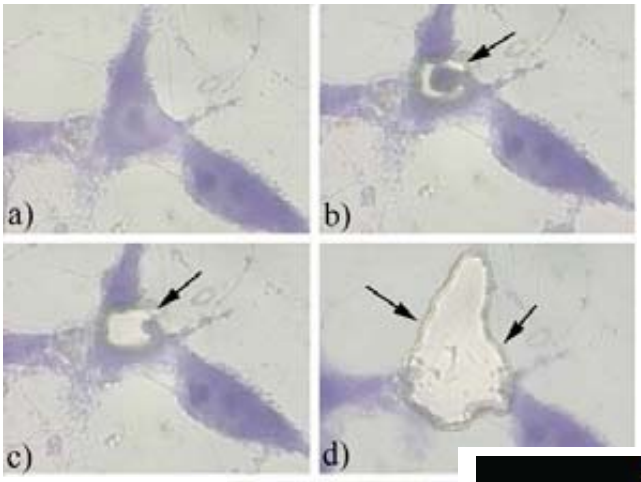
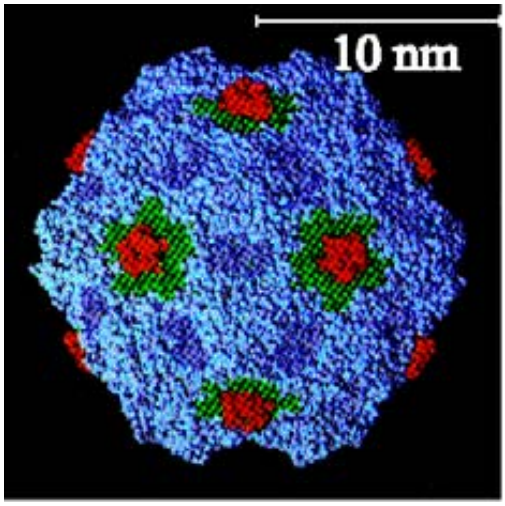
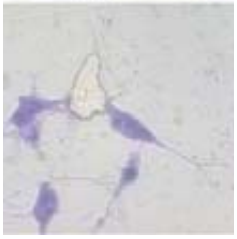
Center for NanoScience
Ludwig-Maximilians-Universität

Annual Report 2000







Introduction

In the year 2000 the activities of CeNS expanded in many ways. The various research efforts of CeNS are illustrated in detail below and demonstrate the success of our joint research efforts through the many publications and invited talks at international conferences. With new members from chemistry (Prof. M. Reichling, Dr. Klaus Meerholz) CeNS is steadily increasing its scientific base. CeNS now has well above 100 graduate students working on diploma and doctoral thesis projects in NanoScience under the guidance of 39 CeNS members at the end of the year 2000. To reflect the interdisciplinary composition of CeNS, Christoph Bräuchle from the chemistry department has followed Jochen Feldmann as a member of the board in November. We thank Jochen for his many contributions to CeNS during the last 2 years. In the year 2000 there have also been 3 faculty positions in experimental and theoretical physics advertised in conjunction with CeNS activities and the large number of highly qualified applicants lets us hope that CeNS will be further strengthened by additional full members in 2001.

Increased interdisciplinary research activities have been stimulated by the various CeNS workshops listed below, which hosted prominent guest speakers from all areas of NanoScience and introduced new students, postdocs and faculty members to the research network of CeNS.

- "Nanostructuring: Self-Assembly vs. Local Manufacturing Techniques", Gene Center, LMU München, June 30, 2000
- "Nanomechanics", Bavarian Alps, August 7 and 8, 2000
- "Research at CeNS 2000"Wildbad Kreuth, October 4 to 6, 2000 (Link)
- "CeNS meets industry", "Physiker im Beruf", LMU München, July 28, 2000 (link)
- "Optoelectronics", Student workshop in the Bavarian Alps, July 28 to 30, 2000

Especially the workshop at Wildbad Kreuth gave members of the Advisory Board the opportunity to get to know many of the CeNS-affiliated doctoral and diploma students and to get acquainted in more detail with the variety of research subjects followed up at CeNS.
In addition to the above mentioned workshops and the weekly "CeNS Oberseminar" (jointly offered with the "Sektion Physik") with many highlight topics, a large number of seminars with many international speakers were part of the weekly CeNS calendar (link) and reflect the international interaction of CeNS. In addition CeNS hosted a large number of prominent guests from all over the world as listed below who interacted fruitfully with CeNS members and students.

The scientific success of CeNS is also reflected by various awards and many outside offers to CeNS members. As a particular highlight, Jochen Feldmann received a prestigious Leibniz Award of the German Science Foundation as well as an attractive outside offer from the University of Vienna. Junior members of CeNS have been offered attractive faculty positions elsewhere and have left LMU to join other research institutes:

- Prof. Jürgen Köhler, chair (C4) at the University Bayreuth
- Dr.. Axel Lorke, chair (C4) at the University Duisburg
- Dr. Manfred Radmacher, professorship (C3) at University Göttingen
- Dr. Tim Salditt, professorship (C3) at the University Saarbrücken
- Dr. Richard Warburton, Reader at Heriot-Watt University, Edinburgh

Dr. Christian Kallinger, Scientific Manager of CeNS since June 1999, left CeNS in November to join the German patent office. We gladly thank him again for his strong commitment which has been of utmost importance, particular in the start-up phase of CeNS.

CeNS members have also submitted a sizable number of patents as listed below and have been unexpectedly successful in business plan competitions and initiating start-up companies. Nanotype (link) won a prize in the final round of the year 2000 Munich Business Plan Competition (link) and has in the meantime successfully been established as a GmbH, starting on the LMU campus. In November 2000 Advalytix also started on the LMU campus as an AG focussing on microfluidics. Jan Behrends, Robert Blick and their joint student Niels Fertig have successfully competed in the Genius Business plan award (link) with new concepts for patch clamp technology. By these success stories others members and students of CeNs have been strongly motivated to write patents and to prepare business plans and we all hope that these spin-off activities of CeNS will continue to thrive.

As a result of the many CeNS activities, CeNS has been approached by outside research agencies, government offices, other german and foreign educational institutions, consulting agencies but also by the popular press for information and advice on issues of Nano-Science and -Technology, often causing astonishment that CeNS is not a large institution with a prominent building and many supporting staff but rather a flexible and efficient low-cost working group living through the voluntary and extraordinary engagement of its members, students and affiliates – and having fun in doing and promoting research and education in the Nanoworld. It is my particular pleasure to thank the whole CeNS family for contributing to the spirit and success of CeNS that by far surpassed all our expectations when CeNS was formed 2 years ago. I very much hope that CeNS will continue its success story in 2001 and beyond through the engagement of all that wish to participate in its mission.

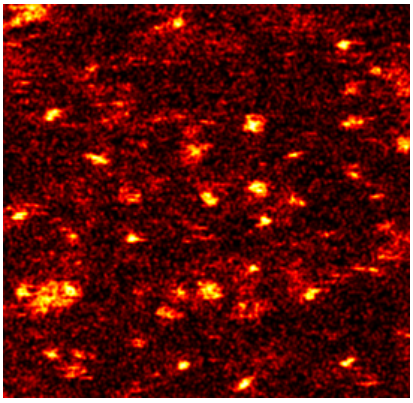
Jörg P. Kotthaus
Spokesman of the board

Research projects:

The members of CeNS all research in the field of nanoscience, but a few key subjects have developed, not least by intense cooperation between the groups:

Electronic and optical properties of nanostructures

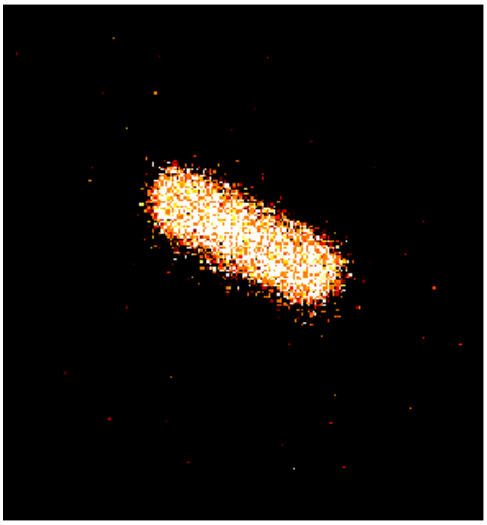
Dynamics and interaction of individual molecular guests in nanoporous host systems (Bräuchle, Deeg, Behrens)



Upon incorporation of molecular guests in nanoporous inorganic molecular sieves, there are very specific interactions between host and guest. Therefore these guest/host systems are a new class of materials with degrees of freedom of the guest molecule drastically different from a molecule in the gas phase, a liquid or a conventional solid matrix. Single molecules can act as local probes for the equilibrium positions and adsorption sites and the electric fields in nanoporous cages and channels. We want to investigate the mechanical degrees of freedom of these guest chromphores like rotation and translation and observe the diffusion of large molecules in the restricted geometry of the nanoporous host by single molecule spectroscopy. The figure shows bright spots due to the fluorescence of individual terrylenediimide molecules in a MCM-48 monolith sample. This is a snapshot from a series of pictures taken with a confocal scanning microscope showing the diffusion of single molecules along the channels of the host. This project is a cooperation with the group of P. Behrens, University of Hannover.

