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Self-propelled Leidenfrost droplet

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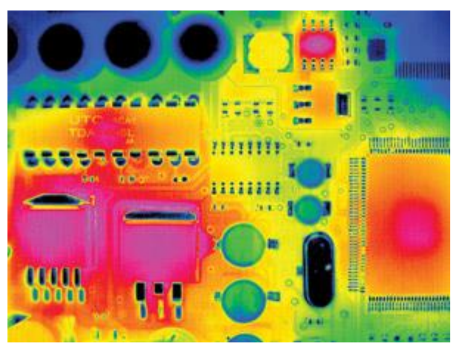
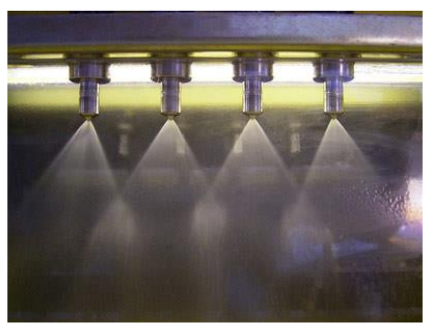
1. Abstract

Directed motion of liquid droplets is of considerable importance in many applications. Although various methods to generate such motion have been developed at low temperature, they become rather ineffective at high temperature, where the droplet transits to a Leidenfrost state. Under such condition, an in-built structural asymmetry of the surface can allow directional propulsion of droplets over long distance. Controlling droplet self-propulsion dynamics at high temperature is quite essential to friction reduction and thermal management.



Local hotspots

Spray cooling



Fuel injection

2. Leidenfrost phenomenon

When a liquid is deposited on the hot surface with temperature higher than a critical value, a continuous vapor layer will be formed between the droplet and the substrate, protecting the water droplet from vigorous boiling. The vapor finally flows outward, keeping the droplet above the surface and evaporating slowly.

