CPP 19: POSTER: Micro and Nano Fluidics

Time: Wednesday 16:00–18:30 Location: Poster B

CPP 19.1 Wed 16:00 Poster B

Cantilever micro rheometer for measurement of sugar solutions — •Marc Hennemeyer and Robert Stark — Dept. Geo und Umwelt, Ludwig-Maximilians-Universität, Theresienstr. 41, 80333 München

Measurement of rheological properties of liquids is of high interest in many areas like medicine and biology. As traditional measurement techniques require relatively big amounts of sample fluid, the last years have seen an increased interest in the miniaturization of measurement tools. Micro mechanical sensors as used in atomic force microscopy are ideally suited as sensors in micro fluidic devices. Although the vibration of cantilevers does not respond to viscosity changes of fluids on macroscopic scales, micrometer scaled plates are affected by the viscous properties of the surrounding fluids. In this work a simple measurement tool for the rheological measurements on arbitrary Newtonian liquids is presented which is based on the analysis of stochastic cantilever oscillations. The system can be operated with standard consumer computer hardware, which dramatically reduces the costs for the system. The system presented in this work is a very cost effective set up that can be used for a wide range of experiments in cost sensitive environments. It could be shown, that for viscosity measurements on basis of the method introduced by Sader, standard computer hardware can be used to substitute expensive data acquisition hardware. The measurements on sugar solutions could evaluate the viscosity and density of the solutions to an accuracy of about 10%.

CPP 19.2 Wed 16:00 Poster B

Dewetting dynamics of thin polymer films on topographic and elastic substrates — •Konstantina Kostourou, Krishnacharya Khare, Martin Brinkmann, Stephan Herminghaus, and Ralf Seemann — Max Planck Institute for Dynamics and Self-Organization, D-37073 Göttingen, Germany

Dewetting dynamics of polymer films in triangular grooves and on elastic substrates are studied experimentally and theoretically. Liquid filaments, in triangular grooves, with convex liquid-vapor interface are unstable and undergo dynamic instability resulting in equally spaced individual droplets with a preferred distance. This instability is driven by the local variation of the Laplace pressure with filament width and resembles a generalized Rayleigh-Plateau instability. From the time scale of the dynamic instability we extract slip properties of the polymer/substrate interface. Additionally we study the dewetting dynamics of thin polymer films on rubber elastic substrates. Here, the dynamics are additionally determined by the dissipative properties of the elastic substrate. We compare the flow behavior of liquid polymer films on substrates of different visco-elasticity and constant wettability. Our experiments show that dewetting is faster on substrates with larger elastic modulus.

CPP 19.3 Wed 16:00 Poster B

Raman spectroscopy on periodic mesoporous organosilica with different pore sizes — •Martin Andreas Schreiber[1], Martin Güngerich[1], Wolfram Heimbrodt[1], Torsten Henning[2], Peter Jens Klar[2], Vivian Rebbin[3], Michael Fröba[3], Lutz Eichhorn[4], Jürgen Brandner[4], and Klaus Schubert[4] — [1]Dept. Physics and WZMW, Philipps University of Marburg, Germany — [2]1. Physics Institute, Justus-Liebig-University of Gießen, Germany — [3]Institute of Inorganic and Analytical Chemistry, Justus-Liebig-University of Gießen, Germany — [4]Forschungszentrum Karlsruhe, IMVT, Eggenstein-Leopoldshafen, Germany

Periodic mesoporous organosilica (PMOs) are organic-inorganic hybrid materials with regular pore systems and well-defined pore sizes in the range of 3 to 15 nm yielding inner surfaces of about $1000\,m^2/g$. Two-point attached organic units within the silica matrix in the pore walls are a genuine part of the 3D pore wall framework. These organic functionalisations is very versatile making these hybrids interesting for applications in catalysis and micro-reactor technology.

Here we study the adsorption and desorption behavior in dependence of the pore-size of benzene-functionalized and ethane-functionalized PMOs in the temperature range between 20 and 140°C by Raman spectroscopy. We find significant differences in the adsorption-desorption behaviour for the solvents ethanol and benzene suggesting that PMOs make a selective separation of solvent vapours possible.

