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Droplets on Micro-decorated Surfaces: Wetting and Phase-Change

Abstract: The close interactions between liquids droplets and films, and solid surfaces are ubiquitous and play a paramount role in many everyday domestic and industrial applications closely related to thermal management, water treatment and harvesting, energy generation, etc.

In this talk I introduce efforts focusing on the systematic fundamental understanding of solid surface intrinsic wettability and micro-features, fluid surface tension, as well as the surrounding ambient, on the wettability and phase-change of small sized droplets following different micro-fabrication approaches. Deterministic deep reactive ion etching, stochastic wet etching and soft lithography enabling the replication of either stochastic or deterministic features are presented. Droplets on deterministic homogeneous structured surfaces adopt different wetting regimes and geometries, which can be tailored by varying the surface tension of the fluid or the surface ambient exposure. The wetting regime and droplet geometry eventually play a role on the evaporation mode and on the deposits.

The use of soft-lithography for the replication of the deterministic structures of the Dalenii or dragon's head sword lily's leaf are also introduced and the performance of the replicated surfaces under condensation phase-change and fog harvesting are compared and discussed. Further, easy and scalable chemical etching enabling the growth of stochastic hierarchical features is also studied. This process is able to create two different surfaces that resemble the lots leaf "super-repellent" and the rose petal "sticky" wetting behaviors. The wettability, wetting regime and condensation performance on these surfaces can also be tailored depending on the exposure to the ambient conditions. Last, the synergistic cooperation of wettability gradient surfaces and low adhesion lubricant infused surfaces and the use of lubricant infused phase-change materials where the wettability, adhesion and heat transfer can be tailored via the phase of the infused material are also briefly reviewed.

Wetting and non-wetting surfaces and mechanisms introduced here suggest promising capabilities for microfluidics, self-cleaning, thermal management as well as condensation phase-change applications.