Confocal microscopy and spectroscopy of heterogeneities in chromophor/molecular sieve nanocomposites (Deeg, Bräuchle, Behrens)

In this project heterogeneities in systems of chromophors as guests in molecular sieve nanocomposites as host materials are characterized by confocal microscopy in combination with optical spectroscopy. Central goal is a detailed documentation of the spatial distribution of encapsulated chromophores as well as the heterogeneities of the optical properties. These properties are evaluated as a function of topology, pore size and polarity of the host as well as size, form, electronic properties and concentration of the guest. As far as possible we want to observe directly the formation of the molecular sieve and the evolution of the specific properties of the nanocomposite. This should allow to define the conditions which are necessary to synthesize composites of chromophores in molecular sieves with well-defined properties with respect to spatial distribution as well as optical properties. The Figure



shows fluorescence of an in-situ synthesized sample of stilbene derivative chromophores in an $AlPO_4$-5 host. Although in this case the loading seems to be homogeneous, the spectral properties vary from location to location within the crystal. This project is a cooperation with the group of P. Behrens, University of Hannover.

Single Nanoparticle Spectroscopy (Prof. Jochen Feldmann)

Metal nanoparticles offer the unique possibility to utilize a well-known solid state effect for sensing the direct chemical environment around a nanoparticle. By measuring the particle plasmon resonance of individual gold and silver nanoparticles the identification of extremely low entities of a given substance is possible.

Ultrafast dynamics in quantum dot lasers (Prof. Jochen Feldmann)

Due to their delta-like density of states quantum dot structures exhibit a series of electronic and optical properties not known from semiconductor quantum wells. This has important implications for the performance of quantum dot lasers. The ultrafast dynamics of the optical gain and of the quantum dot laser emission is investigated by femtosecond up-conversion and optical pump and probe experiments.

Optical properties of quantum dots (Prof. Khaled Karrai)

CeNS Investigators R.J. Warburton, C. Schäflein, F. Bickel, D. Haft and K. Karrai
In collaboration with Prof. Pierre Petroff, Materials Department, UC Santa Barbara

Quantum dots or rings are artificial nanometre-sized clusters that confine electrons in all three directions. They can be fabricated in a semiconductor system by embedding an island of low-band-gap material in a sea of material with a higher band-gap. Quantum dots are often referred to as artificial atoms because, when filled sequentially with electrons, the charging energies are pronounced for particular electron numbers; this is analogous to Hund's rules in atomic physics. But semiconductors also have a valence band with strong optical transitions to the conduction band. These transitions are the basis for the application of quantum dots as laser emitters, storage devices and fluorescence markers. One main field of interest is, how the optical emission (photoluminescence) of a single quantum ring changes as electrons are added one-by-one. We find that the emission energy changes abruptly whenever an electron is added to the artificial atom, and that the sizes of the jumps reveal a shell structure.

Quantum computing (Dr. Bert Lorenz (http://www.nano.physik.uni-muenchen.de/lorenz/index.html))

(together with Robert Blick (http://www.nano.physik.uni-muenchen.de/Blick/Blick.html), Laura Pescini and Andreas Hüttel (http://www.akhuettel.de/research/), CeNS)

Quantum computing in solids still is a big challenge. One possible approach is the realization of quantum bits with coupled quantum dots. Here we investigate laterally defined quantum dots confined in AlGaAs/GaAs heterostructures comprising a two-dimensional electron gas with extremely high mobility and large phase relaxation length. Our goal is to study the intricate mechanisms of wave function interaction in these artificial molecules. We probe the wave function entanglement of coupled quantum dots by applying transport spectroscopy at

ultra low temperatures. We determine the strength of this tunnel coupled mode and monitor the magnetic field dependence.
Such a coherent mode can be regarded as the essential quantum bit, being the building block of any quantum computational device in a semiconductor. It still remains to be shown how many operations on these particular qubits are possible and whether it indeed can be integrated with in more complex schemes. In order to study decoherence and disspation effects we realize ultra small suspended structures, e.g. nanowires in Silicon-on-Insulator material, where the lateral dimensions can be reduced down to 5 to 10 nm.

Silicon Nanoelectronics (Dr. Bert Lorenz (http://www.nano.physik.uni-muenchen.de/lorenz/index.html))

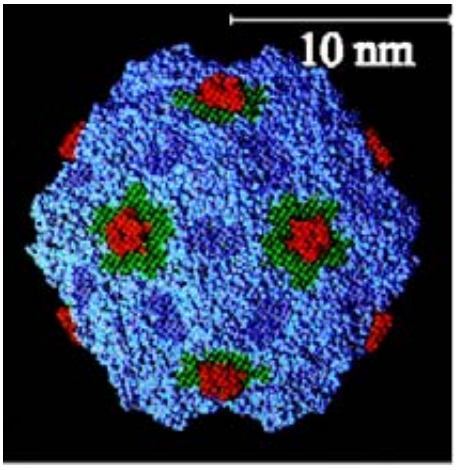
(together with Robert Blick (http://www.nano.physik.uni-muenchen.de/Blick/Blick.html) and Jörg Peter Kotthaus (http://www.nano.physik.uni-muenchen.de/group/joerg.html) , CeNS)

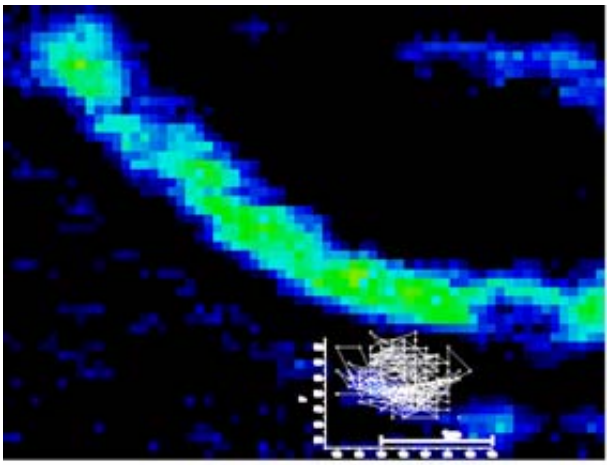
Nowadays single-electron devices are believed to be one of the top-candidates to replace standard Complementary Metal Oxide Silicon (CMOS) transistor technology at the end of the conventional semiconductor roadmap. We investigate the manipulation of electrons in nanostructured semiconductors, especially in silicon with particular emphasis on different realizations of single-electron tunneling devices. Silicon-based fabrication technology further allows the use of the manufacturing processes already established in semiconductor industry. Moreover, the use of Silicon-on-Insulator (SOI) films allows the lithographic definition of the currently smallest structure sizes, which are crucial for the room temperature operation of single-electron devices. Lateral structuring of highly doped silicon films allows us to observe quasi-metallic Coulomb-blockade oscillations in shrunken wires where no quantum dot structure is geometrically defined. Embedding quantum dot structures into the inversion channel of a silicon-on-insulator field-effect transistor Coulomb blockade up to 300 K is observed. In contrast to the quasi-metallic structures, in these devices the influence of the quantum mechanical level spacing inside the dot becomes visible.

Biophysical research on a nanometer scale

Observation of Single Dye Labeled Viruses and Antibodies in Living Cells (Bräuchle, Hallek)

Gene transfer vectors based on adeno-associated viruses (AAV) show great promise for use in





human gene therapy. While AAV can efficiently transfer genes to a number of different cell types it is apparent that a more detailed understanding of the interactions of the virus and the target cell is necessary for further improvements. So far little is known about the process of the AAV infection pathway, e. g. uptake and migration of these viruses in the living cell. Recent developments in fluorescence microscopy of single molecules made this technique an important tool for the possible elucidation of such processes.
In this project we conduct single molecule experiments to follow the migration of adeno-associated viruses in living cells. Only one fluorescent dye molecule is attached to a single virus in order not to influence the physiological behaviour of the virus on its infectious entry pathway. Our investigations started with the observation of diffusion of single Cy5-labeled antibodies and Cy5-labeled adeno-associated viruses in aqueous solution. The next step involved the localisation of Cy5-labeled antibodies at an antigen which was expressed in the cell nucleus after prior exposure
to the virus. Currently the migration of single labeled viruses in human HeLa cells is investigated. The figures show a parvo virus (family of the AAV) and an observed trajectory of the virus in front of a HeLa cell which ends with adsorption of the virus at the cell membrane. This project is a cooperation with the group of M. Hallek, Genzentrum, LMU Munich.

Scanning force microscopy (AFM) (Dr. Reinhard Guckenberger)

The ability of AFM to work very well in fluids. e.g. in buffer, makes the AFM an excellent tool for investigations of biological specimens. Our applications mainly concentrated on the proteasome of archaea which is an essential part in the degredation machinary for proteins. We want to elucidate functional aspects, with emphasis on the interaction forces between proteasome and the proteins to be degraded. In a first step we succeeded in oriented deposition of proteasomes on mica supported NTA-lipid films via His-tags.

More details on the project can be found on the web: www.biochem.mpg.de/spm

AFM-microdissection (Prof. Wolfgang Heckl)

To isolate the chromosomal region of interest with the AFM, the region has to be located. Therefore, surface topography of human metaphase chromosomes following GTG-banding was examined using AFM. Although using a completely different imaging mechanism which is based on the mechanical interaction of a probe tip with the chromosome, the observed banding pattern is comparable to results from light microscopy and a karyotype of the AFM imaged metaphase spread can be generated.

