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Mapping the surface wettability of IP-PDMS micro-hoodoo arrays fabricated by two-photon polymerization direct laser writing

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Superhydrophobic surfaces have an apparent contact angle (CA) with water > 150˚ and a CA hysteresis < 10˚. Such surfaces occur naturally in e.g. lotus leaves and often have up to six levels of structure hierarchy [1]. However, engineered superhydrophobic surfaces often have only one [2] or two [1] hierarchical levels. For example, nanograss textures are known to increase the CA with water [1-3]. Periodic arrays of mushroom-like structures [3-5], also known as micro- or nano-hoodoos [5], can be engineered to display superomniphobic properties, i.e. to repel both water and oily liquids.Such structures have been previously fabricated by two-photon polymerization direct laser writing followed by surface modification [3] or replication [4]. Here, we present the fabrication and characterization of superhydrophobic microarrays, which consist of micro-hoodoo structures arranged in a hexagonal lattice. To the best of our knowledge, this work is the first demonstration of micro-hoodoo structures fabricated by a single step process, i.e. direct laser writing of PDMS. Furthermore, we investigate the surface wettability in relation to the size of individual microstructures and the lattice constant.

A single micro-hoodoo structure is schematically shown in Fig. 1a). To map the influence of various parameters on surface wettability, we chose to vary the size of the micro-hoodoo structures' features, i.e. top diameter Φ_{top}, base diameter Φ_{base}, top height h_{top} and total height h_{total}. For the smallest structures, Φ_{top} is 10 µm, Φ_{base} is 6 µm, h_{top} is 2 µm, and h_{total} is 10 µm. The aspect ratio between the features is always kept constant, so we refer to the different structure sizes simply using the Φ_{top} value, which was either 10, 20, or 30 µm. The disposition of microstructures within the hexagonal lattice is schematically shown in Fig. 1b). Here, the parameter varied was the lattice constant L, which leads to a variation of the surface coverage.

The micro-hoodoo arrays (Fig. 2) were fabricated by two-photon polymerization direct laser writing using a Nanoscribe Photonic Professional GT+ system [6]. A total microarray size of 4 mm × 4 mm was chosen to keep the fabrication time to a minimum while having a large enough area for CA measurements. A 25×/0.8 N.A. objective was used for direct laser writing of the structures on fused silica substrates and in the IP-PDMS resin. The fused silica substrates were cleaned and activated by air plasma treatment prior to fabrication, which was done with a laser power of 80% and a scan speed of 120000 µm/s. After fabrication, the structures were developed by immersion in isopropanol. A flat and contiguous IP-PDMS surface used as reference was prepared by drop-casting the resin on the fused silica substrate, followed by flood UV exposure at 365 nm.

The advancing and receding CA for water were measured using a CA goniometer. The flat and contiguous IP-PDMS surface is hydrophobic, and the CA values measured on it were similar to the literature standards for PDMS, i.e. ~110˚ (Fig. 3a). The tightly packed micro-hoodoo surfaces, i.e. with Φ_{top} = 30 µm, and L = 100 µm, were superhydrophobic, with a CA ~160˚ and a CA hysteresis of ~5˚ (Fig. 3b). Increasing the lattice constant L led to a decrease of the CA. In the future, we will investigate the CA of our micropatterns with oily liquids to determine if the surfaces indeed display superomniphobic properties, as theoretically predicted.

To summarize, we have demonstrated the single-step fabrication of superhydrophobic surfaces by direct laser writing of a PDMS precursor material. The shape factor of individual structures and the lattice constant influence the wetting properties. The surfaces are expected to display superoleophobic properties, in addition to the superhydrophobic ones, but this remains to be investigated.

[1] N. Okulova et al., Nanomater. 8 (2018) 831.
[2] A. Telecka et al., ACS Macro Lett. 5 (2016) 1034-1038.
[3] Z. Dong et al., Adv. Mater. 30 (2018) 1803890.
[4] V. Liimatainen et al., Adv. Mater. 32 (2020) 2000497.
[5] A. Telecka et al., RSC Adv. 8 (2018) 4204-4213.
[6] A.-I. Bunea et al., Micro 1 (2021) 164-480.

