CPP 5: New Materials

Time: Monday 10:00–12:30 Location: C 230

CPP 5.1 Mon 10:00 C 230

Shear stable colloidal crystals as pH- and pressure sensors. — Roy Goldberg and •Hans Joachim Schöpe — Johannes Gutenberg-Universität Mainz, Institut für Physik, Staudinger Weg 7, 55099 Mainz, Deutschland

Opaline hydrogels were produced as polycrystalline bulk material with bcc-structure by immobilization of self-ordered charged colloidal particles crystallized under equilibrium conditions in a poly(acrylamide) matrix. The final size of a polycrystalline sample is about 7 qcm, a single crystal is up to several mm in length. The crystal size is tunable by varying the amount of photoinitiator and the hydrogel volume-change due to swelling. The resulting photonic crystals are of high quality showing high order reflections. These hydrogels show a reversible shift of the diffraction Bragg-peak wavelength in dependence of external conditions due to swelling or shrinking as funczion of the pH and under applied mechanical stress. The wavelength of the photonic band gap can be shifted over the entire spectrum of visible light (500nm). Bulk material offers the possibility to shift the position of the main Bragg reflection to smaller and to larger wavelength simultaneously: under compression the wavelength of the (110)-reflection parallel to the direction of compression decreases while perpendicular to the direction of compression it increases.

CPP 5.2 Mon 10:15 C 230

Novel electro-optic multistage switching in a polar smectic material — •Stephan Stern, Alexey Eremin, Alexandru Nemes, and Ralf Stannarius — Otto-von-Guericke-Universität Magdeburg

We report a very unusual and totally unprecedented electro-optic behaviour in a polar smectic phase of a bent-core mesogen, which cannot be attributed to either conventional antiferro-, ferri- or ferroelectric structures. Although x-ray investigations have shown a tilted smectic phase without in-plane order, the switching properties are very distinctive from those of typical ferro- or antiferroelectric liquid crystals. In order to determine the spontaneous polarization in dependence of the electric field we applied a triangular wave across the liquid crystal cell and found five peaks per half period. This behaviour can be attributed to five switching processes and corresponds to a hysteresis curve containing four loops (four stages of discontinuous switching) at high voltages and one continuous switching at lower voltages. The results were confirmed by measurements of optical transmission, birefringence and Second-Harmonic-Generation activity in the distinct states of the switching process. Based on this experimental results, possible structural arrangements of the mesogens in these distinct states of this mesophase are discussed.

CPP 5.3 Mon 10:30 C 230

PbTiO3/P(VDF-TrFE) nanocomposites for flexible skin — •Markus Krause[1], Norbert Gaar[1], Reinhard Schwödiauer[1], Simona Bauer-Gogonea[1], Siegfried Bauer[1], Bernd Ploss[2], Ingrid Graz[3], Stephanie P. Lacour[3], Martin Zirkl[4], Barbara Stadlober[4], Jian-Zhang Chen[5], and Sigurd Wagner[5] — [1]Soft Matter Physics, Johannes Kepler University, Linz, Austria — [2]SciTec, University of Applied Sciences, Jena, Germany — [3]Nanoscience Centre, University of Cambridge, U.K — [4]Institute of Nanostructured Materials and Photonics, Joanneum Research, Weiz, Austria — [5]Department of Electrical Engineering, Princeton University, Princeton NJ, USA

Flexible electronics is often inspired by nature, for example by the feasibility of skin to sense touch and temperature changes. Mimicking such features of living systems is a challenge in macroelectronics research. Here we show that composites of ferroelectric ceramics and copolymers can be tailored to exhibit exclusively piezoelectric or pyroelectric responses depending on the poling procedure applied. They are therefore suitable for the development of smart skin applications.

0-3 composites of 70/30 P(VDF-TrFE) and 30% PbTiO3 nanopowder inclusions have been prepared and polarized to exhibit either piezo- or pyroelectric functionalities. Such elements on a single foil have been combined with flexible electronic components based on amorphous silicon and organic field-effect transistors. The generated signals are used to alter the conductance of the drain-source channel of the field effect transistors, and enable the demonstration of pressure and temperature sensors, by way of design. Work partially supported by the FWF.

