

## CPP 17: Interfaces and Thin Films I

Time: Tuesday 9:30–12:45

Location: H39

**Topical Talk**

CPP 17.1 Tue 9:30 H39  
**Surviving Structure in Colloidal Suspensions Confined from 3D to 2D** — YAN ZENG<sup>1</sup>, STEFAN GRANDNER<sup>2</sup>, SABINE KLAPP<sup>2</sup>, and REGINE VON KLITZING<sup>1</sup> — <sup>1</sup>Stranski-Laboratorium, Institut für Chemie, TU Berlin — <sup>2</sup>Institut für Theoretische Physik, TU Berlin

Due to miniaturization the question arises how geometrical confinement in thin films affects the structure and dynamics of colloidal suspensions. The film thickness is between 5 - 150 nm and therefore on the same mesoscopic length scale as the distance between colloidal particles. For studying the interaction with the thin film, either a Colloidal Probe AFM or a Thin Film Pressure Balance (TFPB) was used. The resulting structural (oscillatory) forces are characterized by their period, decay length and amplitude. We have proven experimentally the predictions of the Density Functional Theory (DFT) that the confinement does not affect the characteristic lengths of the colloidal dispersion. Our results show that the wavelength obtained by the structure peak from neutron or x-ray scattering experiments at the volume phase is equal to the period of the force oscillation in the film [1,2]. In other word, the average polymer or particle distance, i.e. the concentration remains the same. The effect of different parameters like ionic strength [3] and influence of the properties of the confining surfaces (charge, softness) are shown. [3]. [1] D. Qu, J.S. Pedersen, S. Garnier, A. Laschewsky, H. Möhwald, R. v. Klitzing *Macromolecules* (2006) 39 7364. [2] S. Klapp, Y. Zeng, D. Qu, R. v. Klitzing *Phys. Rev. Letters* (2008) 100 118303. [3] S. Grandner, Y. Zeng, R. v. Klitzing, S.H.L. Klapp, *J. Chem. Phys.* (2009) on Web.

CPP 17.2 Tue 10:00 H39  
**Soft Colloidal Probe AFM - A New Method for the Investigation of Adhesion and Contact of Soft Surfaces** — JOHANN ERATH, STEPHAN SCHMIDT, PETRA ZIPPELIUS, and ANDREAS FERY — Universität Bayreuth, 95440 Bayreuth, Germany

We introduce a novel approach for AFM based adhesion measurements which combines the advantages of the JKR-apparatus and AFM-force-spectroscopy. We create a defined microscopic contact by using a soft colloidal probe made of Polydimethylsiloxane. This allows in-situ determination of the contact area as a function of applied load and elastic properties of the system. Hence, similar to the JKR-apparatus, adhesion energies can be determined from a fit of a whole set of data of well-defined contact areas and load forces. Besides tests on model systems, where we can clearly characterize contributions of capillary forces, hydration forces and hydrophobic interactions, this technique makes a broader range of systems and scientific issues accessible. In this presentation we focus on the lower limit of elastic constants, where the probes will approach typical values for soft biological materials like cells and thus provide elasticity matched partners for adhesion measurements.

CPP 17.3 Tue 10:15 H39  
**Solvent evaporation induced ordered array of colloidal particles** — MOTTAKIN M. ABUL KASHEM, SUTTIPONG WANNAPAIBOON, ADELINE BUFFET, JAN PERLICH, RAINER GEHRKE, and STEPHAN V. ROTH — HasyLab at DESY, Notke Str.85, 22607 Hamburg

Solvent evaporation during drying of a colloidal film or a droplet on a solid substrate can introduce ordering in the final dried film [1]. During solvent evaporation in a droplet of colloidal suspension the colloidal particles are transported towards the periphery while the contact-line among substrate, ambient air and droplet moves towards the center of the droplet. During these two simultaneous processes one or two dimensional ordered nano and microstructures can be spontaneously formed based on the surface free energy of the substrate. Besides, sedimentation of the colloidal particles and capillary forces during drying also play an important role on the formed 3-dimensional ordered structures. In this present investigation, we show the influence of substrate surface on the nano and microstructures formed during solvent evaporation in colloidal droplets containing polystyrene latex microspheres. The arrangement of the nano and microparticles has been investigated and imaged by using optical microscopy, atomic force microscopy (AFM) and grazing incidence small-angle X-ray scattering (GISAXS).