CPP 19.4 Wed 16:00 Poster B

Mechanical properties of wet granular matter — •Mario Scheel, Martin Brinkmann, Stephan Herminghaus, and Ralf Seemann — MPI for Dynamics and Self-Organization

The macroscopic mechanical properties of a dry granulate change dramatically when small amounts of liquid are added. This is due to capillary bridges forming between mutually adjacent grains in the pile, which exert an attractive force by virtue of the surface tension of the liquid. The mechanical properties of a wet model granulate consisting of glass spheres with a narrow size distribution are studied. We determine the critical fluidization acceleration for vertical agitation, the tensile strength, and the yield stress of the granulate for various liquid contents. We compare the results from these different methods with each other and discuss them in the framework of structural information extracted from x-ray tomography images of granulates, i.e. the packing density and the liquid distribution. In-situ x-ray tomography experiments reveal furthermore insights into the redistribution of the liquid within a sheared granulate and the redistribution of liquid within a formerly fluidized granulate.

CPP 19.5 Wed 16:00 Poster B

A Study on the Permeability of Nanoporous Vycor — •Simon Grüner[1], Stefanie Greulich[1], Dirk Wallacher[2], and Patrick Huber[1] — [1]Saarland University, Saarbrücken, Germany — [2]Hahn-Meitner Institute, Berlin, Germany

We have designed and built a membrane flow apparatus (MFA) to measure the liquid permeability K of porous monoliths such as nanoporous Vycor as a function of applied pressure difference ΔP ($0 < \Delta P <$ 70bar), temperature T and pore wall chemistry (silanization). The pore structure of the matrix (mean pore diameter $d \approx 8$nm, porosity $\phi \approx 30\%$) is characterized by nitrogen sorption isotherms at $T = 77$K.

First measurements of the volume flow rate $\dot{V}$ of n-hexane through Vycor at $T = 18°$C nicely confirm Darcy's law, that is $\dot{V} \propto \Delta P$. Nonetheless the derived permeability K is somewhat smaller than expected from calculations assuming the above mentioned values for ϕ and d. We rather obtain a best agreement between experiment and theory with a pore radius 0.4nm smaller than that derived from the sorption isotherm. This reduction corresponds to about one immobile monolayer (boundary layer) of lying hexane molecules at the wall.

This work has been supported by the DFG within the priority program 1164 (HU850/2-1).

CPP 19.6 Wed 16:00 Poster B

Discrete Microfluidics: Combinatorial Chemistry with Emulsions — •Venkatachalam Chokkalingam, Craig Priest, Stephan Herminghaus, and Ralf Seemann — Max Planck Institute for Dynamics and Self-Organization, D-37073 Göttingen, Germany

Microfluidics usually involves single phase liquids transported through microchannel networks. Instead of single phase flow we explore a droplet based discrete microfluidics for possible applications in combinatorial chemistry. The online generation of highly monodisperse emulsions in a single step is studied to compartment liquids within microchannels. Furthermore, we explore the manipulation of monodisperse emulsions using the distinct interaction of the internal length scale of the liquid (drop diameter) with the external provided geometry of the microchannels for positioning, sorting, dividing and exchanging droplets in 'lab-on-chip' style processing. Coalescence between adjacent compartments can be induced applying an electrical potential of a few volts across their lamella. As a first approach towards combinatorial chemistry we study all possible volumetric combinations of two chemicals. Adjusting the temporal concentration of the two chemicals accordingly to the channel geometry down stream when injecting them into the microfluidic channel leads to a 2D reaction library where the two concentration gradients vary along the x- and y-axis, respectively.

