

CPP 31: New Materials

Time: Friday 10:30–12:30

Location: H40

CPP 31.1 Fri 10:30 H40

Piezoelectric properties of polyester ferroelectrets made from polyethylene terephthalate — ●OLENA VORONINA, MICHAEL WEGENER, WERNER WIRGES, and REIMUND GERHARD — University of Potsdam, Institute of Physics, 14469 Potsdam, Germany

Ferroelectrets are cellular polymer foams with macroscopic electric dipoles that are formed by charges trapped on the internal void surfaces. The piezoelectricity of ferroelectrets arises from changes of the void heights (and thus of the dipole sizes) when mechanical or electrical stress is applied. Ferroelectrets are usually relatively soft in the thickness direction which leads to high piezoelectric activities with coefficients up to hundreds of pC/N [1].

Here, we describe the preparation and the resulting properties of new polyethylene-terephthalate (PETP) ferroelectrets [2]. An optimized sequence of steps for preparation is described. It includes foaming of commercial PETP films in supercritical CO₂ accompanied by a heat treatment as well as biaxial stretching and electric charging. The optimized PETP ferroelectrets exhibit piezoelectric thickness coefficients up to 500 pC/N for which the low elastic stiffness of only around 0.3 MPa is essential. The PETP ferroelectrets show unclamped thickness-extension resonance frequencies between approximately 120 and 250 kHz, and are thus particularly suitable for ultrasonic-transducer applications.

[1] M. Wegener and S. Bauer, *ChemPhysChem* 6, 1014-1025 (2005).

[2] W. Wirges, M. Wegener, O. Voronina, L. Zirkel and R. Gerhard-Multhaupt, *Advanced Functional Materials*, in press

CPP 31.2 Fri 10:45 H40

Investigation of structures in diblock copolymer film containing magnetic nanoparticles — ●M. M. ABUL KASHEM¹, J. PERLICH¹, L. SCHULZ¹, S. V. ROTH², and P. MÜLLER-BUSCHBAUM¹ — ¹TU München, Physik-Department LS E13, James-Franck-Str. 1, 85747 Garching, Germany — ²HASYLAB at DESY, Notkestr. 85, 22603 Hamburg, Germany

Nanocomposite materials based on polymeric matrix and inorganic fillers having desired mechanical, electrical and thermal properties have been reported since long. Rendering magnetic properties to the polymer by using magnetic nanoparticles is a rather new idea. We have investigated the nanostructures supported by superstructures formed in ultra thin films of such a new type of nanocomposite materials. The system is a diblock copolymer p(styrene-block-isoprene) matrix with embedded magnetic nanoparticles (metal oxide) covered with polymeric (PS) hairs. The superstructure is formed due to dewetting of the polymer film and the nanostructure due to self-assembly of diblock copolymer. We were able to produce dewetted structures containing magnetic nanoparticles. The nanoparticles retard the dewetting process and control the orientation from a perpendicular to a parallel lamella. Moreover, roughness correlation between the substrate and the film surface has been observed at different film thicknesses resulting from gradient sample. The investigation has been carried out by atomic force microscopy (AFM) in non-contact mode and by using micro-beam grazing incident small angle X-ray scattering (μ GISAXS).

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CPP 31.3 Fri 11:00 H40

Formation and properties of monomolecular nanomembranes — ●ANDRE BEYER¹, CHRISTOPH T. NOTTBOHM¹, BERTHOLD VÖLKE¹, WOLFGANG ECK², and ARMIN GÖLZHÄUSER¹ — ¹Physik Supramolekularer Systeme, Universität Bielefeld, Universitätsstr. 25, D-33615 Bielefeld (Germany) — ²Institute for Molecular Biophysics, The Jackson Laboratory, 600 Main Street, Bar Harbor, ME 04609 (USA)

Recently, a new way was found to reduce the thickness of polymerized nanomembranes to about 1 nm [1]. These membranes can be clamped over several micrometer wide openings and withstand pressures as high as 10 kPa. They are made from self-assembled monolayers which form stable nanosheets by crosslinking with electrons. Free-standing nanomembranes can be fabricated by preparing nanosheets on silicon nitride membranes which are supported by a silicon frame. After dissolving the silicon nitride, the nanosheets of monomolecular thickness remain clamped over the silicon frame.

