Programmable Anisotropic Wetting upon a Hierarchical Elastic Surface

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Abstract: Wetting phenomena with the ability to reshape liquids within a capillary length have many technological applications including coating, adhesion, self-cleaning surfaces, printing and nano-microfluidics. Sinusoidal wrinkle and crease patterns on an elastic substrate can create an ordered roughness with the potential to control droplet motion. Non-uniform distributions of surface energy can cause anisotropic wetting and droplet deformation, while asymmetric chemical or physical patterns on a material surface can cause directional wettability. On a micro-wrinkled surface, the geometrical aspect ratio strongly influences the shape of a droplet. On an elastic wrinkled groove surface, as certain compressive strain is approached, a droplet can start imbibing into the grooves leading to an eventual filling of entire grooves. To achieve highly controllable instabilities and a bi-axial switching droplet shape, we created a patterned elastic surface able to initialize localized surface instabilities and induce reversible surface morphology changes. At equilibrium, our topographic surface consists of a set of circular voids distribute din an equilibrium manner. By using plasma treatment and mechanical stimuli, we investigated the evolution of the nano/micro-structure on surface, which form under mechanical stimuli and redistribute the surface energy. A droplet (≈ 2 µl) placed on our surface is pinned by the topographic features and deforms as the circular shapes elongate to elliptical shapes (Fig. 1). The static, advancing and receding contact angles were measured before and after plasma treatment, showing the enhancement of the surface wettability due to changes in the surface chemistry, morphology and roughness. This finding opens a window to create the robust wetting state surface with potential applications in microfluidics, bio-engineering and soft robots.

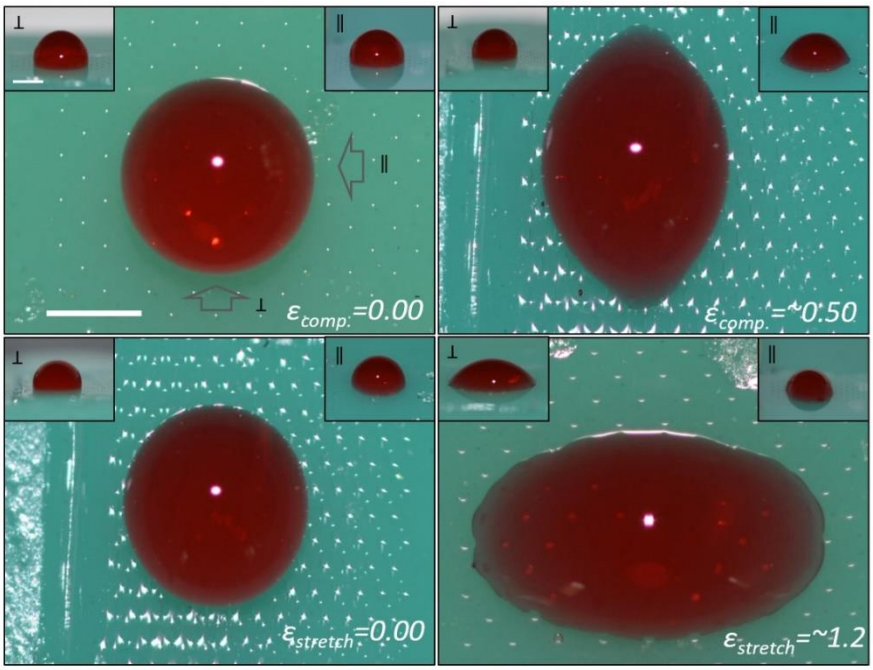

Fig 1. Biaxially Shaping Droplet during compression and stretching process, scale bar = 1 mm