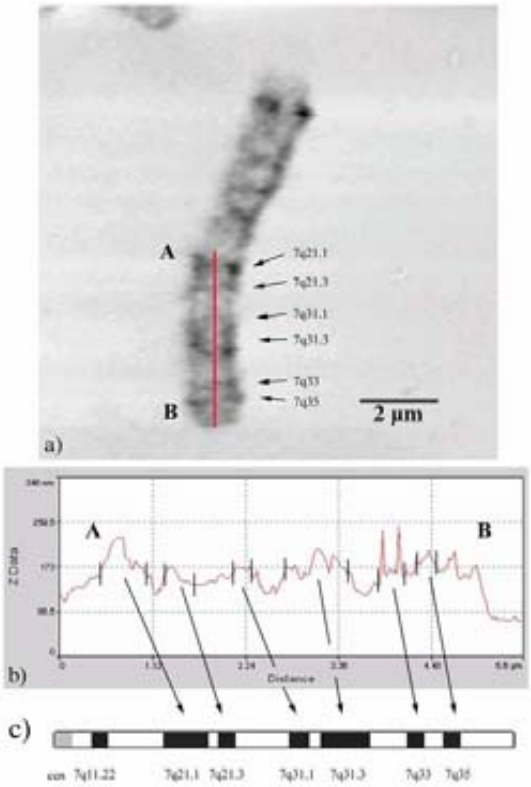


Figure 1: a) AFM image of a GTG banded chromosome 7 homologue, topographic AFM image, gray scale inverted: the bright and dark banding pattern is detectable (bar 2 μm); b) line measurement through point A to B of the q-arm of chromosome 7; c) idiogram of the q-arm of chromosome 7

AFM microdissection: The high-resolution level, necessary to obtain a precise physical mapping of the genome requires homogeneously cleaned samples with a high grade of reproducibility. We performed a correlative high-resolution morphologic analysis of the three-dimensional organization of human metaphase chromosomes with AFM and FESEM.

The established method of non-contact laser microbeam microdissection and laser pressure catapulting (LMM&LPC) was performed for the isolation of TT virus infected tissue sections. TT virus detection was carried out by high-sensitive PCR, using specific primers from the non-coding region.

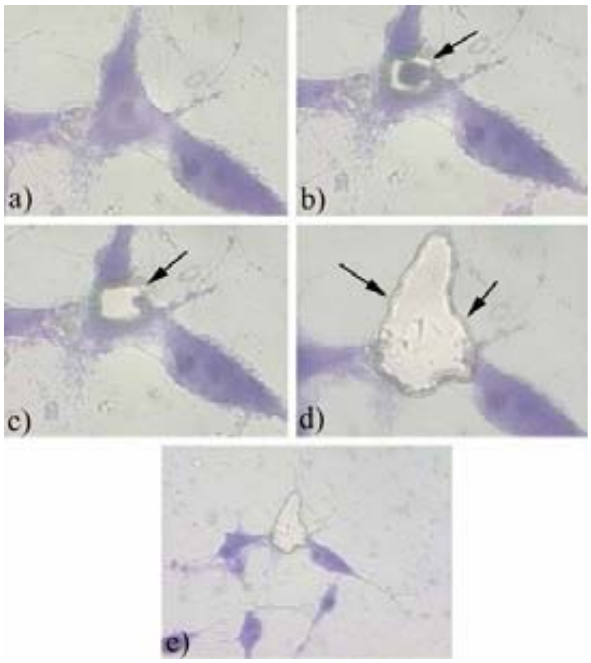
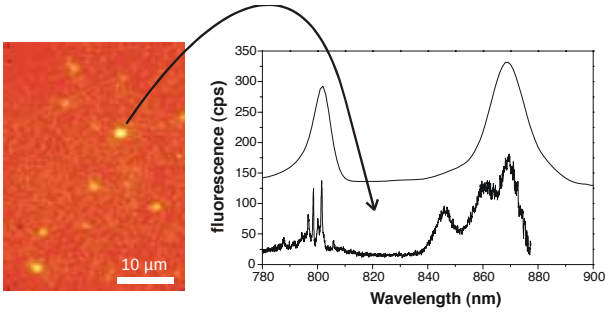


Figure 2: "donut-isolation": laser-based isolation of a single nucleus (see arrow in b)) followed with the subsequent isolation of the remaining cytoplasm (see arrows in d))

Prof. Jürgen Köhler

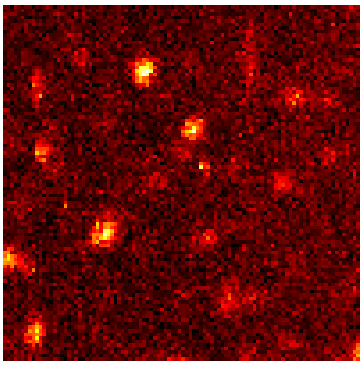


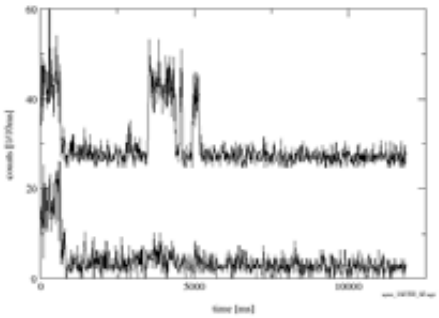
Pigment-protein complexes play an important role in light harvesting of bacterial photosynthesis. They are organised in so called light harvesting complexes (LH1 and LH2) which are responsible for the absorption of sunlight and the rapid transfer of energy towards the reaction centre.
In order to elucidate structure-function relationships of these systems detailed knowledge of the electronic structure of the complexes is inevitable. We obtain the fluorescence-detected absorption spectra of individual complexes (either LH1 or LH2) at 1.4 K which are rich in details usually masked in ensemble experiments by inhomogeneous line broadening effects. Important new insights in the electronic and structural properties of the light harvesting complex 2 of *Rhodopseudomas acidophila* have been obtained.

Single Molecule Spectroscopy of the Phycoerythrocyanin (PEC) (Zumbusch, Bräuchle, Scheer, SFB 533, project B7)

Phycoerythrocyanin (PEC) is the short wavelength absorbing pigment in cyanobacteria. In this work we perform single molecule investigations of PEC at room temperature as well as at cryogenic temperatures in order to gain a better understanding of the energy transfer in PEC. In a collaboration with the group of Prof. H. Scheer (Botanisches Institut, LMU Munich) we are able to investigate the different subunits separately and study the influence of aggregation of the different subunits constituting the native trimeric and hexameric form of the protein.

Results from experiments employing polarization sensitive and spectrally selective excitation and emission detection show a wealth of different behaviours unobservable with common bulk techniques.

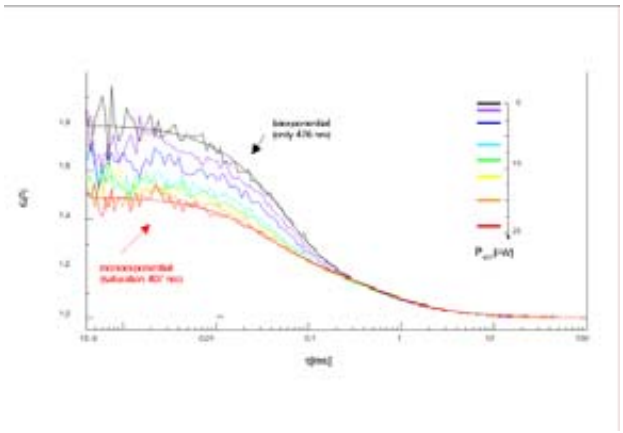


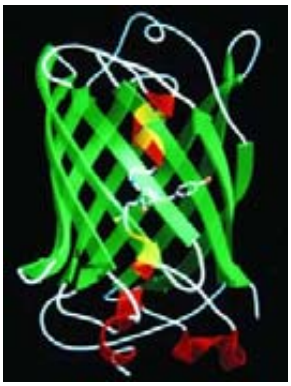


Left: 5µm x 5µm image of single PEC proteins at room temperature; Right: Fluorescence time trajectory of single PEC molecules simultaneously detected in two perpendicular polarization channels. This project is a cooperation with the group of H. Scheer, Bot. Inst., LMU Munich.

Fluorescence Correlation Spectroscopy of the Green Fluorescent Protein (GFP) (Zumbusch, Bräuchle, Steipe, SFB 533, project B7)

The Green Fluorescent Protein (GFP) of the jellyfish Aequorea victoria has lately gained much importance in molecular biology as a fluorescent label. It is currently the only protein that can be expressed in prokaryotic as well as in eukaryotic cells and that fluoresces without the addition of external cofactors. Its widespread applicability led to a quest for new mutants of GFP with altered spectroscopic properties. However any specific mutation aimed at producing a desired spectroscopic change obviously affords an intimate knowledge of the protein's basic photophysics. For this reason we developed a new two color fluorescence correlation spectroscopy (FCS) for investigations of the GFP. The technique employs two color excitation of one chromophore. In contrast to conventional FCS our technique allows us to completely analyze the dynamics of the molecular multilevel system and to determine all the relevant transition rates. These results and those obtained from low temperature high resolution spectroscopy performed in our group yield important information for the production of better mutants.