CPP 19.7 Wed 16:00 Poster B

Thermally Excited Capillary Waves on a Surface Frozen Liquid: A GIXPCS Study — P. Huber[1], •M. Wolff[1], V. Schoen[1], M. Deutsch[2], E. Sloutskin[2], B. Ocko[3], J. Baumert[3], A. Madsen[4], and M. Sprung[5] — [1]Universitaet des Saarlandes, Saarbruecken, Germany — [2]Bar-Ilan University, Ramat-Gan, Israel — [3]Brookhaven Na-

tional Laboratory, NY, United States — [4]European Synrchoton Radiation Facility, Grenoble, France — [5]Advanced Photon Source, Argonne National Laboratory, United States

We present results of grazing incidence x-ray photon correlation spectroscopy (GIXPCS) measurements on thermally-excited capillary waves at the free surface of a tetracosane ($C_{24}H_{50}$) melt as a function of temperature. The measurements have been carried out at the ESRF, Grenoble, France and APS, Argonne National Laboratory, USA.

Upon surface freezing - the formation of a single crystalline monolayer at the melt's surface, close to, but above the bulk solidification temperature - we find a change both in the damping and in the dispersion relation of the capillary waves.

Our findings on the behavior of *microscopic* capillary waves, presented here, corroborate earlier results regarding the changes in the dynamics of *macroscopic* capillary waves upon surface freezing [1].

[1] P.Huber et al., Physical Review Letters **94**, 184504 (2005)

CPP 19.8 Wed 16:00 Poster B

Rheological and structural phase diagrams of salted solutions of the tri-block copolymer EO_{20}-PO_{70}-EO_{20} — •Nicole Voss[1], Marco Walz[1], Max Wolff[2], and Andreas Magerl[1] — [1]Chair for Crystallography and Structural Physics, University of Erlangen-Nürnberg, Staudtstr. 3, 91058 Erlangen — [2]Chair for Condensed Matter Physics, Ruhr-University Bochum, Universitätsstr. 150, 44780 Bochum

Aquaeous solutions of tri-block copolymers have well known rich phase diagrams of ordered structures which can also be identified through rheometry. We have studied the influence of adding electron-rich salts with concentrations up to 1.5 mol/dm^3 on the phase diagram of the tri-block copolymer Pluronic® P123 (central block of 70 propylene oxide units terminated by two end groups of 20 ethylene oxide units). While the morphology of the phase diagram is preserved, a linear shift of -12°C per 1 mol/dm^3 CsCl is observed for the phase boundary of the cubic phase with high viscosity. The results are interpreted by the modification of the water structure, i. e. the ions of CsCl surround themselves with hydration shells and also dehydrate the PPO block. This mechanism decreases the solubility of the polymer and favours micellization at lower temperatures.

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CPP 19.9 Wed 16:00 Poster B

Shear flow pumping in open microfluidic systems — •Markus Rauscher[1,2], Siegfried Dietrich[1,2], and Joel Koplik[3] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart — [2]Institut für Theoretische und Angewandte Physik, Universität Stuttgart, 70569 Stuttgart — [3]Benjamin Levich Institute and Department of Physics, City College of the City University of New York, New York, NY 10031, USA

We propose to drive open microfluidic systems by shear in a covering fluid layer, e.g., oil covering water-filled chemical channels. The advantages as compared to other means of pumping are simpler forcing and prevention of evaporation of volatile components. We calculate the expected throughput for straight channels and show that devices can be built with off-the-shelf technology. Molecular dynamics simulations suggest that this concept is scalable down to the nanoscale.

CPP 19.10 Wed 16:00 Poster B

Dynamics of droplets on open microfluidic Y-junctions — •Fabian Dörfler[1,2], Markus Rauscher[1,2], and Siegfried Dietrich[1,2] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart — [2]Institut für Theoretische und Angewandte Physik, Universität Stuttgart, 70569 Stuttgart

We investigate the dynamics of droplets on chemical channels with Y-junctions driven by body forces. Chemical channels are wetting stripes on otherwise non-wetting surfaces in which liquids can be guided.

We analyse the energy of a droplet in the vicinity of a junction in a capillary model in quasistationary approximation. We investigate the pinning of the droplets in the junction and from the local contact angle we determine thresholds for the spilling of droplets onto the non-wetting substrate.

