer (Fig. 2). We suggest that the separation provided by this water layer allows the underlying lipid bilayer to retain its fluidity and stability [2].

Fig. 2 *Electron density profiles of SLBs with a protein layer (black) and without protein (dashed line). Profiles are extracted from fitting the reflectivity.*

[1] C. Reich, M. B. Hochrein, B. Krause and B. Nickel, Rev. Sci. Instrum. **76**, 095103 (2005).
[2] M. R. Horton, C. Reich, A. P. Gast, J. O. Rädler and B. Nickel, submitted (2007).
[3] C. Dietrich, R. Merkel, R. Tampé, Biophysical Journal **72**, 1701-1710 (1997).

Intracellular Transport Meets Spintronics

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Traffic phenomena occur in biological contexts as well as in mesoscopic quantum systems. Molecular motors move along parallel one-dimensional filaments in cells, serving as biological engines. On the other hand, spintronic devices aim to exploit quantum effects, the spin of electrons, when passing these trough nanowires. Here, we present a generic model that underlies both situations [1]. Allowing particles in an exclusion process to possess internal states, the latter account for several parallel lanes as well as different spin states, where Pauli's exclusion principle is respected. Exploring the system's behavior, we find that it can be tuned by controlling the particle fluxes at the boundaries. In particular, a spontaneous polarization may occur at a certain spatial position and, upon changing the fluxes at the boundaries, be driven in or out of the system. We derive the shape of the density profiles as well as resulting phase diagrams analytically by a mean-field approximation and a continuum limit. Continuous as well as discontinuous lines of phase transition emerge, their intersections induce multicritical behavior. Domain wall theory allows us to analytically study the delocalization of a domain wall when approaching a delocalization transition.

[1] T. Reichenbach, T. Franosch, E. Frey, Phys. Rev. Lett. **97**, 050603 (2006).

Surface-Enhanced Raman Scattering (SERS) in Single Gold Nanoparticle Dimers

M. Ringler[1], T. A. Klar[1], A. Schwemer[1], J. Stehr[1], A. Nichtl[2], K. Kürzinger[2], G. Raschke[1], R. T. Phillips[3], and J. Feldmann[1]

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We have used protein-ligand interaction to assemble gold nanoparticle dimers, which have a well-defined SERS hot spot in the inter-particle gap. Surface-enhanced Raman scattering spectra from individual protein-linked gold nanoparticle dimers were measured, while at the same time the inter-particle geometry was monitored through Rayleigh scattering spectroscopy of the coupled particle plasmon. The Raman emission and Rayleigh scattering spectra are strongly correlated. Raman emission from the dimer hot spot can only be excited when the polarization of the Raman laser beam is parallel to the dimer axis. SERS spectra fluctuate both in shape and amplitude. We discuss possible explanations of these fluctuations.

Growth of $Cu_3(BTC)_2$ Thin Films on Gold Substrates Functionalized With Self-Assembled Monolayers

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Thin porous films are of interest for potential applications in the fields of molecular separation, catalysts and chemical sensing. Recently, the preparation of patterned, thin films of MOF-5 on gold substrates functionalized with –COOH terminated SAMs has been published [1]. In addition, the oriented growth of inorganic compounds such as calcium carbonate on functionalized surfaces was shown [2], and has inspired us to explore the possible oriented growth of metal organic frameworks (MOFs) on self-assembled monolayers.
The preparation of thin crystalline films of porous copper 1,3,5-benzenetricarboxylate ($Cu_3(C_9H_3O_6)_2(H_2O)_3 \cdot xH_2O$ referred to as $Cu_3(BTC)_2$) [3] on gold substrates was performed. Here we focus our attention on the influence of different functionalized self-assembled monolayers on the orientation of $Cu_3(BTC)_2$ crystalline thin films. In order to understand the morphological evolution of such films, an investigation of the crystal growth of $Cu_3(BTC)_2$ on different functionalized self-assembled monolayers on gold substrates was performed.
Drastically different orientations of $Cu_3(BTC)_2$ crystals result from the functionalization of the SAM, showing orientation in [111]-direction for –OH and in [100]-direction for –COOH functionalized SAM. Diffraction patterns of $Cu_3(BTC)_2$ on –OH terminated SAMs show increasing reflection intensities with increasing reaction time. Scanning electron-micrographs show, in detail, for –OH functionalized SAMs the morphological development of the crystals from "rounded"-octahedra of 150-200 nm in diameter at the first stages to 1 µm-sized well-shaped crystals after 45 h reaction time.