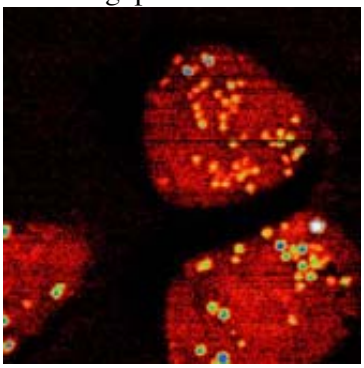




Left: Two color fluorescence autocorrelation functions of the GFP mutant E222Q. Right: Structure of the wild-type GFP (from Brejc et al., PNAS 94 (1997) 2306).
This project is a cooperation with the group of B. Steipe, Genzentrum, LMU Munich.

Coherent Anti-Stokes Raman (CARS) Microscopy (Zumbusch)

Fluorescence microscopic methods based on confocal microscopy or two photon excitation have become important tools in molecular biology. Despite their undeniable value, some problems inherent to fluorescence excitation like phototoxicity of the employed dyes or their bleaching persist. To overcome the need for staining we developed a novel microscopic technique with contrast generation based on Coherent Anti-Stokes Raman Scattering (CARS). In this case the resonant excitation of molecular vibrations of the sample is exploited for selective imaging. Simple tuning of the frequency of one of the exciting lasers now allows for the visualization of structures with different vibrational spectra. Other than IR microscopy and conventional Raman microscopy, CARS microscopy offers high sensitivity at low excitation intensities with a three dimensional spatial resolution similar to confocal microsopy. With this method live cell imaging with a molecular vibrational contrast and visible optical resolution for the first time becomes possible.



The figure shows a CARS microscopic image of live HeLa cells, 30 µm x 30 µm, imaging at 2900 cm^{-1}. The intense features are mitochondria.

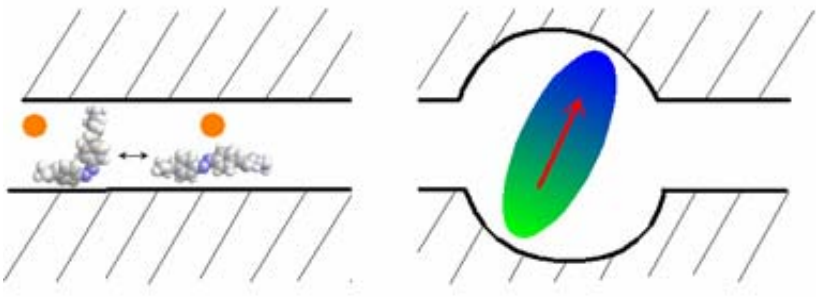
Chemical processes for nanostructural assembly

Functional Nanoassemblies (Nanomachines) with DNA Architecture Characterized by Single Molecule FRET Measurements (Bräuchle, Steipe, SFB 486, project B2).

It has been shown by N. C. Seeman et al. that DNA can be used for building up nanostructures with specific intermolecular associations. In this project a DNA Y-Junction will be prepared (group of B. Steipe) with special antigen-antibody recognition sites. An additional pair of donor/acceptor molecules will detect the receptor ligand bonding of the antigen and the antibody by fluorescence resonance energy transfer (FRET). The function of this nanomachine will be studied in detail. So far first single molecule FRET measurements on donor/acceptor molecules attached to DNA and an Y-Junction have been carried out.
This project is a cooperation with the group of B. Steipe, Genzentrum, LMU Munich.

Optical manipulation of single molecules in nanoporous crystals (Deeg/Bräuchle/Bein, SFB 486, project B1)

Supramolecular structures of organic guests in inorganic and organic cage and channel structures (molecular sieves) have intrinsic mechanical degrees of freedom on the (sub)nanometer scale which depend very subtly on size and form of the guest and extensions and topology of the surrounding void. Through illumination with light these degrees of freedom can be excited and individual chromophores can be moved and switched between two distinguishable states. These investigations shall reveal the conditions necessary for the



function of a molecular switch based on the motion of an individual molecule in a nanometer-sized vessel and the optimization of such a switch.. Long term goal is the realization of molecular rotors, counters and switches in these nanostructured systems. The figure shows a schematic representation of a nanosized molecular lock (left) and a molecular rotor (right).
This project is a cooperation with the group of T. Bein, Physical Chemistry, LMU Munich

Field-directed lateral layer-by-layer self-assembly (Prof. Jochen Feldmann)

The method of layer-by-layer self-assembly has become an important method to produce mixed organic and inorganic thin film heterostructures. By applying electric fields during film growth the deposition of different substances can be controlled perpendicular and parallel to the growth direction.

Organic light emitting diodes (OLEDs) for active flat-panel displays (PD Dr. Klaus Meerholz)

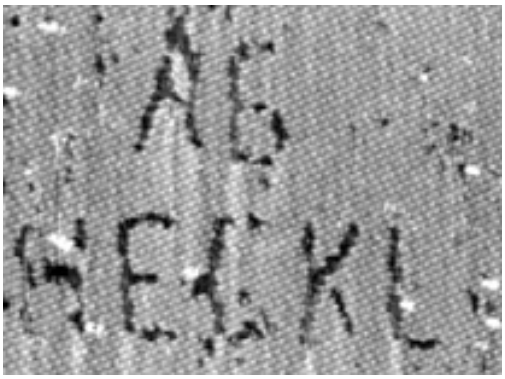
The development of large area active flat-panel displays based on organic electroluminescent diodes (OLEDs) has become one of the target technologies of the near future. Our research activities focus on methods allowing for the micro- or nanostructering of the devices, e.g. for microdisplay applications. Firstly, we fabricate multi-layer devices by using photocross-linkable small molecules which can be used just like an ordinary photoresist [*Macromol. Rapid Publ.* 21, *583 (2000)*]. This principle enabled us for the first time to prepare highly-efficient 5-layer OLEDs by an wet-chemical process [*Chem. Phys. Chem.,* 1, *207 (2000)*]. Secondly, we are studying hole injection from polymeric anodes. By varying the preparation process we were able to adjust the work function to an arbitrary value between 4.5 and 6.0 eV [*Nature* 405, *661 (2000)*]. We prepare combinatorial devices for timely optimization of the devices.

Simultaneous Force and Fluorescence Microscopy of Single Molecules (Seitz, Frank, Zumbusch)

In this project we study the fluorescence properties of single molecules under controlled mechanical stress. For this purpose we simultaneously monitor the force applied onto a single chromophore while detecting changes in its fluorescence spectra, oscillator strengths and fluoresence life times. Quantum chemical calculations of the expected effects are performed in order to gain a better understanding of the experimental results. This unique combination of force micrsocopy, optical single molecule spectroscopy and quantum chemical modeling lets us expect important conclusions relevant for the manipulation of nanostructured materials.
This project is a cooperation with the group of M. Seitz, physics section, LMU Munich

Technological applications of nanoscience

Molecular manipulation of self assembled organic molecules (Prof. Wolfgang Heckl)



Self assembled PTCDA molecular films have been used for basic investigations of elementary processes of structuring on the nanoscale. The tip of a STM can be used for nanoablation on the molecular scale, thus writing patterns with 2 nm line width. These molecular imprints can be written at room temperature in ambient conditions and have demonstrated their stability for weeks up to 50 degrees centigrade. They can be erased mechanically. Thus the primary steps write, read and erase for a molecular storage with theoretically 10 to 100 Terabyte/cm2 could be demonstrated.

From dynamic force microscopy to nanomanipulation

The mechanical extraction of small amounts of biological material for modern analytical methods requires very precise tools. On the micrometer-scale UV-microlaser beam techniques proved its versatility for cutting biological specimen like tissues or cells. Non-contact material extraction is done by the so-called laser-pressure catapulting method, where a short laser pulse is used to separate a dissected part of the specimen from the tissue. In order to allow for a material extraction on a single molecule level, additional nanoscopic methods are needed. Today, the atomic-force microscope is a well-established tool for the manipulation and investigation of single biological molecules.
The combination of conventional microscopic techniques (e.g. brightfield and fluorescence) with the modern techniques of scanning probe microscopy and laser microbalation in one instrument offers a broad range of specimen analysis and sample extraction methods from the micrometer to the nanometer scale.

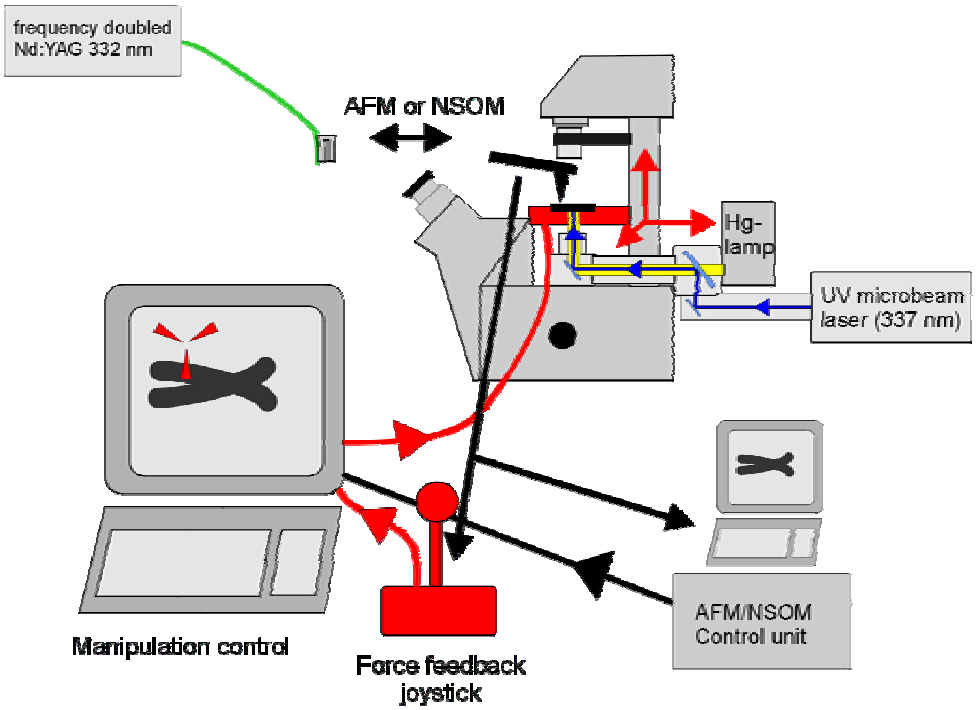


Figure: Multifunctional manipulation setup

Properties of confocal microscopy (Prof. Khaled Karrai)

