Abstract

Directed motion of liquid droplets is of considerable importance in various industrial processes. Despite extensive advances in this field of research, our understanding and the ability to control droplet dynamics at high temperature remain limited, in part due to the emergence of complex wetting states intertwined by the phase change process at the triple-phase interfaces. When the temperature of surface is above a critical temperature, a continuous vapor layer separates the droplet from the hot surface. This so-called Leidenfrost condition is characterized by a minimal friction as well as a low heat transfer between the droplet and hot solid surface. Here we show that the wetting symmetry normally imposed to an impacting droplet at room temperature can be broken or retained by judicious control of structural topography and the range of operating temperatures of solid substrate. Particularly, two concurrent wetting states (Leidenfrost and contact boiling) can be manifested in a single droplet above its boiling point rectified by the presence of asymmetric textures, allowing for subsequent guided transport of droplet from the unwanted Leidenfrost regime to the boiling regime, enabling an efficient energy exchange between the impacting liquid and hot solid for a wide spectrum of applications. We designate this particular state as the mixed boiling-Leidenfrost state (Janus thermal state). We propose that the preferential and rapid droplet motion under Janus thermal state ensues from the
breaking of the symmetry of the triple-phase contact line throughout the droplet. To elucidate how the structural roughness gradient is translated into an asymmetric triple-phase contact line, we developed a dynamic Leidenfrost model to build a connection between the critical Leidenfrost point and surface structure. Owing to the distinctive reliance of Leidenfrost point on the surface roughness, the droplet on the gradient surface is rectified into a heterogeneous wetting state. This wetting symmetry breaking can further be characterized by the unbalanced driving force and retraction velocity of the three-phase contact line after droplet impact. The utility of asymmetric textures demonstrated here might offer new avenue for enhancing energy transfer and stabilizing energy and high temperature thermal systems including high-density electronics, nuclear power plant under a wider range of temperatures.

**About the Speaker**

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**All are welcome!**

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