[1] S. Hermes, F. Schroeder, R. Chelmowski, C. Woell, R. A. Fischer, J. Am. Chem. Soc. **127**, 13744 (2005).
[2] J. Aizenberg, A. J. Black, G. M. Whitesides, J. Am. Chem. Soc. **121**, 4500 (1999).
[3] S. Chui, S. Lo, J. Charmant, A. Orpen, I. Williams, Science **283,** 1148 (1999).

Pulling on Single Siloxane Molecules

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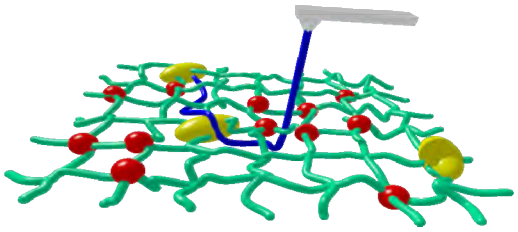
Siliconelastomers are high-performance materials, used in a wide field of applications. Among their remarkable qualities are low temperature dependence of the mechanoelastic properties, high resilience against thermooxidation, high flexibility at low temperatures, inadhesive behavior and physiological harmlessness. On the other hand siliconelastomers also have some disadvantages like low ultimate mechanical strength, vulnerability to hydrolytic reagents and moisture expansion in unpolar environment.



Single molecule force spectroscopy using an AFM offers a unique possibility to investigate the mechanical performance of single siloxane polymer chains and their fixation in thin polymer networks. Both theoretical as well as experimental single molecule measurements can help to gain insights into the properties of the Si-O bond. A vital step towards that end is to achieve the attachement of the elastomer to the AFM cantilever and the substrate by covalent bonds. This poster shows the current state of this project.

Annexin Binding to Solid Supported Membranes

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We study the interaction of Annexin II with anionic lipid membranes using neutron and x-ray synchrotron scattering techniques. Annexin II interacts with negatively charged phospholipids in a calcium dependant manner. Furthermore annexin II is able to bind two adjacent membranes [1]. The solid supported membranes were achieved by vesicle spreading of lipid mixtures of neutral (POPC) and negatively charged (POPS) phospholipids on silicon substrates. The protein was provided by B. Windschiegl and C. Steinem, Universität Regensburg. The system was characterized by fluorescence microscopy the same samples were then measured with x-ray reflectivity at Hasylab (D4) and ESRF (ID01). With this method we gained information about the homogeneity, fluidity and thickness of the underlying membrane. Apart from that measurements with neutron reflectometry at PSI (AMOR) will be presented. In future experiments we will use neutron reflectometry and GISANS at FRM2 (REFSANS) to visualize the protein layer. Here we want to benefit from the possibility of contrast variation due to the scattering length density difference between deuterium oxide and water and visualize membrane structure prior and after protein binding.

[1] M. Menke, M. Ross, V. Gerke, and C. Steinem, Chem. Bio. Chem **5**, 1003 (2004).

Beam resonators under tensile stress

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Nanomechanical beam resonator show a high Q-factor under high tensile stress, as reported in [1]. This result is tried to reproduce with more complex resonators, the dynamic dependence on applied tensile stress is investigated.

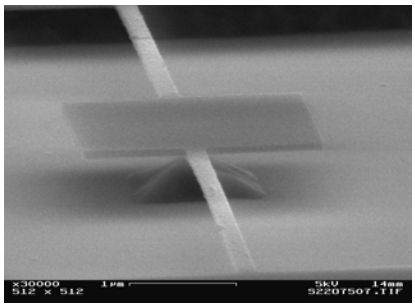

Fig. 1 *SEM picture of a resonator.*

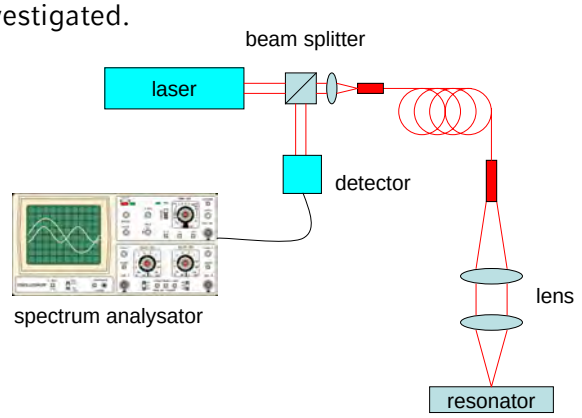

Fig. 2 *Schematic Setup.*

The resonators are defined by means of standard lithographical methods. The resonator is driven using the volume modes created by a thin piezo. The resulting amplitude is measured using an interferometric setup, where the cleaved end of the glass fiber and the resonator form a cavity.