CeNS Investigator X. Lorenz and K. Karrai
In collaboration with Prof. Lukas Novotny, University of Rochester, Institute of Optics

The reflected image of a diffraction limited focused spot is investigated using confocal solid immersion microscopy. We find that the spot's image shows aberrations when reflected off objects with optical indexes lower than that of the solid immersion lens ~SIL! material. We demonstrate that such aberrations are only apparent and that the actual size of the spot at the SIL/object interface remains diffraction limited. The aberrations are due to lateral waves at the SIL surface. These von Schmidt waves originate from the total internal reflected components of a diverging spherical wave front. We make use of this image aberration in conjunction with the spatial filtering inherent to confocal microscopy in order to dramatically enhance the optical contrast of objects with low optical indexes.

Interfacial shear force microscopy

CeNS Investigator I. Tiemann and K. Karrai
In collaboration with Prof. R. D. Grober, Yale university, Department of Applied Physics.

We have developed an experimental investigation of lossy and reactive shear forces at the nanometer scale using quartz-crystal tuning-fork shear-force microscopy. We show that this technique allows us not only to quantitatively measure viscous friction and elastic shear stress with a combination of high spatial and force resolution better than 10 nm, and less than 1 pN, respectively, but also to obtain such quantities with the tip positioned at any arbitrary distance away from direct electrical tunnel contact with the sample surface. We are proposing that, even under vacuum conditions, the measured viscous and elastic shear stress (i.e., velocity

dependent) are directly attributable to a third body filling the tip-sample gap. A simple model has been developed that allows us to obtain its local viscosity and shear modulus as a function of the tip-sample distance, showing that tuning-fork shear-force microscopy can be applied to quantitative analysis in nanotribology.

Single-crystalline silicon lift-off (Dr. Bert Lorenz (http://www.nano.physik.uni-muenchen.de/lorenz/index.html**))**

We have also developed a technique to mount single-crystalline silicon thin films on arbitrary substrates. We show in detail the preparation of a 190-nm-thin silicon metal–oxide–semiconductor field-effect transistor (MOSFET) on a silicon-on-insulator film lifted from its substrate and bonded to quartz. Functioning of this hybrid MOSFET on a rigid surface at room temperature is demonstrated.

Electrically driven nanotweezers (Dr. Bert Lorenz (http://www.nano.physik.uni-muenchen.de/lorenz/index.html**))**

(together with Christine Meyer, CeNS, (**http://centralservices.nano.physik.uni-muenchen.de/meyer/SFB486TPA2.html**))

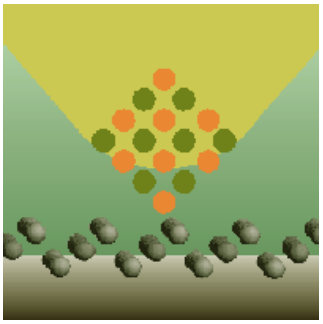
Motivation and aim of this project is to pick up particles with typical sizes in the range between 10 nm and 100 nm and to release them at a predefined location. Nowadays, the manipulation of nanoparticles is mainly done by atomic force microscopy whereby the result is more stochastically. Our goal is to develop electrically driven nanotweezers, which allow a specific manipulation of nanoparticles.

The single virus tracing project

We have invented a completely new method for imaging the different states of a virus infection. This method, called "single virus tracing" is unique. It has a high potential for technical application and marketability in medicine, pharmacy and biotechnology. New information is achieved, which ist useful for the developement of antiviral drugs as well as to create and improve gene-shuttles for gene-therapy. By this method, the customer gets data which allow to develope and to check new pharmaceutical components much faster and more systematically as present. This means a strong improvement of rentability. The single virus tracing project was honored in the first step of the Munich business plan competition 2000/2001.

Theoretical analyses of nanostructures

Quantitative atomic resolution force microscopy on insulators (Prof. Michael Reichling http://www.phys.chemie.uni-muenchen.de/Reichling)



Tip-surface interaction

The process of imaging atomic scale structures on ionic insulators with dynamic mode force microscopy is investigated experimentally as well as theoretically in co-operation with the group of A.L. Shluger (London) and A Foster (Helsinki). Theory is based on a model including background forces between the scanning force tip and the surface and a full quantum chemical treatment of the interaction between the foremost tip ions and surface ions. A quantitative understanding of contrast formation was obtained for $CaF_2(111)$ where it could be demonstrated for the first time that force microscopy is capable of identifying different sub-lattices of an insulating crystal.

Prof. Wilhelm Zwerger

We study the limits of accuracy of nanomechanical single electron transfer in nanostructures, in particular shot noise due to the stochastic nature of the tunneling process. The behaviour of an actual device recently built by A. Erbe and R. Blick in the group of Prof. Kotthaus has been analyzed in detail , including the crucial influence of the driving mechanism (see cond-mat/0011429).

In connection with experiments measuring extremely small shear forces in the group of Prof. K. Karrai, we have calculated the contribution of dissipative Casimir forces to the damping of oscillating tips still far from contact. They are negligible for present experiments but may be relevant in suitable future setups (Diploma thesis S. Rohra, to be published).

Others

Two-dimensional photonic crystal laser (Prof. Jochen Feldmann)

Plastic substrates with two-dimensional Bragg-structures (Bragg-foils) have been employed as distributed-feedback resonators for optically pumped polymer lasers. The laser emission properties can be understood by applying the von-Laue formalism known from X-ray diffraction on real crystals to the photonic crystal structure of the Bragg-foils.

Use of scanning probe microscopes for the investigation of biological macromolecules (Dr. Reinhard Guckenberger)

Part of our AFM work was devoted to a better understanding of the tapping mode AFM. High resolution phase imaging in fluids turned out to be dominated by topography, but this influence can be largely corrected by image processing. For tapping in air, we found that measurement of higher eigenmode oscillation of the cantilever allows to analyze the tip sample interaction in time and gives much more information than just measuring the phase. This work was supported by a collaboration with the group of Wolfgang Heckl.

Scanning near-field optical microscopy (SNOM): Fluorescence allows easy identification of marked parts of biological specimens. In comparison to the confocal laser scanning microscope, the main advantage of the SNOM consists in the simultaneous acquisition of a topographical signal in addition to the optical one. We are currently developing such a SNOM

with enhanced topographical resolution for investigations with biomolecules in fluids. For this purpose we test contamination tips in collaboration with the group of Heribert Lorenz.

More details on the project can be found on the web: www.biochem.mpg.de/spm

Photorefractive polymers for real-time holographic signal processing (PD Dr. Klaus Meerholz)

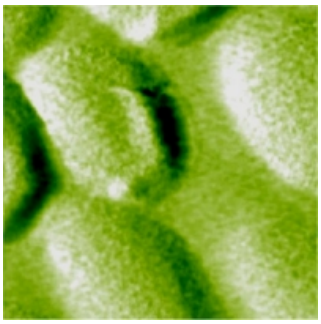
For more than three decades, inorganic photorefractive (PR) materials have attracted a lot of attention, because they are ideal for many holographic applications. Photorefractivity in amorphous organic systems, first discovered in a polymer 1991, became a rapidly growing field of research due to the excellent performance of these new material class.
The low manufacturing cost and the excellent reproducibility may enable the first widespread use of PR materials in practical systems. Applications include dynamic holographic storage and real-time image processing, enabling the non-destructive inspection of spare parts on the nanometer scale. We recently demonstrated an associative memory by multiplexing holograms [*Opt. Commun.*, *185*, *13 (2000)*].

Topography and dynamic phenomena on insulator nanostructures (Prof. Michael Reichling http://www.phys.chemie.uni-muenchen.de/Reichling)

Atomically resolved Ca clusters on a CaF_2(111) surface

Dielectric and metallic nanostructures on fluorides have been investigated with atomic resolution force microscopy. The aim of this study is to establish force microscopy as a standard tool for atomic scale imaging of insulating nanostructures and heterostructures. The emphasis is on a detailed investigation of the chemical interaction between tip atoms and atoms in the nanostructures. It could be demonstrated that for certain atomic configurations of the force sensing cluster, a week coordination of atoms in the nanostructures can be detected. Most interesting dynamic phenomena have been observed, where jumps of atoms from the surface to the tip and their re-arrangement on the tip can directly be observed. This can be exploited for developing new strategies for atomic manipulation with the force microscope.

