MORPHOLOGY AND MECHANICAL PROPERTIES OF LIQUID-AIR INTERFACES CONFINED BY NONWETTING NANOPORES

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The entrapped air cavities in microscopic structures of superhydrophobic surfaces are well-known. Still lacking is, however, a detailed microscopic study of the morphology and mechanical properties of the liquid-air interfaces confined by these nonwetting structures and correlating them to the wetting behavior of the surface. In this study, we imaged the three-dimensional morphology of the water-air interfaces on a series of nonwetting porous surfaces (hydrophobized porous alumina with pore diameter ranging from $\sim 50\ nm$ to $\sim 600\ nm$) beneath a water drop using a high-resolution atomic force microscopy. It was found that water invades partly into the nanopores and the invasion depth is determined by the surface structures. The water-air interfaces are stable during imaging, though they could be deformed under increasing forces. We show that this deformation is reversible under decreasing forces. Furthermore, we determined the stiffness of the water-air interfaces from the force-distance curves and found its size-dependence, which can be correlated to the transition from bouncing to sticking of impinging macroscopic droplets on the nanoporous surfaces. The present work quantitatively resolves the morphology and mechanical property of liquid-air interface at nanoscale, which are correlated to the static and dynamic wetting of structured surfaces.

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