CPP 5.4 Mon 10:45 C 230

Dielectric barrier discharges in ferroelectrets: Spectroscopic characterization and pressure dependence — •Xunlin Qiu, Axel Mellinger, Werner Wirges, and Reimund Gerhard — Institute of Physics, University of Potsdam, 14469 Potsdam, Germany

In recent years, a number of cellular and voided polymer-ferroelectret materials were discovered to exhibit a strong piezoelectric response after proper charging [1]. Charging occurs via a series of dielectric barrier discharges (DBDs); this process is critical for rendering ferroelectrets piezoelectric. In the present work, the transient light emission from the DBDs in cellular polypropylene ferroelectrets subjected to high electric poling fields, and the influence of gas pressure and composition on the DBDs were spectroscopically studied. The spectrum measured in air shows strong emission from the second positive system ($C^3\Pi_u \rightarrow B^3\Pi_g$) of molecular nitrogen (N_2), and the first negative system ($B^2\Sigma_u^+ \rightarrow X^2\Sigma_g^+$) of N_2^+, consistent with a DBD in air. From the strength ratios of selected vibronic bands, the electric field in the discharge was determined and found to be in good agreement with the values predicted by the Townsend breakdown model. Simultaneously, the build-up of the effective polarization of ferroelectrets under suitable voltage waveforms was studied by acoustical measurements. A polarization-voltage (P-V) hysteresis loop was obtained by analyzing the data in the light of an existing electromechanical model [2].

[1] M. Wegener and S. Bauer, ChemPhysChem **6**, 1014 (2005).
[2] X. Qiu, A. Mellinger, M. Wegener, W. Wirges and R. Gerhard, J. Appl. Phys. **101**, 104112 (2007).

CPP 5.5 Mon 11:00 C 230

Nanopatterning of gold particles using a polymer template: in situ GISAXS study — •Ezzeldin Metwalli[1], Sebastian Couet[2], Kai Schlage[2], Ralf Röhlsberger[2], Volker Körstgens[1], Matthias Ruderer[1], Weinan Wang[1], Gunar Kaune[1], Stephan Roth[2], and Peter Müller-Buschbaum[1] — [1]Physikdepartment E13, Technische Universität München, James-Franck-Str. 1, 85747 Garching, Germany — [2]HASYLAB at DESY, Notkestr. 85, 22603 Hamburg, Germany

The organization of metal nanoparticles within self-assembled polymer template is important for developing functional hybrid materials. Microphase-separated structures of mixed diblock-triblock copolymer thin films are used for the incorporation of gold atoms inside the polymer matrix via sputtering of gold. Polystyrene nanospheres are arranged in a liquid-like type with a well defined nearest neighbor distance inside a polyisoprene matrix acting as a template for directing the gold atoms. Sputtering conditions are selected with a low rate and a high pressure of argon gas inside the sputter chamber to avoid clustering in the atmosphere and on the polymer film. Due to the mobility of the gold atoms and the selective interaction with the polystyrene domains of the microphase separation structure, gold is accumulated in the PS spheres as probed with in situ grazing incidence small-angle x-ray scattering. Our study introduces the concept that, without thermal annealing of the gold attached polymer film, the gold assembly is not limited to the flat two dimensional but also included in three dimensional structures.

break

CPP 5.6 Mon 11:30 C 230

Relaxation and cyclic deformation behaviour of multigraft copolymers — Ralf Schlegel[1], •Roland Weidisch[1], Ulrike Staudinger[1], and Jimmy W. Mays[2] — [1]Institute of Materials Science and Technology (IMT), Friedrich-Schiller-University Jena, Löbdergraben 32, D-07743 Jena, Germany — [2]Department of Chemistry, University of Tennessee, Knoxville, USA

Multigraft copolymers consisting of a polyisoprene (PI) backbone chain and several grafted polystyrene (PS) arms form microphase separated morphologies in which the hard phase (PS) is coupled directly by chemical bonds to the soft rubbery phase. As shown in recent work PI-PS multigraft copolymers exhibit higher strains at break as well as lower residual strains in comparison to commercial triblock thermoplastic elastomers [Zhu06]. In this study the materials have been characterized by cyclic deformation (hysteresis measurements) and relaxation

tests. Stress strain curves of the materials have been characterized by applying models of rubber elasticity. It could be observed that the mechanical properties in relaxation and during the hysteresis are significantly influenced by the unctionality and the number of branch points β. In addition the morphology impacts the mechanical behaviour. At low PS-contents at about 16 - 19 wt.-% tetrafunctional multigraft copolymers exhibit a spherical morphology and the values for the modulus increase with β, whereas they decrease in multigrafts with a PS content of about 23 - 25 wt-% forming a cylindrical morphology.