[1] Scott S. Verbridge, Jeevak M. Parpia, Robert B. Reichenbach, Leon M. Bellan and H. G. Craighead, Appl. Phys. Lett. **99** (2006).

High-Throughput Methods in Hydrothermal Syntheses

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High-throughput methods and combinatorial approaches are concepts that were originally developed for the design of active pharmaceutical ingredients. Nowadays they are well established in materials synthesis [1]. In contrast to conventional syntheses, where different substances are synthesized and characterized one by one, the aim of a high-throughput approach is the parallel synthesis of many substances as well as their fast and consequent characterization. Moreover, in a combinatorial approach various components are combined in one step and varied in their stoichiometric composition. Additionally, miniaturization leads to an economic use of expensive or elaborated substrates.

This method is especially useful when trial and error approaches have to be used and vast parameter spaces are to be investigated as it is usually the case in hydrothermal synthesis of inorganic materials, e.g. zeolites and aluminophosphates. In our group a high-throuput methodology for hydrothermal syntheses based on a custom-made multiclave system and a high-throughput X-ray diffractometer has been developed and optimized.

Using this high-throughput approach various scientific aims were being pursued in our group. For the synthesis of porous aluminophosphates we have focused on the substitution

of expensive templates by more economic substances, thereby making this group of solids more interesting for industrial applications. Here were present the structure of a new aluminophosphate based on urea as the structure-directing agent. In another project different, chiral ammonium salts built up in an acetalisation reaction were synthesized and tested for their use as structure-directing agents in zeolite synthesis [2].

[1] N. Stock and T. Bein, Angewandte Chemie **116**, 767 (2004).
[2] M. Davis et al., Nature **425**, 385 (2003).

Synthesis and Optoelectronic Transport Properties of Hybrid Systems Made of Single Wall Carbon Nanotubes and Nanocrystals

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Colloidal II-VI semiconductor nanocrystals (NCs) have fascinating optical properties, and therefore they are widely used in biolabeling and optoelectronic applications. In this project, hybrid systems made of individual colloidal NCs and single wall carbon nanotubes (SWNTs) are synthesized via a self-assembly technique, taking advantage of the strong non-covalent biotin-streptavidin-hydrogen bond interaction. To this end, the SWNTs are first functionalized with biotin molecules and then bound to NCs which are covered with streptavidin molecules.
Individual hybrid systems are adsorbed onto an insulating SiO_2 wafer, analyzed by atomic force microscopy, and finally contacted by Pd electrodes using electron beam lithography. The hybrid systems are characterized using optoelectronic charge transport measurements under resonant optical excitation of the SWCNTs and the NCs, respectively. In addition, quantum transport measurements at low temperature allow the observation of single electron effects such as the Coulomb blockade [1].

[1] T. Smorodin, U. Beierlein, J.P. Kotthaus, Nanotechnology **16**, 1123 (2005).

Resonant Photoluminescence Up-Conversion in a Multi Quantum Well Structure Mediated by Surface Acoustic Waves

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We have investigated the excitation emission spectrum of a multi quantum well (MQW) structure under the influence of a surface acoustic wave (SAW).
Electron-hole pairs can be excited by laser light in semiconductor structures which form excitons at low temperatures.
The recombination of electron-hole pairs leads to emission of photoluminescence (PL) light. This emission energy is in general equal of smaller than the energy of the optical excitation source. In quantum well (QW) structures the emission energy is defined by the lowest quantized energy levels.

PL up-conversion means that the energy of emitted photons is higher than the excitation energy. Such a process can be observed in MQW structures with QWs of different widths (see Fig. 1) by applying a SAW. We explain this effect through a dynamic conduction and valence band modulation leading to a resonant charge carrier population of QWs.

