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Robust Superhydrophobic Surfaces. Synthesis and Applications

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Abstract

Surface patterning is one of the most effective approaches to mechanically modifying surfaces and enhancing their tribological properties. For example, they provide water repellency, lower friction, and greater corrosion resistance. With these advantages, patterned surfaces can be applied to various industrial uses, such as self-cleaning surfaces, cutting tools, submersible vehicles, etc. This study develops an intrinsically hydrophilic system that exhibits robust heterogeneous wetting. A novel nature-inspired flat-top- pillar "double-undercut" surface pattern design is proposed to achieve robust super-hydrophobicity at elevated pressures. An investigation of the main characteristics of the proposed superhydrophobic surfaces such as apparent contact angle, contact angle hysteresis, and critical pressure was performed.

An analytical approach predicted a significant critical pressure increase of more than 1.5 times atmospheric pressure for three different double-undercut designs. A numerical analysis was used to validate the analytical predictions. Finite element simulation was performed using Laminar, Two-phase flow, Horizontal-set approach in COMSOL-Multiphysics. An average of 30% of critical pressure increase was achieved for designs of three distinct permutations of double-undercut angles (50º – 40º, 50º – 36º, and 40º -36º). For comparison, the simulation of a "single-undercut" design with the exact dimensions exhibits only half of the critical pressure observed in "double-undercut" systems. Prototypes of the patterned surface were produced on polysilicon wafers using PolyMuMPs process. A three-step design with decreasing width of each step was adopted to implement the undercut designs for this particular layer-by- layer fabrication method on a silicon wafer.