Growth and self-ejection of single condensate droplet on nanostructured microcones

Nicolò G. Di Novo[1,2], *Alvise Bagolini*[2], *Nicola M. Pugno*[1,3]
[1] *Laboratory of Bio-Inspired, Bionic, Nano, Meta, Materials & Mechanics, Department of Civil, Environmental and Mechanical Engineering, University of Trento, Via Mesiano, 77, 38123 Trento, Italy*
[2] *Sensors and Devices Center, FBK, Via Sommarive 18, 38123 Trento*
[3] *School of Engineering and Materials Science, Queen Mary University of London, Mile End Road, London E1 4NS, United Kingdom*

Presenting author e-mail: nicolo.dinovo@unitn.it

In the last decade, the phenomenon of coalescence-induced droplet jumping has been studied in depth because of the advantages it brings in applications such as anti-frosting, anti-icing, condensation heat transfer, water harvesting and self-cleaning. In this work we show theoretically and experimentally that surfaces structured with micro truncated cones covered by highly hydrophobic nanostructures exhibit a recurrent self-ejection of single condensate droplets in addition to the common jumps induced by coalescence. We analytically modeled both the slow growth of a condensate droplet in conical pores (a simplification of the growth between truncated cones) and the rapid transient for two cases of self-ejection: 1) abrupt wettability change of the lower meniscus that detaches from a less hydrophobic site and 2) rapid swelling of the upper meniscus when it arrives at the apex of the cones. In both cases, viscous and adhesion dissipations were included. Building the model of the system of forces for growth and self-ejection requires a careful choice between external and internal forces, often confused. The modeling with forces, unlike the energetic one, allows to describe the ejection transient and to derive the droplet velocity while maintaining the dependence on the dynamic contact angles of the superhydrophobic walls and of an eventual pinning site, fundamental quantities for the design of real surfaces. The fabrication of silicon micro truncated cones with different tapers, dimensions and wettability (imparted by nanostructures) and condensation experiments allowed us to find the surfaces that maximize the number of self-ejection events (Figure 1). Furthermore, we performed condensation frosting experiments and compared the frost propagation delay of surfaces exhibiting or not self-ejection in addition to coalescence-induced droplet jumping. Future investigations of this new class of surfaces may show advantages also in the other mentioned applications.

Keywords: condensation; self-ejection; divergent structures; nanostructured microcones; anti-frosting

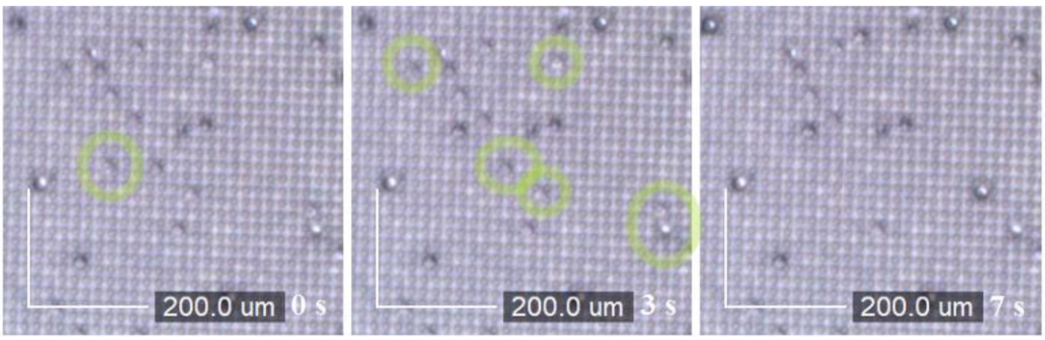

Figure 1. *Condensation experiment (T=1°C, saturation ratio=1,8) on nanostructured truncated cones arranged in a square pattern. For times 0 s and 3 s, green circles indicate the droplets an instant before self-ejection.*