Growth and morphology of nickel clusters on sapphire(Prof. Michael Reichling http://www.phys.chemie.uni-muenchen.de/Reichling)



Ni on Al_2O_3(0001)

Nanometer-sized clusters of Nickel are grown on the (0001) surface of sapphire. Their size, shape and distribution is studied as a function of deposition and annealing conditions with high resolution force microscopy where the emphasis is on the initial stages of nucleation of few atoms on the surface. As a first result, it was found that Nickel precipitates appear in the form of well ordered clusters with a height of one, two or three atomic layers and a shape determined by the crystallographic structure of low index surfaces of Nickel. In co-operation with Th. Risse (Berlin) nanoparticle growth is studied for different surfaces and surface preparations.

Supramolecular Chemistry (Prof. Ulrich S. Schubert)

The combination of organic and metallo-supramolecular chemistry with tailor-made macromolecules and methods from nanoscience offers a novel entrance to functional materials. Such systems reveal new mechanical, thermal, electrochemical, photochemical and magnetic properties. They could lend themselves to a wide range of interesting applications, e.g. in the direction of smart materials, intelligent glues and coatings or electro- and photoactive compounds as well as bio-related and bio-active systems. Besides the organic synthesis of suitable building blocks, the self-assembly to nanostructures, the detailed characterization in solution and in the solid state as well as the preparation of extended ordered architectures on surfaces is another main focus of the group. In addition, supramolecular units are used as initiators for controlled "living" polymerisations and also combined with biological moieties.

Cooperations

Internal CeNS collaborations

- Prof. Christoph Bräuchle, Prof. Dr. Thomas Bein, Chemistry Department
- Prof. Christoph Bräuchle, Prof. Dr. Hermann Gaub
- Prof. Christoph Bräuchle, Dr. Boris Steipe, Gene Center
- Bert Lorenz, Thomas Bein, Jake Reder, LMU Munich, sputter deposition and evaporation of Gold
- Bert Lorenz, Jochen Feldmann, Mingyuan Gao, SEM characterization of ITO on glass
- Bert Lorenz, Jochen Feldmann, Carsten Sönnichsen, SEM characterization
- Bert Lorenz, Jochen Feldmann, Natali Manlikova, SEM characterization
- Bert Lorenz, Jochen Feldmann, Carmen Klingler-Deiseroth, SEM characterization, SiO2- & Si3N4-sputter deposition
- Bert Lorenz, Hermann Gaub, Jan Domke, LMU Munich, SEM characterization
- Bert Lorenz, Hermann Gaub, Rainer Matzke, LMU Munich, development of special force sensors
- Bert Lorenz, Hermann Gaub, Michael George, LMU Munich, SEM lithography
- Bert Lorenz, Hermann Gaub, Martin Benoit, LMU Munich, SEM characterization
- Bert Lorenz, Hermann Gaub, Christian Kirchner, LMU Munich, SEM characterization
- Bert Lorenz, Wolfgang Heckl, Robert Stark, LMU Munich, SEM characterization of force sensors
- Bert Lorenz, Wolfgang Heckl, Stefan Thalhammer, LMU Munich, development of special force sensors
- Bert Lorenz, Johann Peisl, Markus Aspelmeyer, LMU Munich, sputtering deposition of Platinum
- Bert Lorenz, Reinhard Guckenberger, Martin Stark, MPI of Biochemistry, Martinsried, fabrication of submicron silicon gratings for nanoimprint techniques
- Bert Lorenz, Reinhard Guckenberger, Heinrich Frey, MPI of Biochemistry, Martinsried, development of force sensors in combination with an aperture SNOM
- Prof. Schubert, Prof. Dr. Hermann Gaub
- Prof. Schubert, Prof. Dr. Jochen Feldmann
- Prof. Schubert, Prof. Dr. Tim Salditt
- Prof. Zwerger, J. Kotthaus (R. Blick and A. Erbe) and K. Karrai
- Prof. W. Heckl, Dr. Boris Steipe, Genzentrum der LMU
- Prof. W. Heckl., Dr. R. Guckenberger, MPI for Biochemistry

External cooperations

The CeNS members maintain a network of cooperations all over the world:

Prof. Bräuchle:

- Prof. Dr. Michel Orrit, Centre de Physique moléculaire optique et hertzienne,Univ. Bordeaux
- Prof. Dr. Peter Behrens, University Hannover
- Prof. Dr. Michael Hallek, Gene Center, Ludwig-Maximilians Univ. Munich

- Prof. Dr. Hugo Scheer, Botanisches Institut, Ludwig-Maximilians Univ., Munich

Prof. Feldmann:

- Prof. Dr. Kowalsky, Technical University of Braunschweig, Germany
- Dr. Wittwer, Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany
- Dr. Steven Cundiff, JILA, University of Colorado, Boulder, USA
- Prof. Dr. V. Shalaev, New Mexico State University, Las Cruces, USA
- Prof. Dr. Müllen, Max-Planck-Institute for Polymer Sciences, Mainz, Germany
- Prof. Dr. U. Schubert, Technical University of Eindhoven, Netherlands
- Prof. Dr. G. Abstreiter, Walter-Schottky Institute, TU Munich, Germany
- Prof. Dr. F. Aussenegg, University of Graz, Austria
- Dr. Joachim Spatz and Prof. Dr. J. Möller, University of Ulm, Germany

Prof. Wolfgang Heckl

- University of Otago, New Zealand, Biochemistry Department
- University of Bristal, England, Physics Department
- Prof. Dr. Morfil, MPI for Plasma Physics, Garching
- Prof. Dr. Stefan Endres, Medizinische Klinik, Klinikum der Innenstadt der LMU München
- Prof Dr. Gerd Frösner, Max von Pettenkofer Institut
- Prof Dr. Rolf Gebhardt, Institut für Biochemie, Universität Leipzig
- Dr. Pietro Gobbi, Department of Human Anatomy, University Bologna
- Prof Dr. Günther Heubl, Botanisches Institut der LMU München
- Prof. Dr. Andreas Nerlich, Institut für Pathologie der LMU München

Prof. Jürgen Köhler

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- Jan Schmidt, Centre for the Study of Excited States of Molecules, Huygens Laboratory, Leiden University
- Hugo Scheer, Botanisches Institut, University of Munich, Germany
- Leszek Fiedor, Institute of molecular biology, Jagiellonian University, Krakow, Poland
- Hartmut Michel, Dep. of Molecular Membrane Biology, MPI of Biophysics, Frankfurt, Germany
- Richard J. Cogdell, Biochemistry and molecular biology, University of Glasgow

Dr. Bert Lorenz:

- Paul Leiderer, University of Konstanz, development of special shear force sensors
- Patrik Hoffmann, Gerit Jänchen, University Lausanne, characterization of force sensors

Dr. Meerholz: Photorefractivity

- M. Hofmann, Marburg

- D. Psaltis, CALTEC, Pasadena (USA)
- S. Stepanov, Puebla (Mexico)
- R. Wortmann, Kaiserslautern
- F. Würthner, Ulm
- IBM Almaden, San Jose, Californien (USA)

Dr. Meerholz: OLEDs

- P. Bäuerle, Ulm
- D. Neher, Potsdam
- O. Nuyken, TU München
- U. Scherf, Potsdam
- COVION Semiconductors, Frankfurt

Prof. Reichling:

Dr. A. Foster (Helsinki University of Technology)
Dr. Th. Risse (Fritz-Haber-Institut Berlin)
Dr. A.L. Shluger (University College London)

Prof. Schubert:

- Institut für Biophysik, Johann Wofgang Goethe-Universität
- Dr. Walter Mächtle, Kunststofflabor, BASF AG
- Prof. Dr. George R. Newkome, University of Akron, Ohio (U.S.A.)
- Prof. Dr. Harald Fuchs, Westfälische Wilhelms-Universität Münster

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Further publications of CeNS members can be found at the following web sites:
http://www.schubert-group.com
http://www.ep4.phy.uni-bayreuth.de/ag_jkoehler/veroeffentlichungen/index_eng.html

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- H. Gaub, P. Jänker, A. Mittelbach, F. Nitschké, U. S. Schubert, *Reversibel Schaltbare Lack- bzw. Klebstoffprimer und Korrosionsschutz für Metalle,* DE 10002697.4.
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- Bernd Irmer, Armin Kriele, Heribert Lorenz, Martin Wendel, *Rastersondenmikroskop mit Sondeneinrichtung, Sondeneinrichtung sowie Verfahren zum Herstellen einer Sondeneinrichtung*, DE 198 25 404.0-52
- K. Karrai *, Inertial Rotation Device*, Submitted November 22 -2000, GB
- U.S. Schubert, C. Eschbaumer, P. Andres, R.M. Kröll, M.R. Buchmeiser, *Kontrollierte Radikalische Polymerisation mit Heterogenen Katalysatoren auf Heterocyclen-Metall-Komplex-Basis,* DE 100 13 305.3-44.
- U.S. Schubert, C. Eschbaumer, G. Hochwimmer*, Kombinatorische Materialforschung an Blockcopolymeren mittels selbstorganisierender Oligomere, Telechele und Polymere,* DE submitted.
- U.S. Schubert, C. Eschbaumer, G. Hochwimmer, *Maßgeschneiderte (Block) Copolymere über nicht-kovalente Bindungen und Wechselwirkungen,* DE submitted.
- ”Elektrisch leitfähige und/oder lumineszierende oxetan-funktionalisierte Monomere und/oder Präpolymere, daraus hergestellte Polymere und/oder polymere Netzwerke und darauf basierende Bauteile”, submitted 2000.
- Herstellungsverfahren für poröses Silizium und elektronisches Bauelement mit porösem Silizium, AZ 10047664.3 submitted 26. 9. 2000, published 28.3.2001
- Nahfeldoptische Spitze, Deutsches Patent Nr. 195 04 662.5-42

