Imaging superhydrophobic surfaces by confocal microscopy

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Self-cleaning surfaces are a matter of intense ongoing research, due to the large number of potential industrial applications. The contact angle of liquids, especially water, on these surfaces should be as high as possible, allowing drops to roll off easily. In order to realize superhydrophobicity, surfaces must have significant roughness on µm length scale, so that air can be trapped between the drop and the surface. A simple way to create rough surfaces is the sedimentation of colloids on a suitable substrate. Additional hydrophobization may be induced by silanization or fluorination.

Two superhydrophobic states can be distinguished; the Cassie state, where water stays above the air layer, and the Wenzel state, where water wets the rough structure. In general, the contact angle can be large in both cases, but the rolling off angle is larger in the Wenzel state. It is still not completely understood which state dominates in different combinations of liquid and substrate and how a Cassie to Wenzel transition proceeds.

Due to geometry limitations, well-known techniques for surface imaging, such as SEM or AFM cannot be employed to image the air layer separating water and substrate. Confocal microscopy can be applied in this case, instead. The high lateral and axial resolution allow direct observation of the liquid, air and substrate interfaces, see Fig. 1. However, care must be taken in order to avoid artifacts, due to the severe mismatch of refractive index between the three phases. For this reason we employ a state-of-the-art confocal microscope that can measure simultaneously the backscattered light and fluorescent emission of several dyes. Fluorescence from water containing a hydrophilic dye can unambiguously distinguish between the Cassie and Wenzel states (see Fig. 1).

In addition to the superhydrophobic states, the contact angle near the contact line can be measured with high accuracy. The technique requires only a reasonably transparent substrate and fluorescent dyes compatible with the liquid and colloids [1]. By time resolved measurements we study the kinetics of the Cassie to Wenzel transition.