CPP 19.11 Wed 16:00 Poster B

Correlating macroscopic viscosity and microscopic structure of the tri-block copolymer EO_{20}-PO_{70}-EO_{20} — •Marco Walz[1], Max Wolff[2], Nicole Voss[1], Andreas Magerl[1], and Hartmut Zabel[2] — [1]Chair for Crystallography and Structural Physics, University of Erlangen-Nürnberg, Staudtstr. 3, 91058 Erlangen, — [2]Chair for Condensed Matter Physics, Ruhr-University Bochum, Universitätsstr. 150, 44780 Bochum

A neutron scattering study on the structure of the tri-block copolymer Pluronic® P123 (EO_{20}-PO_{70}-EO_{20}) in aqueous solution near a solid boundary is presented. An initially unexpected hysteresis found in the macroscopic viscosity is correlated with solid state orderings observed by near surface diffraction. The alignment of the structures is sensitive to the surface and its chemical termination. With temperature, the fcc lattice constant varies between 218 Å and 231 Å for 18°C and 32°C, respectively. The rocking curves, also with hysteresis, have a clear two-component profile giving information about long range correlations and short range disorder of the micelles.

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CPP 19.12 Wed 16:00 Poster B

Thinning Dynamics of Foam Films from Dodecyl Maltoside (C12G2) — •Silke Stöckle, Rumen Krastev, and Helmuth Möhwald — Max-Planck Institute of Colloids and Interfaces, Potsdam/Golm, Germany

The surface dimensions of foam films range between micrometers and meters while their thickness is in the range of nanometers. These dimensions make the films a valuable system to study the behaviour of liquids in confined geometries. Foam films are liquid films which separate two gas phases. Thin foam films are stabilised by surfactants and consist of two surfactant monolayers in contact with an aqueous core. In order to understand time dependant changes in colloidal systems like the formation of aggregates, or the flow of colloids through micro-channels, the dynamics of film thinning is a crucial aspect to investigate. During the process of thinning, the distance between the film surfaces becomes substantially smaller than the interfacial zone around the surfaces. The interaction of the film surfaces changes not only the diffusion of the molecules adsorbed at the film surface but as well the viscous-elastic properties of the bulk. The contribution shows results on the thinning dynamics of films stabilised by C12G2. The experiments were performed using the *dynamic method* technique. Up-to-date analysis was used to obtain the influence of the film surface dynamic properties on the film thinning. The results show the influence of the surfactant density on the film thinning process.

CPP 19.13 Wed 16:00 Poster B

Wet Chemical and Dry Plasma Surface Hydrophilisation of epoxy-based Polymers (SU-8) — •Ferdinand Walther[1], Polina davidovskaya[1], Stefan Zürcher[2], Michael Kaiser[3], Helmut Herberg[3], Alexander M. Gigler[1], and Robert W. Stark[1] — [1]CeNS and Crystallography, LMU München, Germany — [2]Laboratory for Surface Science and Technology, ETH Zurich, Switzerland — [3]University of Applied Sciences, FB06, Munich, Germany

The effect of oxygen plasma treatment on surface energy, topography and surface chemistry of the negative photoresist epoxy novolak SU-8 was investigated by contact angle goniometry, atomic force microscopy (AFM) and X-ray photoelectron spectroscopy (XPS). Directly after plasma treatment, the surfaces were completely wetted by water with a contact angle between water and the SU-8 surface below five degrees. The surface free energy can be increased significantly depending on the plasma dose. The surfaces remained hydrophilic for several months showing a moderate hydrophobic recovery. The surface topography of the plasma treated SU-8 showed a formation of nanoscale aggregates. The rms-roughness of the topography was correlated with the plasma dose. An increased plasma dose induced aggregates of up to 200 nm in size. XPS measurements revealed changes in surface chemistry due to the plasma process and an increased antimony concentration on the surface.

