Droplet Transport on Microstructured Superhydrophobic Surfaces

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Abstract

Systematic design of microscopic surface roughness can be employed to propel water droplets on flat, inclined, and even upside-down surfaces. Droplets are transported, split, and merged on these engineered surfaces by externally applied mechanical vibration. The conversion of vibration into directed droplet motion is achieved in two ways: (1) by creating surface energy gradients, or (2) by utilizing surface ratchets. In both cases, rough surfaces are designed with microscopic features that trap air between microfabricated pillars, resulting in a superhydrophobic surface where the liquid-solid contact area is confined to the pillar tops ("Fakir state"). For (1), the liquid-solid contact area varies along a track with decreasing apparent contact angle, leading to a hydrophobicity gradient that causes the droplet to move towards regions with lower contact angle; the length of this track is limited by practical geometric constraints. For (2), repetitive surface features produce an anisotropic force bias along the contact line of a vibrating droplet; the resulting tracks have no length limitation and can include loops. This work provides the basis for novel microfluidic systems that process small amounts of liquids on a simple, low-cost, portable platform.