Plenary Talk PV I Mon 8:30 H1

Response of live cells to mechanical stress — •Samuel Safran — Dept. Materials and Interfaces, Weizmann Institute of Science, Rehovot, Israel 76100

Recent research at the interface of physics and biology has shown that cellular processes such as proliferation, differentiation and tissue development, are controlled by the mechanical properties of cells and their environment. This talk reviews current experiments on cell mechanics and their relation to recent theoretical models. The theory includes non-equilibrium cell activity (related to the fact that the cell is alive), local elastic equilibrium, and random forces to determine cell response to static and dynamic stress. Cells also respond to stress via curvature induced-forces and we calculate how the competition of cell contractility and curvature energy allow for different orientations of cells on curved substrates, depending on cell type and substrate curvature. To understand how substrate rigidity determines the polarization of cells, we have generalized the theory of elastic inclusions in solids to living inclusions whose active polarizability, analogous to that of non-living matter, results in feedback in response to matrix stresses. We use this to explain recent observations of the non-monotonic dependence of stem cell polarization on matrix rigidity. These findings provide a mechanical correlate for the existence of an optimal substrate elasticity for cell differentiation and function.

Theoretical collaborations: Y. Biton, B. Friedrich, R. De, A. Zemel and experimental interactions: A. Bershadsky, A. Brown, D. Discher, B. Hoffmann, R. Kemkemer, R. Merkel, F. Rehdfeldt.

Plenary Talk PV II Mon 9:15 H1

Mesoscopic Magnetic Measurements — •Kathryn A Moler — Stanford University

We probe the effects of quantum phase coherence in electronic states using nanomagnetic measurements, including nano-SQUIDs that measure signals smaller than the dipole moment of a hundred electrons.

For example, a mesoscopic normal metal ring should have a persistent current flowing forever around it, despite its finite resistance. Previous experiments disagreed strongly with theory. With our scanning SQUID microscope, we found good agreement between theory and experiment in many individual gold metal rings, measured one at a time [1]. Rings are also a good test of fluctuation theory in 1D superconductors [2].

Nanomagnetic measurement technologies enable us to study vortices in superconductors such as pnictides [3], where we map local materials-correlated variations in the superfluid density, and cuprates [4], where single vortices act like one-dimensional elastic objects moving through materials-determined pinning landscapes.

Finally, nanomagnetic signals provide metrology for devices. A surprising spin-glass-like interface state associated with several metals [5] is likely related to decoherence in superconducting qubits.

[1] H. Bluhm et al., Physical Review Letters 102, 136802 (2009).
[2] N.C. Koshnick et al., Science 318 , 1440 (2007).
[3] C. W. Hicks et al., Physical Review Letters 103, 127003 (2009).
[4] O. M. Auslaender et al., Nature Physics 5, 35 (2009).
[5] H. Bluhm et al., Physical Review Letters 103, 026805 (2009).

Prize Talk PV III Mon 13:00 H1

Quantum degenerate Bose gases: Towards new frontiers with exciton-polaritons — Regis Andre, Jacek Kasprzak, Maxime Richard, and •Le Si Dang — Institut Néel, CNRS-UJF, Grenoble, France — Träger des Gentner-Kastler-Preises

Microcavity polaritons are bosonic quasiparticles which result from the strong coupling between cavity photon modes and excitons modes confined in quantum wells embedded in the microcavity. By contrast to the bulk case, they feature a well defined ground state for in-plane momentum k = 0. Thanks to a mass four orders of magnitude lighter than for free electrons, quantum degeneracy effects could be obtained for very low densities and high temperature, e.g. Bose-Einstein condensation (BEC) demonstrated up to 40 K in 2006 [1].

In this presentation, we review the key parameters to achieve polariton BEC and recent progress on the physics of polariton condensates. Next we examine prospects to produce degenerate Bose gases of polaritons at room temperature in novel confinement geometries such as one-dimensional microwires.

[1] J. Kasprzak et al., Nature 443, 409 (2006).