[1] Roth et al., *Appl. Phys. Lett.* 91, 091915 (2007)

CPP 17.4 Tue 10:30 H39  
**Thermal stability of spin-coated and sprayed colloidal PS-films** — GERD HERZOG<sup>1,2</sup>, ADELINE BUFFET<sup>2</sup>, MOTTAKIN M. ABUL KASHEM<sup>2</sup>, RAINER GEHRKE<sup>2</sup>, PETER MÜLLER-BUSCHBAUM<sup>3</sup>, JAN PERLICH<sup>2</sup>, MATTHIAS SCHWARTZKOPF<sup>2</sup>, WILFRIED WURTH<sup>1</sup>, and STEPHAN V. ROTH<sup>2</sup> — <sup>1</sup>Institut für Experimentalphysik der Universität Hamburg, Luruper Chaussee 149, D-22761 Hamburg, Germany — <sup>2</sup>HASYLAB at DESY, Notkestr. 85, D-22607 Hamburg, Germany — <sup>3</sup>Physik-Department E13, TU München, James-Franck-Str. 1, D-85748 Garching, Germany

Installation of large scale colloidal nanoparticle thin films is of great interest in sensor technology or magnetic storage [1]. Among the methods used are dip-coating, spin-coating and spray deposition. Often, such devices are operated at elevated environmental or thermal conditions. In our study presented here, we investigated in-situ the effect of heat treatment on the structure of differently prepared colloidal solutions of polystyrene nanospheres by grazing incidence small angle x-ray scattering (GISAXS) and optical microscopy. We used two routes to install large scale coatings on silicon wafers, namely spin-coating and spray-coating of colloidal polystyrene (PS) nanospheres, having different outer end groups. Our first results indicate that thermal annealing in the vicinity of the glass transition temperature of pure PS leads to a rapid loss in the long range order in spin-coated films. Our model uses an increased mobility of the nanoparticles to explain this behaviour [2]

[1] Bigioni et al., *Nature Materials* 5, 265-270 (2006) [2] Herzog, Diplomarbeit, Universität Hamburg (2009)

**15 min. break**

CPP 17.5 Tue 11:00 H39  
**Delayed Coalescence of Sessile Droplets with Different but Miscible Liquids** — STEFAN KARPITSCHKA and HANS RIEGLER — Max-Planck-Institut für Kolloid- und Grenzflächenforschung, 14476 Potsdam, Germany

Due to capillary forces two sessile droplets of miscible liquids will fuse when they get in contact with each other. Usually the droplet fusion proceeds very fast, delayed mostly by viscous forces. However, quite unexpected, it was observed recently [1] that the coalescence of sessile droplets of completely miscible liquids can be delayed up to minutes. After first contact, the droplets remain separated by a thin liquid neck and push each other across the substrate before they finally merge.

It is assumed [1] that the coalescence is delayed by a marangoni convection through the thin film connecting the drops. This suggests that the effect is quite common. Meanwhile it could also be modeled in the framework of phase field formalism and lubrication approximation [2]. The delayed coalescence may be relevant for technical applications, e.g. in the field of microfluidics.

We present new results from experiments addressing the influence of the liquid properties on the coalescence behavior. A sharp transition from fast to delayed coalescence is observed when the difference in surface tensions exceeds approximately 4 mN/m. Other parameters like absolute surface tensions, viscosities, and contact angles have been varied to generate a phase diagram of coalescence.

[1] H. Riegler et al., *Langmuir* 24, 6395-6398, 2008.