In this contribution, we will discuss the fabrication of such nanomembranes as well as first measurements of their mechanical prop-

erties. We designed a pressure cell that allows bulge tests with an atomic force microscope. The latter is necessary to determine the membrane deflection. Bulge tests, i.e. measurements of the deflection as a function of an applied pressure difference, allow us to determine the biaxial modulus, changes of the mechanical properties in time and the critical tension at which the nanomembranes start to rupture.

[1] W. Eck, A. Küller, M. Grunze, B. Völkel, and A. Gölzhäuser, *Advanced Materials* 17, 2583 (2005).

CPP 31.4 Fri 11:15 H40

Near-edge x-ray absorption spectroscopy of metalloporphyrins and metalloporphyrin-fullerene dyads — ●NORMAN SCHMIDT¹, JÖRG DANNHÄUSER², THOMAS STRUNSKUS³, ANDREAS HIRSCH², and RAINER FINK¹ — ¹Universität Erlangen. Physikalische Chemie II, Erlangen, Germany — ²Universität Erlangen, Organische Chemie II, Erlangen, Germany — ³Ruhr-Universität Bochum, Physikalische Chemie I, Bochum, Germany

Metalloporphyrins are well-known as electron donors in photoinduced electron transfer processes. [60]fullerene is an excellent electron acceptor, thus stabilizing radical ion-pair states in dyads of metalloporphyrins and fullerene. In these model systems for photosynthesis, the two chromophores are forced into a rigid stacking arrangement by covalent bonding and crystal packing, which leads to an interaction of the electron density of the central metal and the fullerene π -system on both sides of the porphyrin plane. Also a weak back-bonding is found.

In the current study, the electronic structure of thick films of (Mn, Fe, Co, Zn, Sn)-porphyrins and (Mn, Fe, Co)-dyads on Au-plated Si was investigated with NEXAFS spectroscopy. The presented N1s spectra reflect the electronic interaction of the central metal ion with the surrounding N atoms. Differences in the metal 2p-edge spectra between porphyrin and dyad arise mainly from electron density in the d_{z^2} -orbital (single occupation for Fe³⁺ and Co²⁺). The measured spectra will also be compared to DFT calculations. This work was funded by DFG (SFB 583).

CPP 31.5 Fri 11:30 H40

Charging dynamics of cellular polypropylene ferroelectrets: a combined optical and acoustic study — ●AXEL MELLINGER, XUNLIN QIU, MICHAEL WEGENER, WERNER WIRGES, and REIMUND GERHARD — Universität Potsdam, Institut für Physik, 14469 Potsdam, Germany

Ferroelectrets (i.e., charged cellular polymers) are rendered piezoelectric through barrier discharges inside their artificial voids [1]. Controlling and understanding the charging dynamics is a key element in the optimization of present and the development of new materials. In this work, time-resolved imaging has revealed discharge processes in individual voids and led to the discovery of a strong back-discharge glow. Simultaneous acoustic measurements of the inverse piezoelectric d_{33} coefficient show a “butterfly” hysteresis curve. In the framework of the presently accepted electromechanical model [2], their shape can be explained by an effective internal charge density σ_{eff} which depends both on the applied electric field and the charging history. Approx. 75 % of the internal charge density is destroyed through back discharges.

[1] S. Bauer, R. Gerhard-Multhaupt and G. M. Sessler, *Physics Today* 57, 37-43 (2004).

[2] M. Paaanen, J. Leikkala and H. Välimäki, *IEEE Trans. Dielectr. Electr. Insul.* 8, 629-636 (2001).