Plenary Talk PV IV Mon 18:00 H1

Organic Semiconductors: From Lab Curiosities to Products — •Karl Leo — Inst. f. Angewandte Photophysik, TU Dresden, 01062 Dresden, www.iapp.de

Organic semiconductors with conjugated electron system are currently intensively investigated for electronic and optoelectronic applications. This interest is spurred by novel devices such as organic light-emitting diodes (OLED) for flexible displays and lighting, or organic solar cells. When the first devices were demonstrated about 20 years ago, they had lifetimes measured by minutes. However, there has been tremendous progress and recent devices have achieved outstanding efficiencies and lifetimes. In this talk, I will review some of this recent progress and discuss in particular highly efficient OLED and solar cells using doped transport layers /1/. White OLED have recently achieved very high efficiencies of 90lm/W, significantly higher than fluorescent tubes, opening the path to a new form of high-efficiency area lighting devices /2/. For organic solar cells, electrically doped transport layers allow an optimized optical design and efficient charge recombination junctions for tandem cells. Recently, we have achieved solar cells with certified efficiency exceeding 6% on larger areas.

/1/ K. Walzer et al., Chem. Rev. 107, 1233 (2009) /2/ S. Reineke et al., Nature 459, 234 (2009)

I thank J. Blochwitz-Nimoth, T. Fritz, K. Harada, G. He, Q. Huang, B. Luessem, R. Meerheim, M. Pfeiffer, S. Reineke, M. Riede, R. Schüppel, G. Schwartz, K. Walzer, A. Werner, X. Zhou, and many others for their participation in this work.

Plenary Talk PV V Tue 8:30 H1

NMR and MRI: Basic Physics for the Sake of Society — •Richard R. Ernst — Laboratorium für Physikalische Chemie, ETH Zürich, Wolfgang-Pauli-Strasse 10, 8093 Zürich, Switzerland

Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imaging (MRI) became indispensable tools in physics, chemistry, biology, and medicine with numerous applications that are highly relevant for enhancing our understanding of nature and for diagnosing diseases. It is narrated how a fundamental physics experiment took all the way into the medical clinical practice and became useful even for exploring psychological phenomena. George E. Pake has once said: "Magnetic resonance imaging is an irrefutable testimonial to the enormous value of basic research."

Prize Talk PV VI Tue 13:00 H10

Three-dimensional optical metamaterials — •Na Liu — 4. Physikalisches Institut, Universität Stuttgart — Trägerin des Hertha-Sponer-Preises

Metallic metamaterials have shown a number of fascinating properties over the last few years. A negative refractive index, negative refraction, superlenses, and optical cloaking are some of the ambitious applications where metamaterials hold great promise.

We are going to present fabrication methods for the manufacturing of 3D metamaterials. We are investigating their coupling properties and the resulting optical spectra. Hybridization of the electric as well as the magnetic resonances allows us to easily understand the complex optical properties. Lateral as well as vertical coupling can result in EIT-like phenomena. These phenomena allow to construct novel LSPR sensors with a figure of merit as high as five.

The connection between structural symmetry and their electric as well as magnetic dipole and higher-order multipole coupling will be elucidated. It turns out that stereometamaterials, where the spatial arrangement of the constituents is varied, reveal a highly complex rotational dispersion.

Plenary Talk PV VII Wed 8:30 H1

Catalytic model systems studied by high-resolution, video-rate Scanning Tunneling Microscopy — •Flemming Besenbacher — Interdisciplinary Nanoscience Center (iNANO), Aarhus University, DK-8000 Aarhus C, Denmark

The development of renewable, sustainable and green energy resources and the protection of the environment by reducing emission pollutants are two of the largest challenges for the human civilization within the next 50 years Besides the well-known energy resources that power the world today; petroleum, coal, and natural gas, active research and development exploring alternative energy resources such as solar, biomass, wind, and hydrogen is currently being performed.

To realize the vision of a clean society and our vision of plentiful, low cost sustainable energy, research and innovation within the area of the rapidly expanding fields of nanoscience and nanotechnology, multidisciplinary by nature involving physics, chemistry, biology, molecular biology, is mandatory. For decades single-crystal surfaces have been studied under ultra-high vacuum (UHV) conditions as model systems for elementary surface processes. This "surface science approach" has contributed substantially to our understanding of the processes involved in especially catalysis.