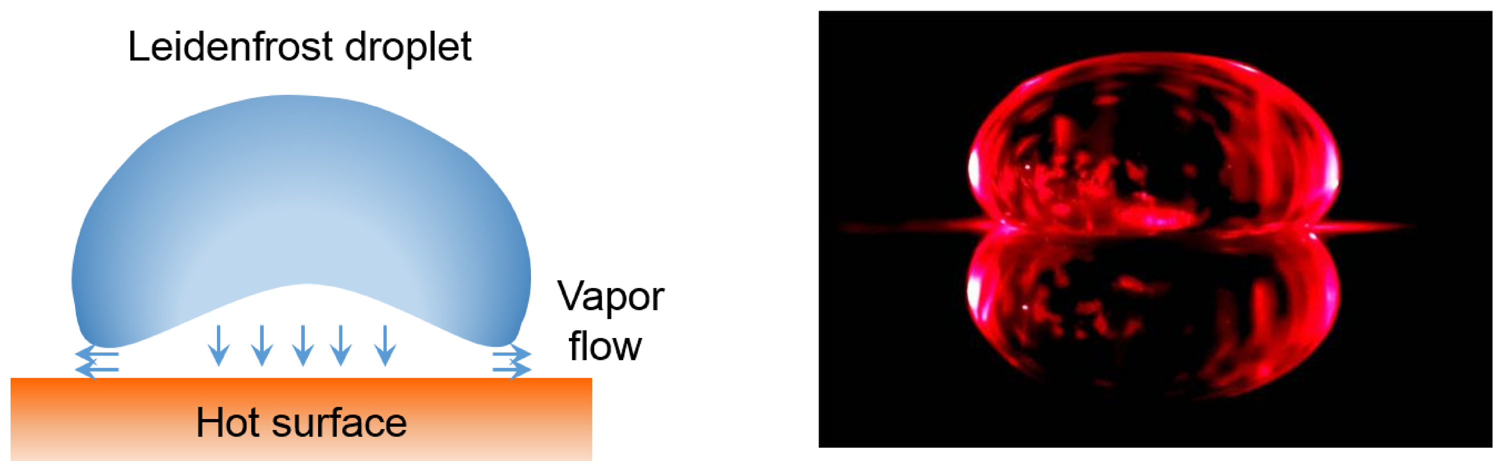


Figure 1. Leidenfrost phenomenon

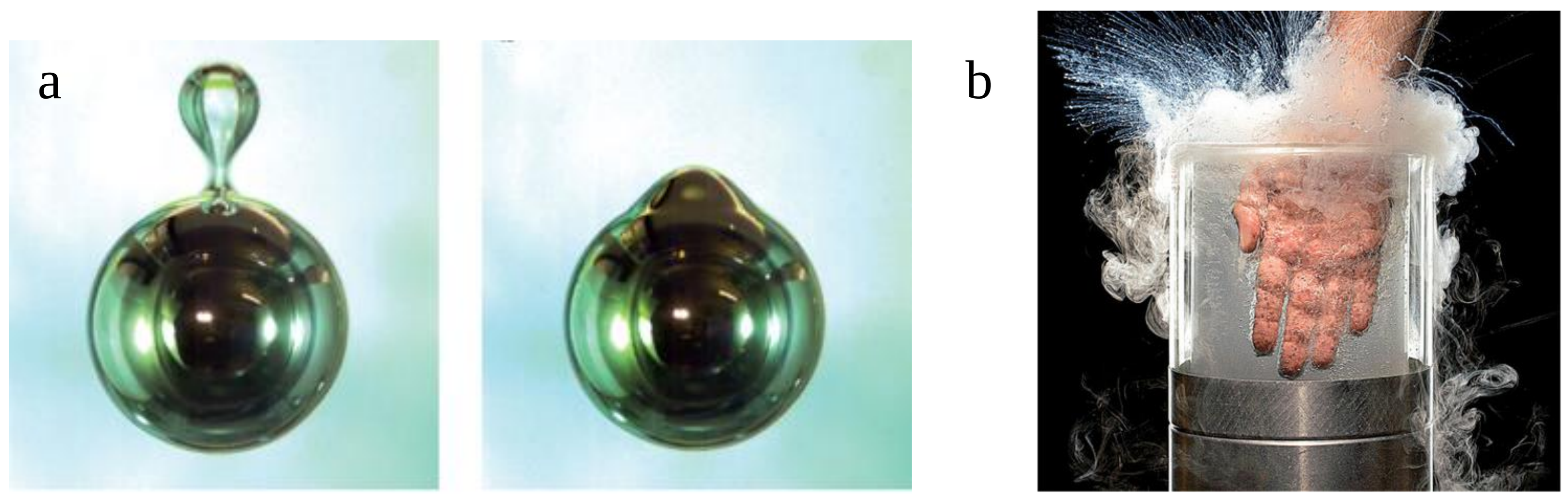


Figure 2. (**a**) Stabilization of vapor layer (**b**) Leidenfrost phenomenon of liquid nitrogen