CPP 19.14 Wed 16:00 Poster B

Characterization of Colloids, Polymer Solutions and Nanoparticles Suspensions Flow by Surface Sensitive Scattering — •J.-F. Moulin[1], V. Körstgens[1], E. Metwalli[1], W. Wang[1], S.V. Roth[2], and P. Müller-Buschbaum[1] — [1]TUMünchen, Physik-Department E13, James-Franck-Str. 1, D-85747 Garching, Germany — [2]HASYLAB@DESY, Notkestr. 85, D-22603 Hamburg, Germany

We will present the results of microbeam grazing incidence x-ray scat-

tering (GISAXS) performed on fluidic channels. GISAXS enables to characterize the in plane ordering at the substrate surface and has proven a valuable technique for the characterisation of thin films and interfaces. Combining these strengths with fluidics opens a new field of potential studies: the formation of thin films from solutions can be followed as a function of the relevant parameters (e.g. flow, nature of the solvent), phenomena such as size sorting of colloids, influence of shear on polymers at interfaces (slippage) can also be investigated. The design of the experiment as well as experimental results demonstrating the feasibility of such measurements will be presented.

Funding of this work by the DFG priority program SPP 1164, project Mu 1487/2 on Nano and Microfluidics is gratefully acknowledged.

CPP 19.15 Wed 16:00 Poster B

Fingering instability in entangled polymer films — •Julia Mainka[1], Chiara Neto[2], Oliver Bäumchen[1], and Karin Jacobs[1] — [1]Saarland University, Experimental Physics, D-66041 Saarbrücken, Germany — [2]Department of Applied Mathematics, Research School of Physical Sciences and Engineering, Australian National University, 0200 Canberra A.C.T., Australia

Viscous fingering is a prevalent phenomenon in dewetting polymer melts that arises at the interface between the moving liquid and the solid substrate. In our investigations we consider the fingering instability that occurs at the linear three phase contact line of a liquid polystyrene film. The film retracts from a highly non-wettable solid substrate only under the action of capillary driving forces. The investigations are realized by means of optical and atomic force microscopy under different external conditions. When dewetting starts, the material removed from the dewetted area forms a rim at the front of the receding film. The rim grows in size, and after a certain time, begins fluctuating in height and with. With increasing undulations, and further retracting of the contact line, material in the shape of fingers is left behind. The fingering is a consequence of an analogon of the Rayleigh-Plateau instability. The aim of our investigations is to show how parameters like molecular weight of the polymers, film thickness and slippage influence the dynamics and the morphology of the emerging finger structures. In particular, slippage and entanglement of the polymer seem to contribute to the understanding of the observed fingering instabilities.

CPP 19.16 Wed 16:00 Poster B

Semiflexible and sheared: actin filaments in microflow — •Dagmar Steinhauser, Holger Stark, and Thomas Pfohl — Max-Planck-Institut für Dynamik und Selbstorganisation, Bunsenstraße 10, 37073 Göttingen

Actin filaments, aside from their biological renown as providing the 'skeleton' of cells, also proffer an ideal platform from which to study - more generally - the properties of semi-flexible polymers. Microfluidic devices made using soft-lithography are easily adapted in dimension and geometry to create well-defined flow environments. Actin filaments inside microfluidic channels are visualized by stroboscopic laser light illumination. Single filaments are considered in a symmetric channel with Poiseuille velocity profile, and the stochastic and deterministic behaviors of the filaments are analyzed for different flow rates. A detailed analysis of the center-of-mass probability distribution along a cross-section of the channel is reported, and a spatial varying orientation and conformation of the filaments are found. This work is supported by the DFG within the priority program SPP 1164.

CPP 19.17 Wed 16:00 Poster B

Free Standing Filaments Formed by Bent-shaped Molecules — •Alexandru Nemes, Alexey Eremin, and Ralf Stannarius — Institute of Experimental Physics, University of Magdeburg, Universitätsplatz 2, D-39106 Magdeburg, Germany

In few mesophases of bent-shaped liquid crystals, stable free standing filaments can be prepared with slenderness ratio (length to diameter ratio) of more than 1000 (Jákli et al. 2003). Their bundle-like structure was found with help of X-Ray, AFM, SEM and optical measurements [1]. In previous experiments it has been observed that the filaments respond with a lateral deflection to a strong DC electric field applied perpendicular to the filament axis. This technique was used as an excitation method to pluck the filaments and forced them, when the DC field was removed, to damped oscillations. The model we used to describe these free oscillations helps us to understand which forces are dominant in such liquid chords [2]. To understand the nature of the electric forces on the filaments, AC electric fields are applied perpendicular to the filament axis. The analysis of the Fourier transformed response of the filament oscillations reveals the functional interactions of the electric field with the material.