Invited talks

Prof. Christoph Bräuchle

- 03.03.200012. Deutsche Zeolith-Tagung, Garching
- 13. – 16.03.2000:DPG-Frühjahrstagung, Potsdam
- 13.04.2000:Analytica 2000, Symposium „Einzelmolekülspektroskopie“, Munich
- 14. – 17.05.2000:Current Trends in Nanooptics, Bad Honnef
- 06./07.07.2000:Bayer AG, Leverkusen
- 21. – 23.07.2000:XVIII. IUPAC Symposium, Dresden
- 09. - 13.09.2000:3rd European Biophysics Congress 2000, Munich
- 20. – 22.09.2000:International Discussion Meeting der Deutschen Bunsen-Gesellschaft, Berlin
- 09. – 11.10.2000:World Congress on Cellular and Molecular Biology, Jena
- 16./17.10.2000:BASF AG, Ludwigshafen
- 20.11.2000:Bayer AG, Leverkusen

Prof. Jochen Feldmann

- “Nano-optics with surface plasmons“, 30th Winter Colloquium on The Physics of Quantum Electronics, Snowbird, USA 2000.
- “Ultrafast spectroscopy of metal nanoparticles“, 18th General Conference of the Condensed Matter Division of the European Physical Society, Montreux, Switzerland, 2000.
- “Optoelectronics with organic materials“, Workshop on Microstructuring, Kassel, Germany 2000.
- „Optoelektronik im 21. Jahrhundert: Plastik statt Halbleiter?“, Spring Meeting of the German Physical Society, Bonn, Germany, 2000.
- “Optical properties of molecular and semiconducting nanostructures in the vicinity of metal nanoparticles“, SFB 486-Workshop, Munich, Germany, 2000.
- “Nano-optics with surface plasmons“, Workshop on Current Trends in Nano-Optics, Bad Honnef, Germany 2000.
- “Laserlicht aus biegsamen Polymerfolien“, Polymerwerkstoffe 2000, Halle, Germany 2000.

Prof. Wolfgang Heckl

- **Nanotechnologie,** Symposium der TU Berlin und der Philip Morris Stiftung, Berlin, 2.2.2000
- **Reise in den Nanokosmos, Rastersondenwerkzeuge dirigieren Moleküle**, Deutsches Museum Bonn, 24.2. 2000
- **NanoEndoscopy**, Universita degli studdi di Bologna, Italy, 26.4.2000
- **Nanotechnologie,** FH München, 10.5.2000
- **NanoScience,** Expo Hannover 2000, „Science and Technology- Thinking the Future“, Global Dialogue, 13.7.2000
- **Perspectives of Nanotechnology in Medicine and Genetics,** NanoBioTec, Münster 28.9.2000

- **Nanotechnologie und neue Werkstoffe,** Holzbauforum Rosenheim 2000
- **Perspectives of Nanotechnology in Medicine and Genetics,** Jena, 10.10.2000
- **Bio-Nanotechnologie,** Symposium Biodiversität, Bioanalytik, Biotechnologie, Trier, 11.10.2000
- **Genetically Based Supramolecular Architectures from Self Assembled DNA-Bases coding for Amino Acids,** 1st int. symposium on Nanoarchitectonics Using Suprainteractions, Tsukuba, Japan, 15.11.2000
- **Nanomicroscopy in GeoSciences,** Dept. of Earth and Planetary Sciences, University of Tokyo, 16.11.2000
- **Self Assembly and Manipulation of Molecules,** The Third International Symposium on "Atomic Scale Processing and Novel Properties in Nanoscopic Materials" Osaka, Japan, 13. 12. 2000

Prof. Khaled Karrai

- 11th International Winter school on New Developments in Solid State Physics, Mauterndorf, Austria 21-25 February 2000.
- Interband optics of single, charge-tunable quantum rings March Meeting 2000
- Shear and Friction force microscopy , CNRS Spring- School on Near-Field optics (20 -24 March 2000) La Londe les Maures (Var) - France
- Optical spectroscopy of Charge-tuneable quantum dots, CNRS Spring- School on Near-Field optics (20 -24 March 2000) La Londe les Maures (Var) - France
- CeNS Topical Conference, Wildbadkreuth 4-6 Oktober 2000: Shear and friction force microscopy

Prof. Jürgen Köhler

- *Optische Spektroskopie an einzelnen Photosynthetischen Antennenkomplexen* Frühjahrstagung der Deutschen Gesellschaft für Biophysik e.V., Sektion Membranen, Zellen, Netzwerke, Gomadingen, Germany, 22. – 24.03.2000.
- *Unravelling the Electronic Structure of Individual Photosynthetic Pigment-Protein Complexes*. 231. WE- Heraeus Seminar: Current Trends in Nano-Optics, Physikzentrum, Bad Honnef, Germany, 15. – 18.05.2000.
- *Unravelling the Electronic Structure of Individual Photosynthetic Pigment-Protein Complexes*. Yamada Conference LIII, 2000 International Conference on Excitonic Processes in Condensed Matter, EXCON2000, Osaka City University, Japan, 22. – 25.08.2000.
- *Spectroscopy of Individual Photosynthetic Pigment-Protein Complexes*. 3rd European Biophysics Congress, Eurobiophysics 2000, München, Germany, 9. – 13.09.2000.

Dr. Ulrich Lemmer

- „Organic Lasers with a Twodimensional Photonic Bandstructure", Spring Meeting of the German Physical Society, Regensburg, Germany, 2000.
- "Organic Lasers using 2D Photonic Crystals", International Conference on Science and Technology of Synthetic Metals, Bad Gastein, Austria, 2000.

Dr. Bert Lorenz

- "Coherent modes in artificial Molecules - Possible Definition of Quantum Bits in Coupled Quantum Dots" IEEE International Symposium on Circuits and Systems ISCAS 2000, Geneva, Switzerland
- " Manipulation of Electrons in Nanostructured Semiconductors" 4th International Workshop on Quantum Functional Devices QFD 2000, Kanazawa, Japan

PD Dr. Meerholz

- "Organic Electronics: Physics, Materials and Devices", Bad Honnef, Nov. 6-8, 2000.
- Thomson Multimedia, Hannover, Nov. 1, 2000.
- American-German Polymer Symposium of Younger Scientists, Chicago, Aug. 7-11, 2000.
- SPIE annual meeting, San Diego, CA, July 31 – Aug. 4, 2000.
- Jahrestagung der Deutschen Bunsen-Gesellschaft, Würzburg, June 1-3, 2000.
- E-MRS, "Photorefractive Materials – Physical Phenomena and Applications", Strasbourg, France, May 28-31, 2000.
- ICONO-5, Davos, Switzerland, March 12-16, 2000.

Dr. Gero von Plessen

- "Ultrafast Dynamics in Noble-Metal Clusters", James Franck Symposium, Wildbad Kreuth, Germany, 2000.
- "Observation of thermal electron pressure in the vibration dynamics of metal nanoparticles", MRS Fall Meeting, Boston, USA, 2000.

Dipl.-Phys. Stefan Riechel

- „Organic Semiconductor Thin Film Lasers", 244. WE Heraeus Seminar: Organic Electronics: Physics, Materials and Devices, Bad Honnef, Germany, 2000.
-

Prof. Ulrich Schubert

- U.S. Schubert, C. Eschbaumer, G. Hochwimmer
  NEUARTIGE COPOLYMERE MIT METALL-BINDUNGSSTELLEN
  Fachgruppentagung, Fachgruppe Makromoleulare Chemie der GDCh, 21.03.00

- U.S. Schubert
  ALPENFORUM: WERBUNG EINES CHEMIENACHWUCHSES
  Jungchemikerkongreß, Regensburg, 22.03.00

- U.S. Schubert, C. Eschbaumer, C.H. Weidl, G. Hochwimmer
  SYNTHESE UND ANWENDUNG AUSGEWÄHLTER *N*-HETEROCYCLEN
  Chemiedozententagung, Regensburg, 22.03.00

- U.S. Schubert, C.H. Weidl, C. Eschbaumer
  SUPRAMOLECULAR GRIDLIKE ASSEMBLIES BASED ON N-HETEROCYCLIC LIGANDS
  219th ACS National Meeting, San Francisco, USA, 26.03.00

- U.S. Schubert, C. Eschbaumer, M. Heller
  DIRECTED SYNTHESIS OF METHYL-SUBSTITUTED 2,2'-BIPYRIDINES
  219th ACS National Meeting, San Francisco, USA, 26.03.00

- U.S. Schubert, C. Eschbaumer
  FUNCTIONAL (BLOCK) COPOLYMERS WITH METAL-COMPLEXING SEGMENTS
  219th ACS National Meeting, San Francisco, USA, 27.03.00

- U.S. Schubert, C. Eschbaumer, C.H. Weidl, A. Vix, Q. An, T. Salditt
  THIN FILMS OF METALLO-SUPRAMOLECULAR ASSEMBLIES VIA SELF-ASSEMBLY TECHNIQUE
  219th ACS National Meeting, San Francisco, USA, 27.03.00

- U.S. Schubert, C. Eschbaumer
  MALDI-TOF MS FOR THE ANALYSIS OF SUPRAMOLECULAR ASSEMBLIES AND POLYMERS
  219th ACS National Meeting, San Francisco, USA, 27.03.00

