Gas-perfused porous surfaces: Actuating droplets without levitating them

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Porous surfaces are widely used for wetting phenomena control exploiting either the gas entrapped on the porous network, or their ability to be infused, or impregnated by lubricants[1]. Still gas entraps (pockets) tend to collapse after prolonged exposure to liquid environments, or at high liquid pressures, while lubricants tend to cloak the droplets and gradually dry out. In our study we combine the two aforementioned approaches and we use porous media and have them perfused with gas to dynamically actuate, and manipulate droplets on their surfaces. By adjusting the backpressure, i.e. the pressure from the rear side of the porous medium, the droplet may be actuated, and its downward velocity may be controlled without completely levitate it. This entails low values of backpressure, in the order of few mbar, depending on the porous network characteristics.

In this work we are going to present the basic principles of this approach[2,3], and demonstrate it in various applications including droplet impingement[2], valving in digital microfluidics[4], and droplet logic operations[5].

The mechanisms of actuation have been studied by means of simulations encompassing the momentum conservation and the continuity equations along with the Cahn−Hilliard phase-field equations in a 2D computational domain. The droplet actuation mechanism involves depinning of the receding contact line and movement by means of forward wave propagation reaching the front of the droplet, yielding to a forward skipping of the droplet[6].

New experimental results with highly viscous liquids and on non-symmetric surfaces will be shown.

References

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