CPP 58: Wetting, Nano- and Microfluidics II (joint session CPP/DY, organized by CPP)

Time: Thursday 15:00–16:45 Location: H42

CPP 58.1 Thu 15:00 H42

How water advances on superhydrophobic surfaces — •Frank Schellenberger, Noemí Encinas, Doris Vollmer, and Hans-Jürgen Butt — Max Planck Institute for Polymer Research, Mainz, Germany

To a certain degree, it is possible to control the macroscopic wetting properties of a surface by its nano- and microstructure. In particular, super liquid-repellant-surfaces have received interest due to their many potential applications, such as anti-fouling for for example. Super liquid-repellency can be achieved by nano- and microstructuring a low energy surface in a way, that the structure can entrap air underneath the liquid. The common criteria for super liquid-repellency are a high apparent advancing contact angle and a low contact angle hysteresis.

For a better understanding of how a drop advances and recedes on such a structured surface, we imaged the motion of a water drop on a superhydrophobic array of micropillars by laser scanning confocal microscopy (LSCM). With LSCM, we imaged an advancing water front on a superhydrophobic surface at a resolution of 1 *m. The results give a qualitatively new picture of how water advances on the microscopic scale. We demonstrate that in contrast to traditional goniometer measurements, the advancing contact angle is close to 180° or even higher.

In contrast, the apparent receding contact angle is determined by the strength of pinning. We propose that the apparent receding contact angle should be used for characterizing super liquid-repellent surfaces.

CPP 58.2 Thu 15:15 H42

Traction forces of water droplets on super-hydrophobic surfaces — •Martin Tress, Alexander Saal, Frank Schellenberger, and Noemí Encinas — Max Planck Institute for Polymer Research, Mainz

Surfaces with super-hydrophobic properties play an important role in both nature and science. Thereby, the artificial surfaces typically try to copy the characteristic features of their natural pendants. That is in general, a hydrophobic surface chemistry combined with a structured topography. To investigate the particular impact of these characteristics model surfaces with pillars of varying size, arrangement and surface coating have been employed [1]. While many studies used rigid pillars to maintain a well-defined topography, in the present work flexible pillars are focused. When imaged with a Laser Scanning Confocal Microscope, these flexible pillars act as cantilevers to detect traction forces of a drop resting on their top. By that, the distribution of the forces in parallel to the surface along the contact line is recorded. Especially the traction forces of the receding contact line of an evaporating drop will be illuminated.

[1] P. Papadopoulos et al. PNAS 9 (2013) 3254

CPP 58.3 Thu 15:30 H42

Bioinspired Nanofur as Superhydrophobic Transparent Coatings and Translucent Films for Optical Applications — •Felix Vüllers, Maryna Kavalenka, Matthias Worgull, and Hendrik Hölscher — Institute of Microstructure Technology, Karlsruhe Institute of Technology, 76344 Karslruhe, Germany

A combination of high optical transmission with self-cleaning, water-repellency and anti-icing is of high interest for various optical applications and boosted interest to transparent superhydrophobic surfaces. We demonstrate a highly scalable hot-pulling method to produce flexible superhydrophobic thin nanofur films made from polycarbonate, which can be used both as a transparent coating and a translucent film. The surface of thin nanofur films is covered with densely packed high aspect ratio nano- and microhairs which are fabricated using heated sandblasted steel plates, making complex and expensive mold fabrication unnecessary. The films exhibit high water contact angles (>170°), low sliding angles (<4°) and self-cleaning abilities. Through index matching the thin nanofur coating's reflection in the visible regime is reduced to less than 4%. The translucent film's transmission is more than 85% with high forward scattering. Applied to OLEDs these optical properties lead to an efficiency increase of more than 10%. By combining these exceptional optical properties with the water-repellent and self-cleaning properties of the thin nanofur film, the films are beneficial for further optical devices. In addition plasma treatment changes the film wettability to underwater superoleophobic enabling the use of thin nanofur films as underwater oil-repelling coatings.

CPP 58.4 Thu 15:45 H42

Dynamics of Drop Condensation on Lubricant-Impregnated Surfaces — •Tadashi Kajiya[1], Frank Schellenberger[1], Periklis Papadopoulos[2], Doris Vollmer[1], and Hans-Jürgen Butt[1] — [1]Max Planck Institute for Polymer Research, Ackermannweg 10, 55128 Mainz, Germany — [2]University of Ioannina, Dept. of Physics, 45110 Ioannina, Greece

We explored the dynamics of water drops condensing on a lubricant-impregnated surface, i.e., micropillar arrays infused with a ionic liquid. Growing drops were imaged in 3D using a laser scanning confocal microscope equipped with a temperature and humidity control. On a lubricant-impregnated hydrophobic micropillar array, different stages of condensation can be discriminated: - Nucleation on a lubricant surface. - Regular alignement between micropillars and formation of a three-phase contact line on a bottom of the substrate. - Deformation and bridging by coalescence, leading to a detachment of the drops from the bottom substrate to pillars*top faces. However, on a lubricant-impregnated hydrophilic micropillar array, the condensed water covers the micropillars by dewetting the lubricant. As a result, the surface loses its slippery property. Our results provide fundamental concepts how these solid/liquid hybrid surfaces can be applied for facile removal of condensed water.