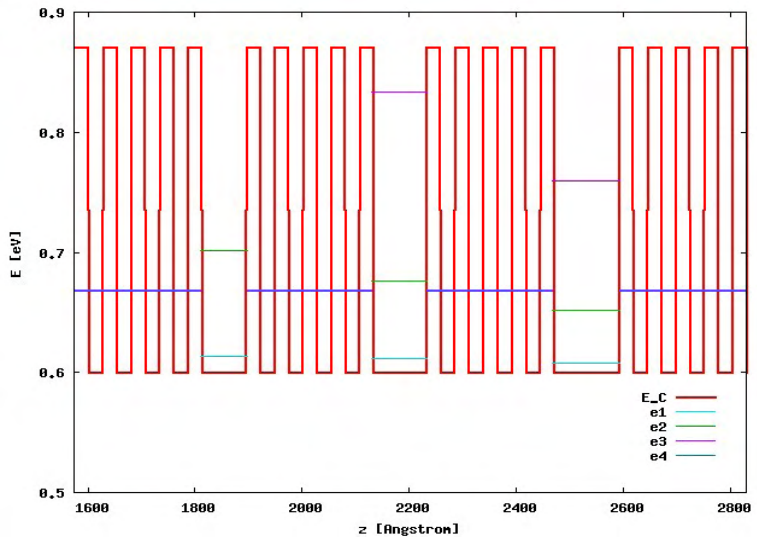

Fig 1 *Simulated conduction band diagram of a MQW structure. There are shown three QWs, the supperlattices between them and the quantized electron states.*

Interaction of Hot Electrons in a Two-Dimensional-Electron-Gas

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We electrostatically define a tunnel barrier towards a broad two dimensional channel in a high mobility, two-dimensional-electron-gas (2DEG) of a standard GaAs/AlGaAs heterostructure.
By applying a Source-Drain voltage, hot electrons can be injected via the barrier into the channel. Quantum Point Contacts along the channel are used to determine the electrons energy spectrum at different distances from the barrier. As expected hot ballistic electrons are generated by the barrier. Strikingly, some of these electrons have a kinetic energy considerably larger than the applied potential drop across the barrier. A simple model shows that this observation can be explained by scattering between hot electrons. These scattering-processes are in competition to the interaction of the hot electrons with Fermi-sea electrons leading to a thermal distribution of the electron gas. In addition, the emission of acoustic phonons will cool the 2DEG in the channel. Focusing experiments confirmed a high scattering rate nearby an injection barrier.

Spectroscopic Nearfield Microscopy Powered by THz Frequency Combs

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Based on two Ti:Sa femto second lasers we utilize a coherent frequency-comb spectrometer in the THz regime (0.3-2.5 THz), which allows rapid acquisition of 375 spectra/second at a snapshot time of 3µs per spectrum without moving parts in the setup.

This new spectrometer will be used to illuminate and read out a scattering scanning near-field microscope (s-snom). It therefore allows to overcome the diffraction-limited resolution of THz waves, (1THz corresponds to a wavelength of 300µm!) as the near field focus is only limited by the tip dimensions.

Fluctuating Polymer Rings

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Geometric constraints have been proven to induce interesting behavior on polymers. We consider polymer bundles confined to a ring-like structure. This constraint causes an additional bending stiffness and coupling of bending and twisting modes. To describe polymer bundles we derived an analytic model for a semiflexible polymer ring with anisotropic bending stiffness and twist stiffness. This model predicts the mean square diameter of a ribbonlike ring thus giving a novel parameter to determine bending and twist stiffnesses of polymer bundles in experiments.
Furthermore the asymmetric shape of polymer rings with symmetric cross section is investigated over the whole range of flexibility by Monte Carlo simulations. For semiflexible polymers a scaling argument explains the change of the polymer's asphericity with increasing flexibility.

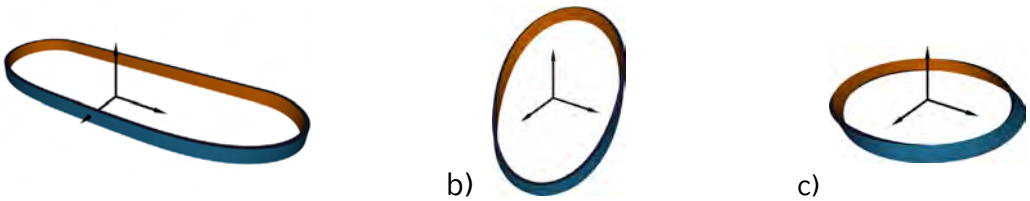

Fig. 1 *Depicted are the first bending and twisting modes to show the coupling of out-of-plane bending and twisting to each other and to in-plane bending induced by the ring geometry: a) independent in-plane mode, b) out-of-plane bending induces both in-plane bending and twisting, c) twisting causes both in-plane and out-of-plane bending .*

