Surface Wetting on Micro-milled or Laser-Etched Aluminium with Ion-Beam Post-Processing

Authors: Kirill Misiiuk[1,2]; Sam Lowrey[1,2], Richard Blaikie[1,2]; Josselin Juras[3]; Andrew Sommers[3]; Jérôme Leveneur[4,2]

[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

[4]National Isotope Centre, GNS Science - Te Pū Ao, Institute of Geological & Nuclear Sciences.

Many unique surface wetting properties are found in nature based on complicated micro-scale surface topography. The most common example is superhydrophobicity of the lotus leaf, which combines microscale bumps with superposed nanohairs [1, 2, 3]. Furthermore, nature has evolved structures that passively transport water droplets: a surface tension gradient and a Laplace pressure difference helps Namib beetles to harvest water out of fog, for example. This structure consists of a biphilic (hydrophilic/hydrophobic) surface, which promotes mass transfer via droplet rolling along the tilted elytra to the mouth of the beetle [4].

In this work, we investigate two approaches of microfabrication for mimicking such effects in engineered materials: micro-milling and laser-etching in combination with ion-beam surface modification techniques to influence on surface wetting properties. Ion-beam post-processing, like ion-beam deposition, provides a nanoroughness over a microstructure, and like ion implantation a controllable change in the Gibbs surface energy of the substrate material. These properties, combined with the micro-scale surface engineering via milling or laser etching, should provide sufficient degrees of freedom to achieve simultaneous hydrophobicity and mass-transport, for application in atmospheric water harvesting or condensation control on industrial heat exchangers.

We investigate the surface wetting properties for a range of micro/nanofabricated aluminium surfaces (Fig. 1) via imaging goniometry (Fig. 2). We compare in-plane spreading for control (smooth) surfaces, and micro-patterned surfaces and combined micro-patterned and ion-beam processed surfaces. This combination of micro and nanofabrication methods is promising for coating-less surfaces with unique wetting characteristics to enhance liquid-solid interaction. Such surfaces have potential applications in advanced heat-exchanger technology (increasing the air-side heat transfer coefficient during condensation) [5] and wind turbine technologies (delaying or eliminating ice/frost formation under extreme weather conditions) [6].

References:

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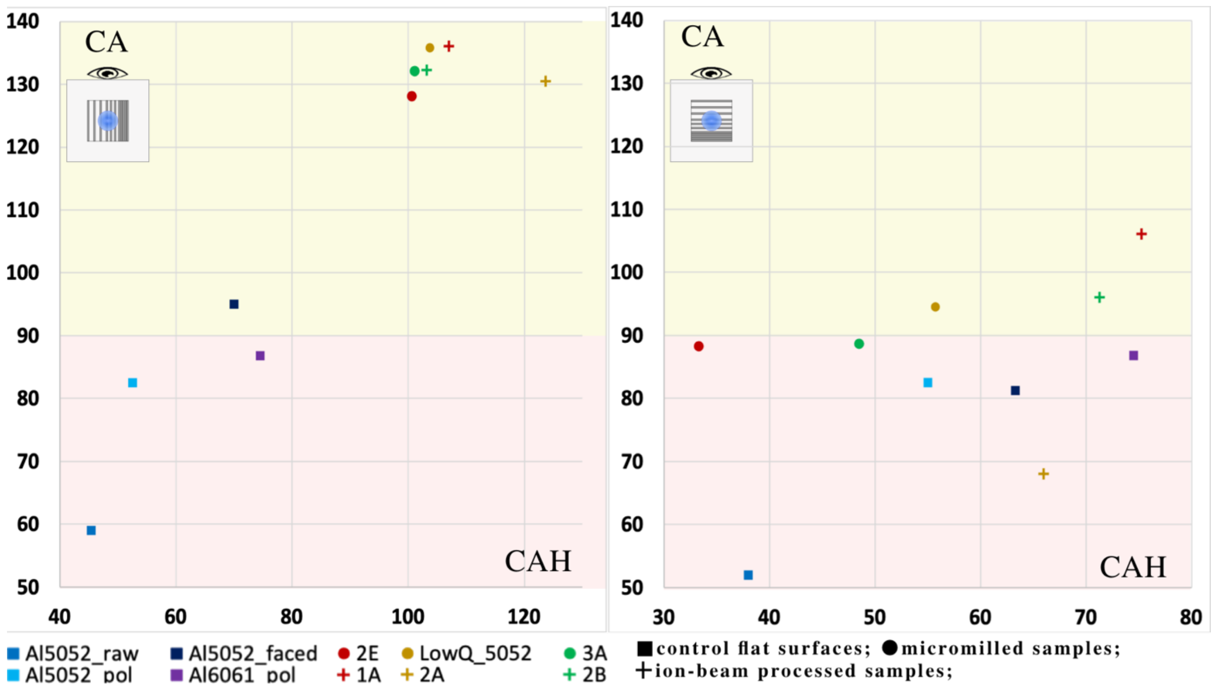

Figure 1. CA compared with CAH of different Al-samples with and without processing: (left) for parallel view, (right) for orthogonal view (*pol* – polished, “*faced”* means “*levelled*”).

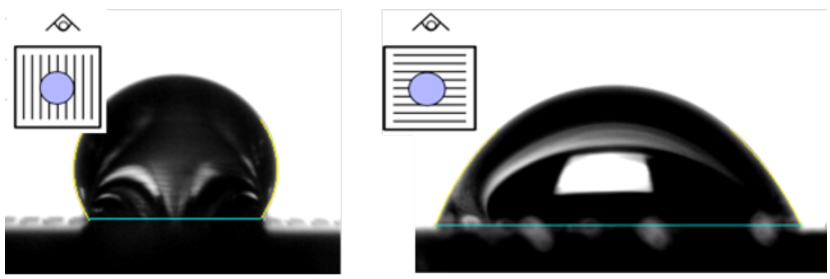

Figure 2. Anisotropic spreading of a water droplet on a processed surface: (left) parallel view, (right) orthogonal view