Development of Coating-free Super Water-repellent Micropatterned Aluminium for Spontaneous Droplet Motion

Authors: Kirill Misiiuk[1,2]; Sam Lowrey[1,2], Richard Blaikie[1,2]; Josselin Juras[3]; Andrew Sommers[3]
[1]Department of Physics, University of Otago, New Zealand
[2]MacDiarmid Institute for Advanced Materials and Nanotechnology
[3]Department of Mechanical & Manufacturing Engineering, Miami University, Ohio, USA

Nature has demonstrated various approaches to promote superhydrophobic (SHPB) surface states. For example, the lotus leaf, where the origin of superhydrophobicity is due to microscale bumps with superimposed nanoscale hairs, resulting in a hierarchical structure [1, 2, 3]. Other natural systems have evolved passive transportation of water droplets. For example, the silk web of the cribellate spider shows passive motion of sub-millilitre water drops, due to combined surface tension gradients and Laplace pressure difference due to spindle-knot/joint couplings [4].

We aim to use these combined these wetting properties and produce an all metal, coating-less surface having both the super-water repellence of the lotus leaf and the surface tension gradient driven motion demonstrated on spider-silk. Such kind of all-metal SHPB surfaces promote dropwise condensation over film-wise, whereas a surface tension gradient generates an in-plane motion due to an actuating force that promotes spontaneous droplet motion. Such a combination may improve surface water droplet removal and could potentially be used for refrigeration heat exchanger surfaces, improving the air-side heat transfer coefficient [5], and promoting delay (or elimination) of ice-/frost-formation under extreme weather conditions, which is also problem for wind turbine blades [6].

We present a survey of microfabrication approaches for fabricating microstructures with fixed-pitch and variable-pitch along with their resultant wetting properties. From this, we have designed and developed micromachined all-metal hierarchical superhydrophobic gradient surfaces, based on Wenzel and Cassie-Baxter wetting theory (Fig. 1). We present results clearly demonstrating passive gradient-driven droplet motion on these surfaces (Fig. 2), and will discuss future modifications that will lead to improved droplet transport efficiency.

References:

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Te Whare Wānanga o Otāgo

NEW ZEALAND

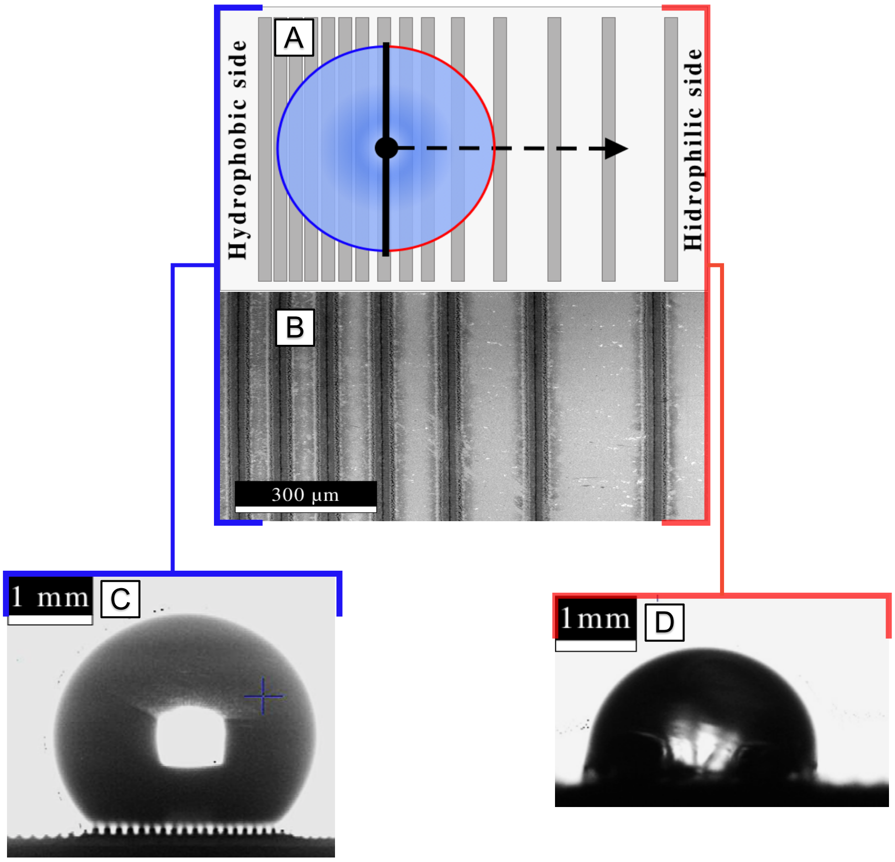

Figure 1. (A) An illustration of a topographic gradient, (B) a plan-view of the laser-etched gradient sample (C) microwetting state on the hydrophobic side of gradient shown in (A), (D) microwetting state on the hydrophilc side of gradient shown in (A).

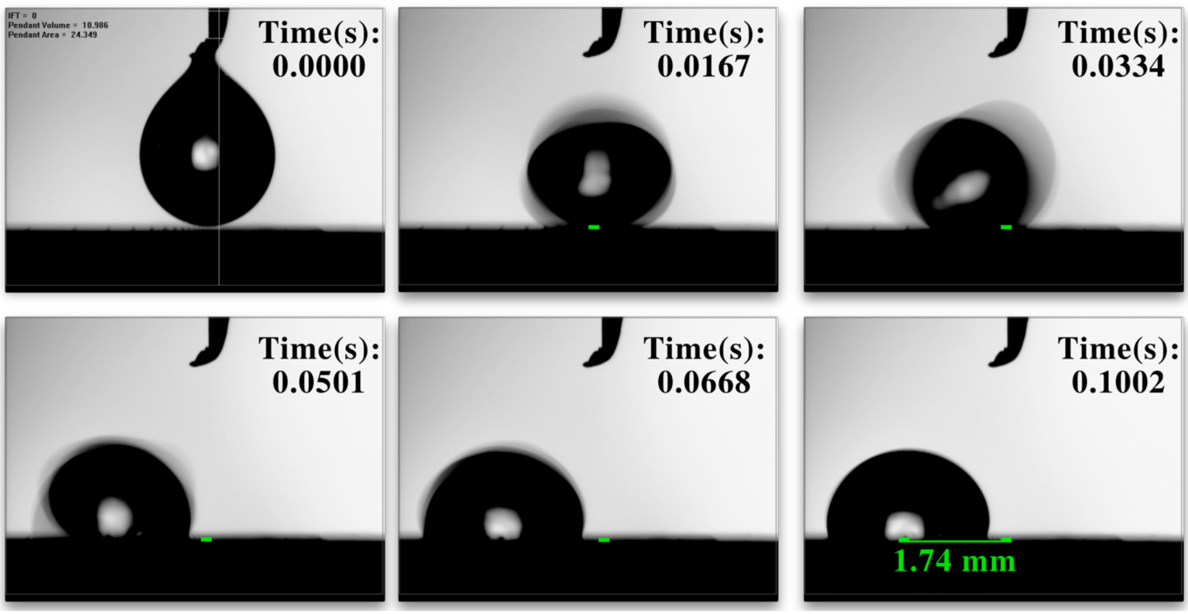

Figure 2. Spontaneous droplet motion in the Cassie-Baxter state (ends up in Wenzel state) on the laser-etched topographic gradient.