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SEM image of an individual micro-post decorated with nanostructures.

ESEM images of water condensation behavior on the hierarchical surface.

Hierarchical Superhydrophobic Copper for Sustained Dropwise Condensation

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Engineering surfaces that sustain continuous dropwise condensation, and are composed of materials commonly employed in heat transfer applications, are of great interest for scaled-up industrial systems. We fabricate hierarchical micro/nano-structured superhydrophobic surfaces on copper substrates. Condensate droplet growth dynamics on the as-fabricated samples were investigated using an environmental scanning electron microscope (ESEM; FEI Quanta 3D, ~6 torr, ~3 °C stage). Time-lapse ESEM images show that the condensate droplets preferentially nucleate at the bases of the hill-shaped microstructures (40 s). The droplets at the microstructure bases coalesce; merged droplets rise and appear to be suspended atop adjacent microstructures (180-220 s). These droplets, when triggered by coalescence, can gain sufficient kinetic energy by a reduction in droplet surface area/energy to spontaneously depart from the substrate. This droplet motion sweeps additional droplets in the trajectory and exposes fresh space for formation of new droplets (220-250 s). These droplet growth and departure dynamics are facilitated by the combination of microscale and nanoscale roughness features on the surface, and the behavior provides important insight into surface design requirements for sustaining dropwise condensation in thermal management applications.