CPP 31.6 Fri 11:45 H40

Fabrication of nano-porous electrode arrays by self-assembly — ●THEOBALD LOHMÜLLER¹, ULRICH MÜLLER², MARTIN STELZLE², STEPHAN LINKE³, MARKUS KACZOR³, and JOACHIM SPATZ¹ — ¹MPI für Metallforschung & Universität Heidelberg, 70569 Stuttgart — ²Naturwissenschaftliches und Medizinisches Institut, 72770 Reutlingen — ³HL Planartechnik GmbH, 44227 Dortmund

Colloidal particles are used as a lithographic tool for the fabrication of a nano-porous electrochemical sensor. The system consists of a bottom and a porous top electrode separated by an insulating layer of predefined thickness. Polystyrene particles of different sizes act as a shadow mask for the deposition of the top electrode. After the particle lift-off, the porous metal layer is used as an etching resist to remove the insulating material. By adjustment of the nanoelectrode spacing and its

pore diameter defined electrode arrays are generated. We demonstrate the control of particle films with particle sizes up to $1\ \mu\text{m}$ by a simple dipping procedure. This enables a fast and reproducible processing of a lithographic mask. The particle adsorption is influenced by electrostatic particle/particle and particle/surface interactions, resulting in an extended monolayer of ordered particles on the surface. In this context we present solutions how the pore size and spacing can be adjusted in order to improve the nanopore geometry. Enhanced electrochemical sensitivity is achieved by redox-cycling between the top and bottom electrode. So far, amplification factors > 50 have been demonstrated. Currently the system is optimized to obtain maximum signal amplification.

CPP 31.7 Fri 12:00 H40

Magnetorheology of polymer bottle brushes — ROBERT KRAUSS¹, BIRGIT FISCHER¹, YOUYOUNG XU², AXEL MÜLLER², and REINHARD RICHTER¹ — ¹Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth — ²Makromolekulare Chemie II, Universität Bayreuth, D-95440 Bayreuth

By dispersing polymer bottle brushes [1] in a magnetic liquid synthesized in paraffine oil we are creating a new type of inverse ferrofluid [2]. The brushes differ in their cylindrical symmetry, their semi flexible nature and their ramified nano structure from the compact, spherical objects commonly immersed in ferrofluid [3]. The properties of the new magnetorheological fluid are studied by oscillatory measurements of the storage and loss moduli for varying magnetic induction B . For moderate $B < B_c \approx 10\ \text{mT}$ the storage modulus is hardly affected, whereas for larger B we observe a logarithmic increase. The threshold B_c may be interpreted as the percolation transition of a magnetic field induced network of bottle brushes, connecting the bottom with the top plate. Chain formation of the brushes is corroborated by the magnetic field dependent shear thinning observed in rotational measurements of

the viscosity. [1] M. Zhang, A. H. E. Müller, J. Polym. Sci. Part A: Polym. Chem. **43**, 3641 (2005). [2] A. T. Skjeltorp, Phys. Rev. Lett. **51**, 2306 (1983). [3] R. Saldivar et al., J. Chem. Phys. **125**, 084907 (2006).

CPP 31.8 Fri 12:15 H40

Magnetic and structural properties of thin polymer films with embedded superparamagnetic $\gamma\text{-Fe}_2\text{O}_3$ nanoparticles —

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We investigate lamellae-forming polystyrene-b-polyisoprene diblock copolymer films with embedded $\gamma\text{-Fe}_2\text{O}_3$ nanoparticles. The used block copolymer is asymmetric and forms a microphase separation structure. For the thin film preparation we apply two techniques, spin coating and solution casting. Magnetisation measurements at 2 K and 300 K show that the saturation magnetisation is linear dependent on the nanoparticle concentration. A constant coercitive field and increasing fields of remanence for different nanoparticle concentrations are verified. AC-susceptibility measurements exhibit non-interacting superparamagnetic behaviour of the nanoparticle ensemble. Ageing effects confirm spin-glasses in the surface of the nanoparticles. Structural composition and distribution of the nanoparticles within the thin films are obtained by grazing incidence small angle X-ray scattering (GISAXS) and X-ray reflectivity. An increasing nanoparticle concentration results in forming smaller characteristic structure sizes. GISAXS experiments are performed at beamline BW4 at HASYLAB/DESY in Hamburg.