[2] R. Borica et al., *Phys. Fluids*, submitted.

CPP 17.6 Tue 11:15 H39  
**The Softer the Better: Fast Condensation on Soft Surfaces** — MORDECHAI SOKULER<sup>1,2</sup>, GÜNTER K. AUERNHAMMER<sup>1</sup>, MARCEL ROTH<sup>1</sup>, CHUANJUN LIU<sup>1,2</sup>, ELMAR BONACCURSO<sup>1</sup>, and HANS-JÜRGEN BUTT<sup>1</sup> — <sup>1</sup>MPI Polymer Research, Mainz, Germany — <sup>2</sup>Center of Smart Interfaces, TU Darmstadt, Germany

Condensation on soft elastic surfaces differs significantly from condensation on hard surfaces [1]. On polymeric substrates with varying cross-linking density, we investigate the nucleation and the growth of condensing water drops. Surface roughness and apparent contact angle are shown to be very similar on all surfaces. The surfaces differ in the elastic module and viscosity. With increasing softness of the substrates, we find (1) increasing nucleation density, (2) longer relaxation times for drop shape equilibration after merging of two drops, and (3) prevention of merging on very soft surfaces. These effects lead to higher surface coverage and overall condensed volume on soft surfaces.

[1] M. Sokuler et al. Langmuir (2009), DOI: 10.1021/la903996j

CPP 17.7 Tue 11:30 H39

**Au-Nanoparticle on the Water Surface** — ●VOLKER SCHÖN<sup>1</sup>, PATRICK HUBER<sup>1</sup>, PHILIP BORN<sup>2</sup>, and TOBIAS KRAUSS<sup>2</sup> — <sup>1</sup>Saarland University, 66123 Saarbrücken, Germany — <sup>2</sup>Leibniz-Institut für Neue Materialien gGmbH, 66123 Saarbrücken, Germany

This contribution has been withdrawn.

CPP 17.8 Tue 11:45 H39

**Surface plasmon induced structuring of azobenzene thin polymer films** — ●NATARAJA SEKHAR YADAVALLI<sup>1</sup>, TOBIAS KÖNIG<sup>2</sup>, and SVETLANA SANTER<sup>3</sup> — <sup>1</sup>Department of Microsystems Engineering (IMTEK), Freiburg — <sup>2</sup>Freiburg Institute for Advanced Studies (FRIAS), Freiburg — <sup>3</sup>Department of Experimental Physics, Potsdam

There is a strong demand on methods for precise manipulation of nano-objects on surfaces. Recently we report on a phenomenon observed with a certain type of thin polymer films, suggesting that the substrate by itself can induce motion of adsorbed objects (Santer, 2006). The proposed mechanism of motion is based on a dynamically fluctuating force field, emerging during topography switching. It results in competing surface forces acting on the particle, which leads to a motion and repositioning of the particle. In this work, we choose UV-illumination for changing the topography of photosensitive thin polymer films. Here we present azo thin films (Seki, 2007) with integrated optically active elements supposed to support and steer the response of polymer films to external illumination. The nano-scale metallic structures were fabricated on glass substrate using Au/Ag by colloidal lithography. During irradiation the surface plasmon waves are generated on a metallic mask, which results in printing of near field intensity distributions into topography with the pattern size below the diffraction limit. We found that the topography can be driven reversible. We examined the influence of size of the metallic patterns. The results are confirmed by FDTD simulations and compared with imprints of photolithographic mask.

CPP 17.9 Tue 12:00 H39

**Single molecule diffusion in liquid crystals** — ●MARTIN PUMPA and FRANK CICHOS — Molecular Nanophotonics Group, University of Leipzig

Liquid crystals show a strong orientational order along a certain director, while lacking spatial order of their centers of mass. For uniaxial molecules the orientational properties lead to an anisotropy in the optical properties of the material and the mobility as well.

