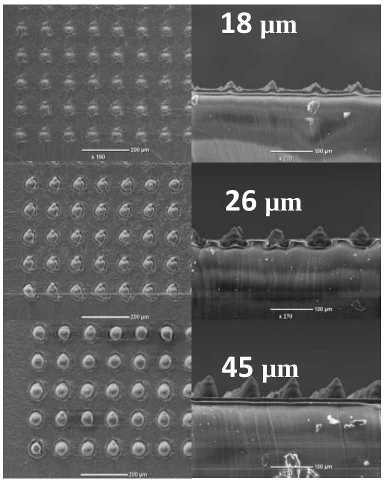
Super-hydrophobicity of casted PDMS surfaces

Ellen Jose[1,2], Simon Ashforth[1,2,3], Claude Aguergaray[1,2,3], M. Cather Simpson[1,2,3,4]

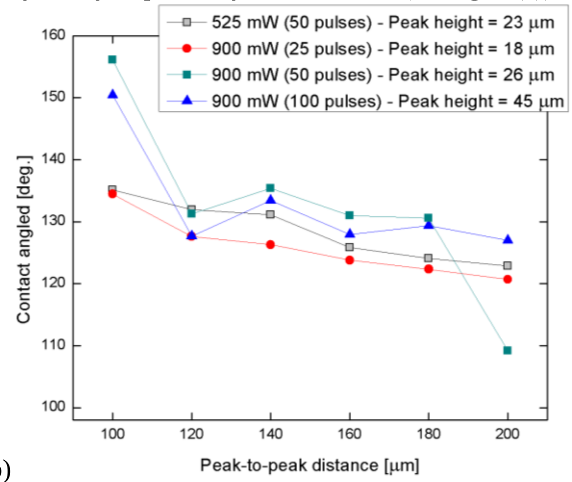
[1]Photon Factory, University of Auckland, 23 Symonds Street, New Zealand;
[2]The MacDiarmid Institute for Advanced Materials and Nanotechonology and The Dodd Walls Centre for Quantum and
[2]School of Chemical Sciences, University of Auckland, 23 Symonds Street, New Zealand;
[4]Department of Physics, University of Auckland, 23 Symonds Street, Auckland, New Zealand;
Corresponding author: c.aguergaray@auckland.ac.nz

The expansion over the last decade of super-hydrophobic surfaces (surfaces having a water droplet contact angle greater than 150° and a sliding angle less than 10°) has been motivated by a number of industrial applications ranging from anti-icing/clogging surfaces for power transmission, radars and telecommunication antennas, to self-cleaning windows, clothing, or micro-fluidic. This behaviour is typically achieved through the control of surface roughness with well-designed microstructures. Artificial super-hydrophobic surfaces can be fabricated by a number of techniques figuring photolithography, plasma treatment, wet chemical reactions, or electrospinning and so on [1-3]. While sometimes efficient, these techniques do not allow for the wide scale manufacturing required for these surfaces to spread into the market. The method we explore herein relies on laser micro-machining. Patterning can be obtained either through direct laser irradiation [4] or via transfer of the laser-engraved pattern through casting [5]. In the present study we use a casting method to improve the hydrophobic properties of a section of polydimethylsiloxane (PDMS). PDMS was used as the substrate and casted using a machined stainless steel as a mould. We chose polymer casting with PDMS as this technique is fast, cost effective and suitable for large scale operation and because PDMS features excellent mechanical and chemical properties for such application (intrinsic deformability, hydrophobic properties, softness and low surface energy). PDMS already found multiple applications in micro-fluidic, lithography and medicine for example.

In this study we aim at improving the efficiency, the reliability and the processing time to obtain uniform treated surfaces through precise evaluation of the different parameters accessible. A Ti:Sa amplified femtosecond laser (110 fs, 800 nm, 1 k Hz) was used to create a 2D matrix of uniform holes in 316 stainless steel. We investigated the laser parameters through the power of the beam and the number of shots per hole to study their effect on the size of the features. We also looked into various patterning designs by changing the distance between the centre of each peak thus alter their distribution and ultimately the hydrophobicity of the surface (cf. Fig. 1 (a)).



(a)



(b)

Fig. 1 (left) Casted pattern with 100 µm peak spacing with different peak heights (insert value). (b) Measured contact angle between the surface and the droplet of water.

Measurements of the contact angles of water droplets on each area showed a strong correlation between the spacing of each feature and the hydrophobicity of the substrate. Larger contact angles were found for lower peak-to-peak distances (100 µm). A contact angle of 156˚ was found with peak height of 26 µm and a peak base width of 39.2µm (cf. Fig. 1). SEM measurements also confirmed that the number of shots was the predominant parameter to control the holes features and thus the shape of the casted peaks. We will present at the conference a complete analysis of the parameter space and of the associated hydrophicity behaviour of the treated samples.

References:

[1] Y. Yan, et al., “Mimicking Natural Superhydrophobic Surfaces and Grasping the Wetting Process: A Review on Recent Progress in Preparing Superhydrophobic Surfaces,” Advances Colloid and Interface Science, Vol. 169, p.80 (2011).
[2] V. Ganesh, et al., “A Review on Self-Cleaning Coatings,” Journal of Material Chemistry, Vol. 21, No. 41, p. 16304 (2011).
[3] S. Lee, et al., “Continuous Fabrication of Bio-Inspired Water Collecting Surface Via Roll-Type Photolithography,” Int. J. Precis. Eng. Manuf.-Green Tech., Vol. 1, No. 2, p. 119 (2014).
[4] S. Van Pelt, “Local wettability tuning with laser ablation redeposits on PDMS,” Applied Surface Science, p. 456 (2014).
[5] C. Ngo, et al., “Transparency and Superhydrophobicity of Cone-Shaped Micropillar Array Textured Polydimethylsiloxane,” International Journal of Precision Engineering and Manufacturing, Vol. 16, p. 1347 (2015).