In this talk I will show how Scanning Tunneling Microscopy (STM) can reveal fundamental processes in relation to catalysis, and how we can extract quantitative information on surface diffusion of adatoms and molecules; diffusion of vacancies; interstitials and molecules, e.g. water molecules on oxide surfaces; sintering and diffusion of nanoclusters on oxide surfaces [1]; diffusion of intermediate species [2]; identification of active sites and determination of new nanostructures with novel, catalytic properties from time-resolved, high-resolution STM images/movies (see www.phys.au.dk/spm). The atomic-scale information obtained may even lead to the design of new and improved catalysts in certain cases.

[1] D. Matthey et al., Science 315, 1692 (2007)
[2] S. Wendt et al. Science 320, 1755 (2008)

Prize Talk PV VIII Wed 13:00 H1

Epitaxial graphene: a new electronic material — •Thomas Seyller — FAU Erlangen-Nürnberg — Träger des Walter-Schottky-Preises

The discovery of graphene, a two-dimensional, sp^2-bonded honeycomb lattice of carbon atoms, has created an enormous interest in its properties, fabrication, and application. Due to its peculiar band structure, charge carriers in graphene are described by the Weyl-Hamiltonian for massless, relativistic Fermions. Extraordinary transport properties such as an unusual quantum Hall effect were observed with graphene samples obtained by mechanical exfoliation. A large mobility of charge carriers and prospects for room-temperature ballistic transport raise hopes for application of graphene in electronic devices. Applications, however, demand growth methods suitable for producing graphene layers on a wafer scale. While this goal is impossible to reach with exfoliation, epitaxial graphene (EG) grown on the basal plane surfaces of silicon carbide (SiC) offers a much better prospective. In this talk I shall review studies of the structural, electronic, and transport properties of EG grown on SiC by solid-state decomposition at elevated temperatures. The first part describes a study of the electronic structure and structural properties of EG which can conveniently be determined using surface science techniques. In the second part I demonstrate how the growth of EG is improved by going from the traditional growth environment, namely ultrahigh vacuum, to an Argon atmosphere. The latter method leads to vastly improved EG films with properties similar to those of exfoliated graphene. Finally I shall report on ongoing work related to the development of graphene transistors.

Evening Talk PV IX Wed 20:00 H1

Geht nicht gibt's nicht - der Wettlauf um den kleinsten Transistor und warum Handys immer kleinere Transistoren brauchen. — •Christoph Kutter — Infineon Technologies AG, Munich

Die Entwicklungsgeschwindigkeit ist schon verrückt. Vor 20 Jahren wussten wir noch gar nicht was ein Handy ist und heute gibt es mehr Mobiltelefone in Deutschland als Einwohner. In dieser rasanten Entwicklung sind Handys immer kleiner geworden - natürlich nur bis zur Grenze der menschlichen Finger - immer energiesparender und immer schlauer. Dies alles war nur durch hochintegrierte Chips möglich. Dabei geht es nicht nur um die Integration möglichst vieler Transistoren auf einem Chip, sondern auch um die Integration von verschiedenen Funktionen, wie zum Beispiel Hochfrequenz, Recheneinheit und Stromversorgung. Die Dimensionen der Transistoren sind längst im Bereich der Nanometer Skalen angekommen. Die Kunst besteht nicht in der Fertigung eines einzelnen Rekordtransistors, sondern in der höchstreproduzierbaren Beherrschbarkeit der Herstellung von Millionen und Milliarden integrierter Transistoren, sodass die Produktion von Chips wirtschaftlich ist. Nur durch diese Hochintegration können die neuen Standards der Mobilfunktechnik erfüllt werden, da die immer höheren Datenraten enorme Rechenleistung benötigen. Da die Batterien der mobilen Endgeräte nicht größer werden, darf auch die Leistung der kleinen Superrechner nicht ansteigen. Wie geht es weiter? Keiner kann das wirklich beantworten. Nur eines ist sicher: Die atemberaubende Entwicklung wird weiter gehen. Wir werden auch in den kommen Jahren hochspannende Innovationen erleben.