Recent studies have focused on the diffusion of macroscopic particles in the matrix of the liquid crystal. In case of macroscopic probes the director structure around such colloids is strongly altered due to anchoring effects at the particle surface, leading to distortions in the orientation of the liquid crystal and therefore to an rotational contribution to the measured drag forces. Such effects are absent in the study of single molecule diffusion in liquid crystals. We thus present results on the translational and rotational diffusion of single fluorescent probe - molecules in the nematic phase of 5CB and the smectic phase of 8CB. We used single molecule tracking to determine the anisotropy of translational diffusion of PDI molecules and time resolved fluorescence microscopy to observe their rotational behavior. We are able to relate

our results directly to the director structure of the liquid crystalline phases by means of polarization contrast microscopy.

CPP 17.10 Tue 12:15 H39

**Single Molecule Orientation and Binding on Surfaces** — ●STEFAN KRAUSE<sup>1</sup>, DANNY KOWERKO<sup>1</sup>, RICHARD BÖRNER<sup>2</sup>, CHRISTIAN HÜBNER<sup>2</sup>, and CHRISTIAN VON BORCZYKOWSKI<sup>1</sup> — <sup>1</sup>Chemnitz University of Technology D-09107 Chemnitz, Germany — <sup>2</sup>University of Lübeck, D-23538 Lübeck, Germany

Orientation of molecules at a solid interface is an important issue for the modification of surfaces, synthesis, catalysis or photovoltaic. Optical single molecule detection is one of the powerful tools to determine the orientation of even a single molecule via measurement of the orientation of the electric dipole transition. One of the most suited dye molecules to study single molecule orientation is the perylene diimide-type system (PDI) featuring high quantum efficiency and photo stability. Here we present three methods to determine single molecule orientation of PBI selectively bonded via pyridyl groups to silicon dioxide [1]. Using microscope objectives with high numerical aperture allows for the direct determination of the time-dependent three dimensional orientation of the transition dipole and the molecule axis [2]. In the second method we directly follow via two detection channels the polarisation of single molecule emission. The third method makes use of the orientation dependent distribution of fluorescence intensities of single molecules and the comparison to calculated distributions.

[1] D. Kowerko, J. Schuster, C. von Borczykowski, 2009. *Molecular Physics*, 107, 1911- 1921

[2] J. Hohlbein, C. G. Hübner, 2008. *Journal of Chemical Physics*, 129, 094703

CPP 17.11 Tue 12:30 H39

**Analysis of heterogeneous diffusion in ultra-thin liquid films via single particle tracking** — ●INES TRENKMANN, DANIELA TÄUBER, MICHAEL BAUER, and CHRISTIAN VON BORCZYKOWSKI — Chemnitz University of Technology, Institute of Physics, Germany

It has been well known for some years that the dynamical behavior of tracers in ultra-thin liquid films differs from the behavior in a bulk liquid. In previous studies of single dye diffusion in TEHOS-films (deposited on Si wafers with a thermally grown oxide layer) we could show that single particle tracking can reveal heterogeneous behavior of the used tracers [1]. Thereby the diffusion is influenced by dynamic and static heterogeneities [2]. The first ones are caused by changes between layers with distinct diffusion coefficients and the influence of the hydrodynamic boundary conditions. The latter are caused by surface heterogeneities, such as the inhomogeneous distribution of silanol groups on the silicon oxide surface. In recent studies we could show that the determined diffusion coefficients depend strongly on the applied evaluation method [3]. The determinations of the mean squared displacement just yield averaged diffusion coefficients. We are using short range diffusion coefficients from the analysis of scaled squared displacements at different time lags to obtain further information about the contributing heterogeneous components.

[1] Schuster, J., et al.: *Eur. Polym. J.* 40 (2004) 993

[2] Bauer, M., et al.: *Diffusion Fundamentals* 11 (2009) 70

[3] Trenkmann, I., et al.: *Diffusion Fundamentals* submitted

[4] Täuber, D.; et al.: *Diffusion Fundamentals* 11 (2009) 76