3. Droplet self-propulsion

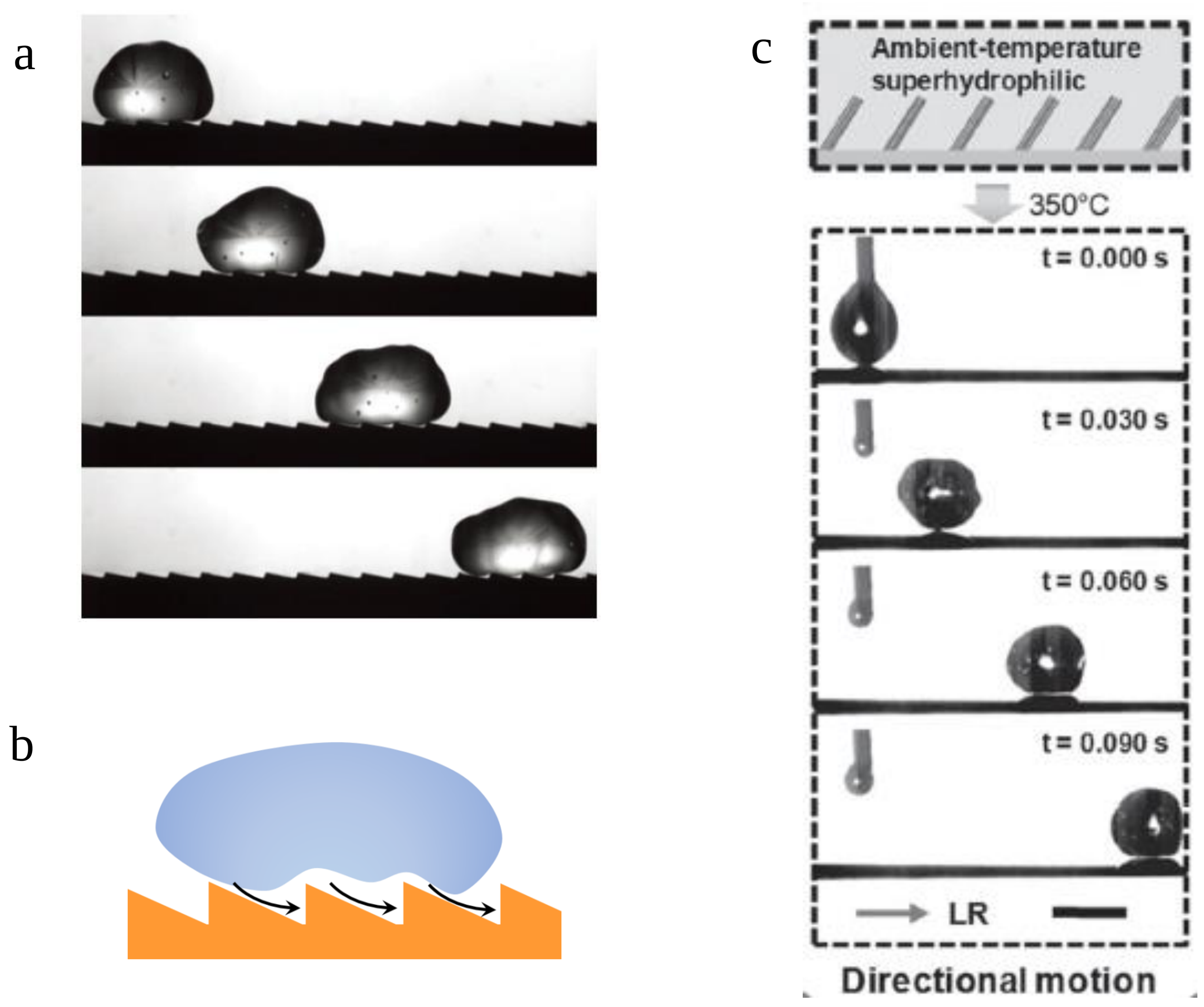


Figure 3. (a) Directed Leidenfrost droplet on macroscale ratchet structure. (b) Unbalanced vapor flow which drives the droplet move against ratchet structure. (c) Explosion and directional bounce of drop deposited on the surface with titled nanowire array. Here, the direction of droplet movement is mainly controlled by the asymmetric wettability along the titled nanowire array.

4. Directed Janus droplet

The wetting symmetry of a droplet can be broken at high temperature by creating two concurrent thermal states (Leidenfrost and contact boiling) on a topographically patterned surface that engenders a preferential motion of droplet toward the region with a higher heat transfer coefficient.

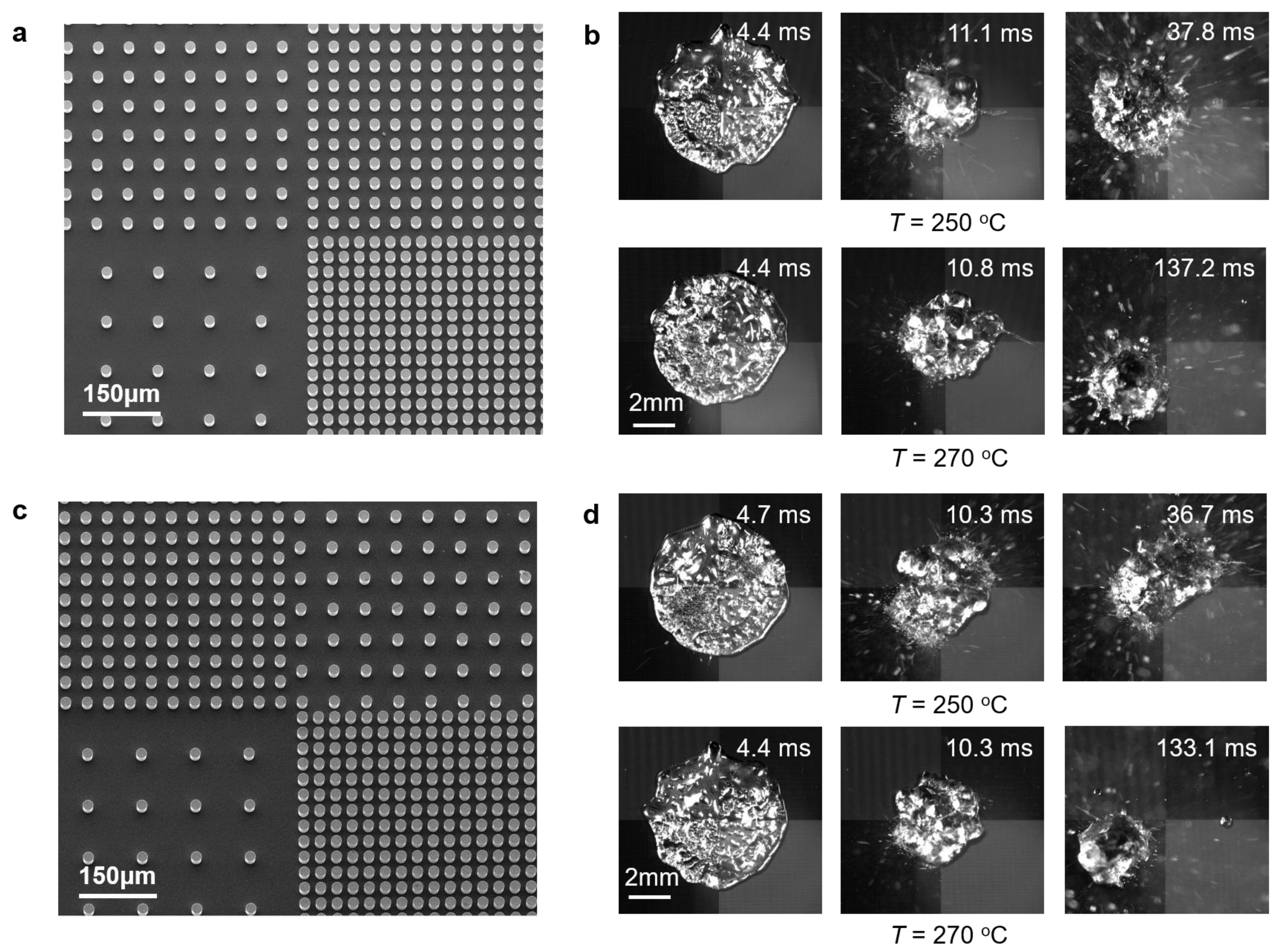


Figure 4. Controlling droplet vectoring and confinement.