[Zhu06] *Zhu, Y.; Burgaz, E.; Gido, S.P. *Macromolecules*, 2006, 39, 4428-4436

CPP 5.7 Mon 11:45 C 230

Astonishing change of the hypersonic behaviour in a commercial gel due to supercooling of the sol-gel transition — •Ulrich Müller[1], Martine Philipp[1], Jan Kristian Krüger[1], Roland Sanctuary[1], Bartosz Zielinski[1], Jörg Baller[1], Ravindrakumar Bactavatchalou[1], and Patrick Alnot[2] — [1]Université du Luxembourg, LPM, Campus Limpertsberg, L-1511 Luxembourg — [2]Université Henri Poincaré - Nancy I, Nancy, France

The sol-gel transition in the commercial gel Kaisers glycerol gelatine (MERCK), composed of water, glycerol and gelatine is based on the formation of percolated physical network of the gelatine molecules. The measurements are performed by Brillouin spectroscopy for the determination of the hypersonic properties, polarimetry for the investigation of the network formation and refractometry. It will be shown that the hypersonic properties of that gel strongly depends on the thermal history of the material on one hand but that no special acoustic anomaly is found in the vicinity of the temperature of gelation on the other. Although differently supercooled gel states are clearly in thermodynamic non-equilibrium they did not show relaxations towards their equilibrium state. In agreement with that result different glass forming behaviour was observed.

CPP 5.8 Mon 12:00 C 230

Phases Sequences of a Gelatine Based Physical Gel at Low Temperatures — •Martine Philipp[1], Ulrich Müller[1], Claude Lecomte[2], Emmanuel Wenger[2], Roland Sanctuary[1], Jörg Baller[1], Bartosz Zielinski[1], Patrick Alnot[2], Didier Rouxel[2], and Jan Krüger[1] — [1]LPM, Université du Luxembourg, Luxembourg — [2]Université Nancy, Nancy, France

Only little is known about the low temperature properties of physical gels like gelatines dissolved in glycerol/water. Because of the inherent disorder of the gelatine molecules, depending on the cooling scenario different equilibrium and non-equilibrium low temperature states can be created. Taking Kaisers glycerol gelatine (Merck) as a model substance we will demonstrate that the low temperature behaviour of this gel is very interesting. Different stable glassy states have been found including that of a glass-ceramic. The latter is usually created by thermo diffusion (Soret effect) and grows in form of ball-like structures. Brillouin spectroscopy, X-ray scattering and optical microscopy are used to identify the different low temperature phases. An interpretation for the growth of the ball-like ceramic objects based on the Soret effect is proposed. The results are compared with the low temperature properties obtained for pure glycerol/water mixtures. In addition, the influence of inorganic nanoparticles on the phase formations within Kaisers glycerol gelatine is discussed.

CPP 5.9 Mon 12:15 C 230

The isopod cuticle: A model to study the influence of the structure and chemical composition on the mechanical properties of a biological composite material — •Sabine Hild[1], Andreas Ziegler[1], and Othmar Marti[2] — [1]Central Facility for Electron Microscopy; University of Ulm, Germany — [2]Experimental Physics; University of Ulm, Germany

The mineralized exoskeleton (cuticle) of crustaceans is an excellent model to study biological nano-composites. The cuticle consists of an organic matrix composed of chitin-protein fibers associated with various amounts of crystalline and amorphous calcium carbonate (ACC). Although this structural principle is ubiquitous for the cuticle of crustaceans, their mechanical properties are well adapted to their various habitats and escape strategies. To show possible adaptations of the mechanical performance of the exoskeleton to its biological requirements the chemical and structural composition of different isopod species were analyzed. Using confocal micro-Raman microscopy, SEM and SFM it was shown that for all investigated species the mineral phase is arranged in distinct layers. Calcite is restricted to the outer area of the cuticle, whereas ACC is localized in the middle having only little overlap with the calcite layer. Nano-indentation tests performed on the cross sections of the cuticle of different isopods reveals higher mechanical strength for the crystalline than for the ACC-rich phase. Our results suggest that variations in the thickness of the calcite containing layers as well as the amount of organic material leads to variations in exoskeleton hardness and flexibility.