Plenary Talk PV X Thu 8:30 H1

Complex Networks: From Statistical Physics to the Cell — •Albert-Laszlo Barabasi — Northeastern University/Harvard Medical School

Highly interconnected networks with amazingly complex structure describe systems as diverse as the World Wide Web, our cells, social systems or the economy. In the past decade we learned that most of these networks are the result of self-organizing processes governed by simple but generic laws, resulting in architectural features that makes them much more similar to each other than one would have expected by chance. I will discuss the statistical mechanics of our interconnected world and its implications to network robustness and spreading processes. Much of these advances were inspired by maps of real networks, informing the modeling and analytical efforts. Yet, in the past few years the richness of data has improved considerably, allowing us to look deeper into the role of the nodes and links that shape the network topology and function. My goal is to move beyond the topology and to potentially review a few recent results, from the role of distance in shaping our social networks to controllability in biological and technological networks.

Prize Talk PV XI Thu 13:00 H1

Electronic Correlations in Models and Materials — •Dieter Vollhardt — Center for Electronic Correlations and Magnetism, University of Augsburg, D-86135 Augsburg, Germany — Träger der Max-Planck-Medaille

Correlations among electrons strongly influence the properties of solids. For example, they can lead to the transition from metallic to insulating behavior, long-range magnetic order, or lattice transformations. In my talk I will first describe characteristic correlation phenomena and explain them on a model level using the dynamical mean-field theory. This discussion is then extended to real materials. Here a combination of ab initio methods for the calculation of band structures and the dynamical mean-field theory has recently led to important new insights into the fascinating properties of correlated electron materials.

Plenary Talk PV XII Thu 18:00 H1

Making and Breaking of Atomic Bonds in Carbon Tribocontacts — •Peter Gumbsch[1,2], Michael Moseler[1], and Lars Pastewka[1] — [1]Fraunhofer IWM, Freiburg, Germany — [2]KIT, Karlsruhe, Germany

Modelling of tribological contacts, of friction and wear processes, has to cover many orders of magnitude in length and time scales from the atomic scale to the size and lifetime of engineering components. Atomistic processes are obviously crucial for the mechanics of the contacts which in turn determine the wear processes that limit the lifetime of machining components. The physics-based modelling and simulation of friction and wear processes is still in its infancy. I will describe first atomistic approaches to the simulation of tribocontacts between diamond surfaces and diamond-like carbon (DLC) films. Different levels of approximations are required to assess the evolution of the friction contacts. Considerable attention must be paid there to extracting relevant information from large scale atomistic simulations, which in turn first requires an atomistic model for the hydrocarbons that can describe well the making and breaking of the atomic bonds. I will present results for the evolution of an atomically determined friction coefficient during running-in of such a contact and will later turn to the question of how the polishing of diamond proceeds.

Plenary Talk PV XIII Fri 8:30 H1

Controlling Magnetism by Light — •Theo Rasing — IMM, Radboud University Nijmegen

The interaction of light with magnetic matter is well known: magneto optical Faraday or Kerr effects are frequently used to probe the magnetic state of materials. or manipulate the polarisation of light .

The inverse effects are less known but certainly as fascinating: with light one can manipulate magnetic matter, for example orient their spins. Using femtosecond laser pulses we have recently demonstrated that one can generate ultrashort and very strong (~Tesla*s) magnetic field pulses via the so called Inverse Faraday Effect. Such optically induced magnetic field pulses provide unprecedented means for the generation, manipulation and coherent control of magnetic order on very short time scales, including the complete reversal of a magnet with a single 40 fs laser pulse and the demonstration of inertia-driven spin switching in antiferromagnets. In principle this opens the way for all-optical recording of magnetic bits at extremely high data rates. Recent results demonstrate that both linearly and circularly polarized light can be used to manipulate magnetic order at fs timescales, increasing the possibilities of all-optical control of magnetism even more.

Plenary Talk PV XIV Fri 9:15 H1

Transparent Electronics — •Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II

The use of transparent conductors such as indium tin oxide or ZnO:Al is already wide spread, e.g. in front contacts to displays and solar cells, in low emissivity windows and current spreading layers. Further advances in transparent semiconductors and transparent gate contacts allow the fabrication of transparent thin film transistors (TTFT) and will enable completely new applications such as fully transparent displays and functional surfaces. We review the state of the field, the device concepts and the material physics behind it, and present high-gain inverters and transparent logic integrated circuits based on transparent Schottky contacts to zinc oxide.