[1] A.Nemes, A.Eremin, R.Stannarius, M.Schulz, H.Nádasi, W.Weissflog, Phys.Chem.Chem.Phys., 2006, 8, 469

[2] R.Stannarius, A.Nemes, A.Eremin, Phys. Rev. E, 2005, 72,020702

CPP 19.18 Wed 16:00 Poster B

Flow NMR of complex systems — •Ulrich Scheler and Frank Bagusat — Leibniz-Institut für Polymerforschung Dresden e.V, Hohe Str. 6, D-01069 Dresden

A combination of NMR imaging and pulsed field gradient (PFG) NMR is applied to investigate flow. NMR longitudinal relaxation is used to generate contrast in a binary system of oil and water. The spatial distribution of each component and its flow pattern are measured separately. As a model a Couette cell with an additional area of high shear is used as model geometry. While a flat smooth interface is found a t rest, the interface become bent under rotation, finally emulgation starts because of the velocitiy differences between the components. Flow from a submillimeter tube into a wide box and out of the box is investigated as well to understand shear-induced mixing and demixing.

CPP 19.19 Wed 16:00 Poster B

Towards a microscopic understanding of slip — •Dorothee Meier[1], Max Wolff[1], Marco Walz[2], Nicole Voss[2], Renate Fetzer[3], Karin Jacobs[3], Andreas Magerl[2], and Hartmut Zabel[1] — [1]Lehrstuhl für Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]Lehrstuhl für Kristallographie und Strukturphysik, Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [3]Lehrstuhl für Weiche Kondensierte Materie, Universität des Saarlandes, 66041 Saarbrücken, Germany

In recent years, the increasing interest in flow in confined geometries has raised the need for a deeper understanding of the microscopic origin of boundary slip.

Neutrons are exceptionally well suited for the investigation of soft matter systems. This is related to their high transmittance through many kinds of materials as well as to the high scattering length density of deuterium in comparison to the x-ray cross section of hydrogen. Furthermore, sample properties can be tuned via isotopic substitution.

We have investigated the density in the near surface region in systems which undergo boundary slip via neutron and x-ray reflectometry. Our model systems are stationary and flowing liquids in contact with polystyrene coated silicon crystals as well as polystyrene films on OTS and DTS grafted to a silicon wafer. The reflectivities show differences in the density profiles of systems which are known to undergo slip in comparison to non-slipping samples. This could be related to different interdiffusion properties of the distinct substances used.

This work is supported by the DFG Priority Program SPP 1164.

CPP 19.20 Wed 16:00 Poster B

Thin liquid polymer films: Preparation parameters impact polymer dynamics — •Ludovic Marquant, Daniel Podzimek, Renate Fetzer, and Karin Jacobs — Saarland University, Experimental Physics, D-66041 Saarbrücken, Germany

The dynamics of polymer films dewetting from hydrophobic substrates can be influenced by several phenomena. First the impact of the boundary conditions can be developed. When we observe the profile of a growing rim of polystyrene film dewetting either from octadecyltrichlorosilane or dodecyltrichlorosilane (respectively OTS and DTS) bounded to a silicon wafer, we can observe that the slip length is varying in both cases and the dewetting process is significantly faster on DTS than on OTS brushes [1]. One other important phenomenon we focus on is the polymer chain dynamics. The influence of different conformations of the macromolecules within the solvent used for spin-coating is investigated by acting on the polymer / solvent interaction. In other words the use of a range from good to theta solvents allows us to analyse the properties of the polymer coating. The films are prepared with a thickness in a range of several tens up to several hundreds of nanometres. The methodologies developed are scanning probe microscopy, ellipsometry and optical microscopy.

[1] R. Fetzer, M. Rauscher, A. Münch, B. A. Wagner and K. Jacobs, Europhysics Letters 75 (2006) 638