Dear Editor,

We are pleased to submit our manuscript entitled “**Sessile droplet jumping behaviors on hot substrates: from vibration to explosion**” to *Physical Review Letters* for review as an original research article.

There are two typical vapor bubble growth modes in boiling heat transfer process. In **inertia-controlled growth mode**, the bubble growth rate is governed by the momentum interaction between the bubble and the surrounding liquid, *i.e.*, it is limited by how rapidly it can push back the surrounding liquid. During **heat-transfer controlled growth mode**, however, the vapor bubble growth is limited by the relatively slower transport of heat to the bubble interface. In this paper, we report an innovative method to agilely modulate vapor bubble growth modes on hot microstructured surfaces and then manipulate liquid droplet jumping behaviors thereon.

Inspired by the elegant micro/nanostructures decorated on biomaterials in nature, *e.g.*, lotus leaves, a variety of engineered substrates have been developed with broad applications such as surface self-cleaning, ice-resistant substrate, thermal management and condensation controlling. Nevertheless, dropwise condensation on these engineered substrates usually form in the Wenzel state, in which the surface microstructures penetrate the condensate droplets and hence the condensates are pinned on the surface. Moreover, the accumulation of the Wenzel state droplets can eventually incur condensate flooding on the substrate, giving rise to deteriorated heat transfer. On the other hand, the long-term dwelling of the droplets would easily lead to surface corrosion. These issues would consequently cause the failure of surface functionalities if no external stimuli are employed for the sessile droplet purging. Even though direct external stimuli such as mechanical vibration, electrical/magnetic/photothermal fields are effective methods for droplet removal, the sophistication and cost of these devices prevent their wide acceptance. Alternatively, Leidenfrost effect could be adopted for droplet purging, but it typically requires a heated substrate, *e.g.*, at a temperature as high as >200 °C for water in ambient environment. Due to their intricate nature, our understanding of the liquid-substrate interactions and the inherent droplet behaviors remains elusive, impeding simple engineered surfaces for droplet removal.

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FIG. 1. **(a)** Side-view snapshots of droplet vibration jumping on a 130 °C substrate consisting of a micropillar matrix with micropillar diameter (), periodicity () and height (), hereafter named as . **(b)** Top-view of **heat-transfer-controlled vapor bubble growth** on hot substrate . Inset, micrograph of the micropillared surface. **(c)** Diagram of prolonged droplet vibration detachment within seconds. **(d)** Side-view snapshots of droplet explosion jumping on substrate heated at 130°C. **(e)** Top-view snapshots of **inertia-controlled vapor bubble growth** on hot substrate . **(f)** Diagram of drastic droplet explosion detachment within milliseconds.

Here we introduce a simple but effective method to control and manipulate droplet jumping behaviors on micropillar-arrayed substrates at moderate superheat of only 20 °C - 30 °C by modulating the vapor bubble growth modes thereon. For droplet in Wenzel state, the micropillar matrix can function as a fin array for heat transfer modulation to control the vapor bubble growth. Specifically, we find that the vapor bubble growth at the droplet base can be transferred from the heat-transfer-controlled slow growth mode (Figs 1 a b c) to the inertia-controlled rapid growth mode (Figs 1. d e f) by simply increasing the micropillar height from 20 mm to 80 mm. Correspondingly, the vapor bubble expanding velocity increases remarkably from ~ 1 of the heat-transfer-controlled mode to ~ 4 of the inertia-controlled mode during the vapor bubble growth. The rapid inertia-controlled vapor bubble growth at the droplet-substrate interface induced by the vapor bubble explosion makes it possible to achieve droplet out-of-plane jumping within several milliseconds. In comparison, it takes only several seconds for the boiling droplet to fully detach from the substrate with shorter micropillars due to the prolonged vibration of droplet. **As far as we know, we are the first to observe and modulate versatile vapor bubble growth behaviors in a boiling microdroplet, which has thrilling applications in various fields.**

Our observation provides an effective strategy for rapid droplet detachment from a properly designed surface. In applications, understanding the fundamental mechanisms of heat transfer during different bubble growth modes can offer the baseline knowledge for enhancing electrospray cooling or mitigating condensate flooding and surface corrosion. Moreover, our investigation of adaptively tuning bubble growth modes also sheds lights on designing versatile surfaces avoiding the damage of vapor bubble explosion in a variety of industrial applications.

All authors listed in the paper have contributed to this work. To the best of our knowledge, no conflicts of interest, financial or others exist. We have included acknowledgements and financial information in the manuscript. PDF of manuscript is in correct order upon submission.

This manuscript has not been previously published and is not under consideration in the same or substantially similar form in any other peer review media. All data needed to evaluate the conclusions in the paper are present in the paper and the Supplementary Information. The prepared manuscript follows the Ethics in publishing as described in Author Guidelines.

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