Poster Sessions

Tuesday, 13.02.
Marktsaal, Mauterndorf village

da Como	Enrico
Damsma	Gerke
de Bruin	Karla
Druzhinina	Tamara
Gaudreau	Louis
Harbusch	Daniel
Hennemeyer	Marc
Herzer	Nicole
Höfling	Felix
Holleitner	Alex
Hrelescu	Calin
Ivanchenko	Sergey
Jamitzky	Ferdinand
Katayama	Yoshihiko
Kirstein	Johanna
Kraus	Robert
Kroner	Martin
Kucera	Jan
Kuhr	Jan-Timm
Ludwig	Stefan
Maier	Anne-Kathrin
Müller	Barbara Katrin
Obermayer	Benedikt
Prechtel	Leonhard
Qian	Huihong
Reichenbach	Tobias
Ringler	Moritz
Schwaderer	Peter
Unterreithmeier	Quirin
Vieyra Villegas	Hugo Abdiel
Vögele	Xaver
von Ribbeck	Hans-Georg
Walch	Hermann
Weiss	Kathrina
Winkler	Karen

Thursday, 15.02.
Rittersaal, Mauterndorf castle

Abel	Benjamin
Cauda	Valentina
Döblinger	Markus
Engelke	Hanna
Georgiadou	Dimitra
Hallermann	Markus
Helmer	Ferdinand
Hennig	Martin
Horton	Margret
Huth	Martin
Kecht	Johann
Keilbach	Andreas
Kobler	Johannes
Kucerova-Kosova	Gabriela
Larlus	Oliver
Nickel	Bert
Plabst	Monika
Regler	Markus
Reich	Christian
Scherb	Camilla
Seidel	Kirstin
van Heyden	Hendrik
Völk	Stefan

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For your notes:

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CeNS Winter School in Mauterndorf "Nanosystems: From Quantum Devices to Biological Engines"

	11.02.07	Monday, 12.02.07	Tuesday, 13.02.07	Wednesday, 14.02.07	Thursday 15.02.07	Friday, 16.02.07
8:45		**Opening**				
9:00		*Darwin meets Nano* **Robert H. Austin**	*The Lateral Structure of Biological Membranes: Lessons from Model Systems* **Luis Bagatolli**	*Extending the Possibilities of Optical Manipulation* **Pál Ormos**	*Structure of Fungal Fatty Acid Synthase: a 2.6 MDa Molecular Assembly Line* **Marc Leibundgut**	*Single-Atom Nanoelectronics and Spintronics for Silicon-Based Qubits* **Bob Clark**
9:45		*Spatial Mutation of Signaling Networks in Living Cells* **Jay Groves**	*Molecular Motors: Single Molecules, Cargo Transport, and Cooperative Behavior* **Reinhard Lipowsky**	*The Two Channel Kondo Effect* **Yuval Oreg**	*Protein Crystal Structures in Biomedical Research: Molecular Players in Proprotein Activation* **Manuel Than**	*Tailoring the Material-Biology Interface* **Christopher K. Ober**
10:30		Break Coffee/tea	Break coffee/tea	Break coffee/tea	Break coffee/tea	Break coffee/tea
11:00		*Single-Molecule Fluorescence Studies of Gene Transcription* **Achilles Kapanidis**	*Mesoscopic to Universal Crossover of Transmission Phase of Multi-Level Quantum Dots* **Jan von Delft**	*Single-Molecule Tracking of mRNA Exiting from RNA Polymerase II* **Jens Michaelis**	*Biological Hydrodynamics* **Gerhard Gompper**	*Uptake of Artificial Viruses into Cells* **Nadja Ruthardt**
11:45		Lunch & informal discussions	Lunch & informal discussions	Lunch & informal discussions	Lunch & informal discussions	**13:30 ski-race**
17:00	**IDK organized** **Students' seminar**	Break coffee/tea	Break coffee/tea	Break coffee/tea	Break coffee/tea	Break coffee/tea
17:15		*Lateral Nanostructures - From Quantum Point Contacts to Triple Quantum Dot Circuits* **TUTORIAL** **Andrew Sachrajda**	*Observation of Electron Entanglement via Coulomb Interactions and via Exchange Statistics* **Izhar Neder**	*Crystallography at the Frontiers* **TUTORIAL** **Anton Meinhart**	*Ex(e/o)rcising Demons: Quantum Brownian Motors* **Peter Hänggi**	*Multiple Scattering of Light: From Anderson Localization to the Brain* **Georg Maret**
18:00			**Poster session I** **(in the "Marktsaal" at Mauterndorf village)**		**Poster session II** **(in the "Rittersaal" at Burg Mauterndorf)**	
18:45						**From 19.00h on Farewell party (open end)**