- T. Salditt, A. Vix, Q. An, A. Plech, C. Eschbaumer, C. Weidl, U.S. Schubert
  STRUCTURE AND GROWTH OF SELF-ASSEMBLED THIN-FILM MATERIALS PROBED BY X-RAY SCATTERING
  219th ACS National Meeting, San Francisco, USA, 28.03.00

- U.S. Schubert, G. Hochwimmer
  INTRODUCTION OF METAL-BINDING UNITS INTO BIODEGRADABLE POLYMERS UTILIZING METALLO-SUPRAMOLECULAR INITIATORS
  219th ACS National Meeting, San Francisco, USA, 28.03.00

- U.S. Schubert, C.H. Weidl, C. Eschbaumer
  METALLO-SUPRAMOLECULAR ASSEMBLIES BASED ON TRANSITION-METAL IONS
  219th ACS National Meeting, San Francisco, USA, 28.03.00

- U.S. Schubert, C.H. Weidl, M. Heller C. Eschbaumer
  SYNTHESIS OF NOVEL FUNCTIONALIZED *N*-HETEROCYCLES UTILIZING STILLE-TYPE COUPLING PROCEDURES
  219th ACS National Meeting, San Francisco, USA, 29.03.00

- U.S. Schubert, M. Heller, G. Hochwimmer
  NOVEL FUNCTIONAL ARCHITECTURES VIA METALLO-SUPRAMOLECULAR INITIATORS
  219th ACS National Meeting, San Francisco, USA, 30.03.00

- U.S. Schubert, M. Heller, G. Hochwimmer
  METALLO-SUPRAMOLECULAR INITIATORS FOR LIVING AND CONTROLLED POLYMERIZATIONS
  4. Österreichische Polymertage, Innsbruck, Österreich, 27.04.00

- U.S. Schubert
  METALLO-SUPRAMOLECULAR ASSEMBLIES AND POLYMERS
  Frontiers of Chemistry, GDCh/ACS Meeting, Kloster Seeon, 07.07.00

- U.S. Schubert, Philip Andres, Christian H. Weidl, C. Eschbaumer
  METALLO-SUPRAMOLECULAR ASSEMBLIES AND POLYMERS ON SURFACES AND IN SOLUTION
  ICSM, Bad Gastein, Austria, 16.07.00

- U.S. Schubert
  METALLO-SUPRAMOLECULAR ASSEMBLIES AND POLYMERS BASED ON MODIFIED TERPYRIDINES
  CeNS Workshop2000, Wildbad Kreuth, 05.10.00

- U.S. Schubert
  METALLO-SUPRAMOLEKULRARE ARCHITEKTUREN: MATERIALIEN MIT NEUEN EIGENSCHAFTEN?
  Tranfer-Workshop "Materialforschung – Querschnittswissenschaft und Innovations-motor", FCI/BMBF, Degussa-Hüls, 18.10.00

Awards

C. Bräuchle, G. Seisenberger, T. Endress

Single virus tracing project. Honored in the first step of the Munich business plan competition 2000/2001.

Prof. W. Heckl

Member of Kuratorium Deutsches Museum München

PD Dr. Meerholz

Nernst-Haber-Bodenstein-Preis der Deutschen Bunsengesellschaft für Phys. Chemie

Prof. U. Schuber

Dozentenstipendium of the „Fonds der Chemischen Industrie“

External presentations

CeNS in the press

- CHIP April 2000, Report on Nanotechnology, pp. 220-224
- c´t 5/2000 (SIEHE ATTACHED PDF FILE)
- Focus Nr. 22 2000 page 170 ff (SIEHE ATTACHED PDF FILE)
- Kölner Stadtanzeiger 2.2.2000
- Münchener Merkur 9.3. 2000
- Münchener Merkur (27.6.2000)
- *Nanoscience scales up in Germany*, Chemical & Engineering News, 78(8), 27 (2000). Nachrichten aus der Chemie, 48(11), 1383 (2000).
- News site der LMU (6/2000)
- News site der Max-Planck-Gesellschaft (6/2000)
- Rheinzeitung 26.1.2000
- Spiegel Nr. 35/2000 page128-130, Im Legoland der Moleküle (SIEHE ATTACHED PDF FILE)

CeNS in television

- Interview in den Tagesthemen, 22.7.2000
- Zukunftschance Nanotechnologie in „Power Berlin“ im FAB (Fernsehen aus Berlin), 21.6.
- Nano in 3sat, 11.7.
- ARTE ARCHIMEDES, 12.7.2000
- ARTE ARCHIMEDES „NanoEndoskop“, Mai 2000
- HiTech, Sendung über Nanotechnologie in 3SAT für Zeit TV Berlin, 27.1.2000

- Laborfilm über Rastertunnelmikroskopie und molekulares Schreiben im ZDF, „Aus Forschung und Technik“, 8.3.2000
- Phoenix Kanal, Dt. Fernsehen: Studiogast bei „Wissenschaft Live“, 31.1.2000

Participation in Fairs etc.

Materialica 2000

New Companies founded from CeNS groups

Falls möglich mit Links auf die jeweiligen Webseiten

PhD and Diploma theses, “Zulassungsarbeiten”

PhD Theses

- R. Baumann, *Untersuchung der der molekularen Dynamik in eingeschlossenen Flüssigkeiten*, LMU Munich (2000).
- Markus Groß, Dipl. Chem., *„Poly(4,4’-dimethoxybithiophen)-Filme als polymere Anoden mit variabler Austrittsarbeit“*; LMU 12/00.
- Imke Libon: *THz-Spektroskopie an Halbleitern und Flüssigkeiten*
- S. Mais, *Spektroskopie und Mikroskopie einzelner Farbstoffmoleküle im Festkörper zwischen 1.4 Kelvin und Raumtemperatur*, LMU Munich (2000).
- Elmar Schmälzlin**,** Dipl. Chem., *“Bestimmung der NLO-Eigenschaften neuartiger organischer Molekülsysteme mit laserspektrokopischen Methoden“*; LMU 5/00.
- Robert Stark: *„dynamische und quasistatischeRasterkraftmikroskopie zur Material-charakterisierung: Theorie und Experiment“*
- Armin Tilke: "*Einzelelektronentransport in Silicon-on Insulator-Nanostrukturen*"
- Christian H. Weidl, *Metallo-Supramolekulare Ansätze zu Assoziaten und Makromolekülen auf Basis von N-Heterocyclen* (April 2000)
- Cristoph Weiss*, Theoretische Untersuchungen zur Genauigkeit von Einzel-Elektron-Bauelementen*, Dezember 2000
-

Diploma Theses

- D. Aktah, *Mechanisch induzierte chemische Reaktionen: quantenmechanische Simulationen*, LMU Munich (2000)
- Evangelos Angelopoulos: *Development and construction of an ambient air STM*
- R. Auer, *„Aufbau und Test eines Langzeitmesstands zur Charakterisierung von organischen Leuchtdioden“,* FH München 7/00.
- T. Endress, *Wechselwirkung von Antikörpern und Viren mit lebenden Zellen unter besonderer Berücksichtigung des Diffusionsverhaltens*, LMU Munich (2000)

- Aron Filep, *Aufbau von Polymeren mittels kontrollierter radikalischer Verfahren: Untersuchungen einer ATRP-Variante*, August 2000
- C. Hellriegel, *Konfokale Mikroskopie und Einzelmolekülspektroskopie von organischen Gastmolekülen in nanoporösen anorganischen Wirtsmatrizen*, LMU Munich (2000)
- Carmen Klingler-Deiseroth, "*Selbstorganisierende photonische Kristalle für neuartige Halbleiterlaser*"
- Bernd Krombholz "*Emissionsdynamik von CdTe-Nanokristallen in selbstorganisierten Multischichtstrukturen*"
- Gunnar Raschke, "*Entwicklung eines konfokalen Mikroskops zur Spektroskopie einzelner Makromoleküle*"
- Stefan Rohra, *Dissipative Casimir Kräfte*, Dezember 2000
- U. Röhrig, *Quantenmechanische Untersuchung von Chromophoren und Polyenen unter mechanischem Zug*, LMU Munich (2000)
- Christooph Stadler: *Planung und Bau eines Pocket Size STM*

„Staatsexamensarbeiten“

- Stefan Geier "*Nasse Plasmonen: Streuspektren einzelner Metall-Nanopartikel in Wasser*"

Guests

- Martijn Ketelaars, Leiden University, The Netherlands (February 2000 until August 2000)

- Michio Matsushita, Centre for the Study of Excited States of Molecules, Huygens Laboratory, Leiden University

- Prof. Dr. Vladimir Shalaev, New Mexico State University, Las Cruces, USA (March 2000 until July 2000)

Funding

- BASF AG
- Bayer AG
- Bayerische Forschungsstiftung
- Bayern Innovativ
- Bundesministerium für Bildung und Forschung (BMBF)
- CMI company
- COST “Chemistry Working Group” (European Community)
- Daimler Chrysler Aerospace
- Deutsche Forschungsgemeinschaft (single projects and participation in SFB 348, SFB 338, SFB 377, SFB 533)
- Dutch Polymer Institute
- European Space Agency
- European Union
- Fonds der Chemischen Industrie
- „Neue Materialien“ (FORMAT), Land Bayern
- VolkswagenStiftung