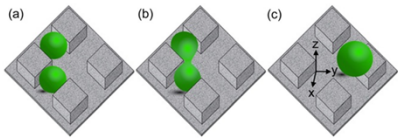
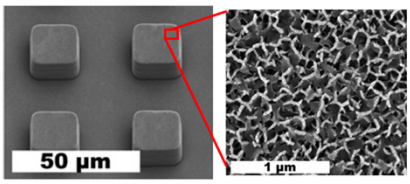
Nanotextured Micropillars Accelerate Ice/Water Removal from Surfaces for Heat Exchangers





Two-tier roughness consisting of silicon micropillars coated with aluminum nanostructures facilitate sweeping removal of water drops in-plane by inducing coalescence between neighboring drops at micropillar edges.

Work was performed as User Project at the Center for Nanophase Materials Sciences , at Duke University, and at the University of British Columbia.

Scientific Achievement

Superhydrophobic surfaces consisting of nano-textured micropillars induce sideways jumping of water droplets, which can rapidly remove water condensate from the surface in a "chain reaction".

Significance and Impact

Rapid removal of liquid drops due to coalescence – induced drop jumping can increase heat transfer rates by up to a factor of ten, leading to enhanced performance in refrigeration, heating and power generation applications.

Research Details

- Nano/micro roughness needed to induce lateral droplet motion was realized by coating silicon micropillars with nanoroughened aluminum.
- In contrast to previous reports where drop motion was perpendicular to the surface, drops coalesce at micropillar corners, resulting in a lateral sweeping removal of liquid across the surface resulting from subsequent coalescence of neighboring drops.

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Narrative Highlight Text:

The use of suitably textured superhydrophobic surfaces presenting roughness on both the nanoscopic and microscopic length scale has resulted in lateral self-propelled removal of condensate drops, due to coalescence-induced droplet jumping. Droplets are removed rapidly from the surface, which can result in up to an order of magnitude increase in heat transfer rates in applications such as refrigeration, air conditioning, heating, power generation, and more compared to conventional filmwise condensation. However, dropwise removal typically requires external forces such as gravity, which results in the requirement for out-of-plane orientations and the use of millimetric drop sizes, which limits its utility. In-plane droplet jumping triggered by coalescence becomes possible however for superhydrophobic surfaces having roughness on two different scales: the microscopic, defined by combinations of lithography and etching of silicon, and the nanoscopic, due to coating of the silicon micropillars with aluminum, followed by a hydrothermal reaction that converts the aluminum film to nanotextured aluminum hydroxide.

Reference

"Self-Propelled Sweeping Removal of Dropwise Condensate"
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