CPP 58.5 Thu 16:00 H42

Connecting and disconnecting nematic disclination lines in microfluidic channels — •Hakam Agha and Christian Bahr — Max Planck Institute for Dynamics and Self-Organization (MPIDS), Am Fassberg 17, 37077 Göttingen, Germany

The controlled creation of a disclination line in nematic liquid crystal (NLC) spanning along the microfluidic channel as a result of imposed anchoring conditions on the four confining channel walls has proven to be a novel and successful approach to guided transport of microfluidic cargo, with the disclination line serving as a soft rail [1]. In this study, we report on a method to connect and disconnect disclination lines using the interplay between anchoring, flow, and electric field. We design the anchoring conditions in a way that the formation of the disclination is suppressed in one or several short sections of the channel. The application of an external electric field across the channel and perpendicular to the NLC flow can overcome the imposed anchoring conditions and allows the disclination line to span across the forbidden regions, establishing a continuous disclination along the complete channel. Thus, the manipulation of the anchoring conditions combined with the effect of the electric field allows us to interrupt and to reestablish the transport of colloidal particles through the microchannel.

[1] A. Sengupta, C. Bahr, S. Herminghaus, Soft Matter, 2013, 9, 7251.

CPP 58.6 Thu 16:15 H42

Lateral Adhesion Forces at Solid-Liquid Interfaces — •Nan Gao, Florian Geyer, Sanghyuk Wooh, Dominik Pilat, Doris Vollmer, Hans-Jürgen Butt, and Rüdiger Berger — Max Planck Institute for Polymer Research, Mainz, Germany

Using a laser deflection system we investigate lateral adhesion forces at solid-liquid interfaces. Our set-up consists of a laser, a deflectable capillary, and a position sensitive detector (PSD). Substrates of TiO2 nanopillars with various spacing distances between the nanopillars are used to regulate surface wettabilities. Drops of liquid resting on the nanopillar substrates have different lateral adhesion forces due to the surface wettabilities. In order to measure the forces at the solid-liquid interfaces, the drops are moved laterally against the substrates using the deflectable capillary. A laser beam incident on the capillary is reflected to the PSD, which instantly generates electric signals according to the lateral adhesion forces. With assistance of optical imaging, we have been able to resolve the drop motion synchronised to the force measurement. Our measurements have demonstrated that the instantaneous lateral adhesion forces at the solid-liquid interfaces are determined by the front and rear contact angles as well as the contact width. The values are in good agreement with theoretical predictions.

CPP 58.7 Thu 16:30 H42

Light-driven delivery and release of materials using liquid marbles — •Maxime Paven[1], Hiroyuki Mayama[2], Takafumi Sekido[3], Hans-Jürgen Butt[1], Yoshinobu Nakamura[3,4,5], and Syuji Fujii[4] — [1]1Physics at Interfaces MaxPlanck Institute for Polymer Research Ackermannweg 10, D-55128 Mainz, Germany — [2]2Department of Chemistry, Asahikawa Medical University 2-1-1-1 Midorigaoka-Higashi, Asahikawa 078-8510, Japan — [3]3Division of Applied Chemistry, Graduate School of Engineering Osaka Institute of Technology 5-16-1 Omiya, Asahi-ku, Osaka, 535-8585, Japan. — [4]4Department of Applied Chemistry, Faculty of Engineering, Osaka Institute of Technology 5-16-1 Omiya, Asahi-ku, Osaka, 535-8585, Japan. — [5]5Nanomaterials Microdevices Research Center Osaka Institute of Technology 5-16-1 Omiya, Asahi-ku, Osaka 535-8585, Japan.

Remote control of the locomotion of small objects is a challenge in itself and may also allow for the stimuli control of entire systems. Here, we describe how encapsulated liquids, referred to as liquid marbles, can be moved on a water surface with a simple near-infrared (NIR) laser or sunlight. Using light rather than pH or temperature as an external stimulus allows for the control of the position, area, timing, direction and velocity of delivery. Our approach makes it possible to not only transport the materials encapsulated within the liquid marble but also to release them at a specific place and time, as controlled by external stimuli. Furthermore, we show that liquid marbles can work as light-driven towing engines to push or pull objects.