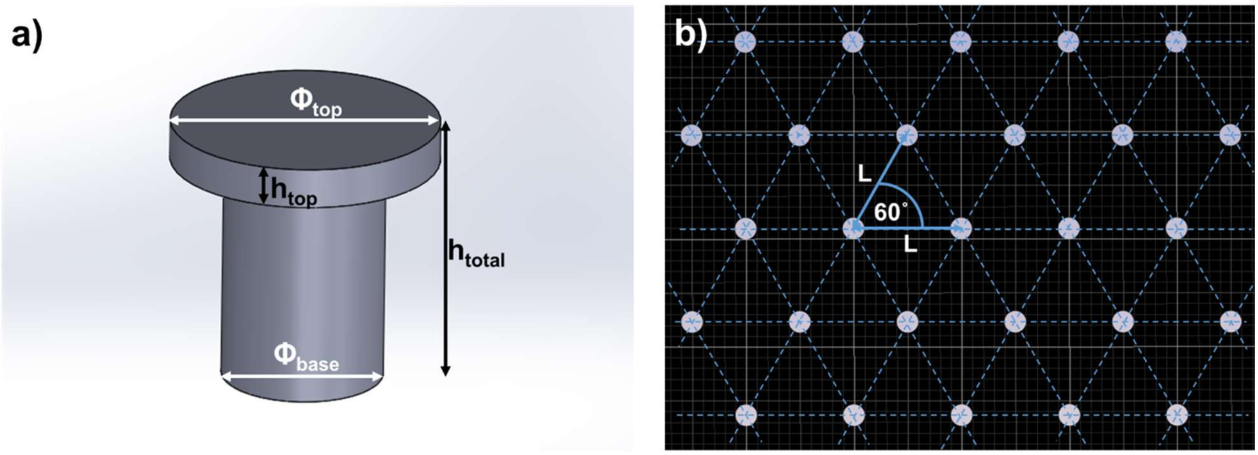

Figure 1. Schematic representation of (a) a single microstructure and (b) the hexagonal array micropattern.

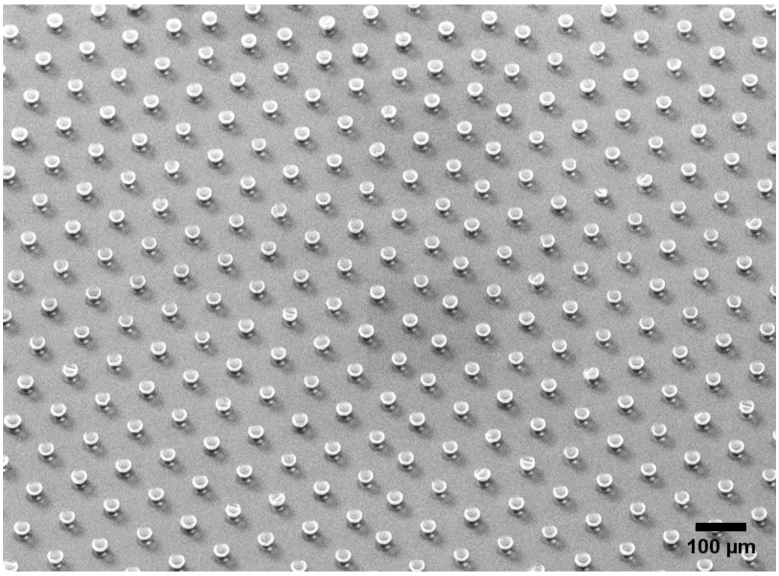

Figure 2. Scanning electron micrograph of a hexagonal array of microstructures with a top diameter Φ_{top} of 30 µm and a lattice constant L of 100 µm. The image was acquired with a stage tilt of 30˚.

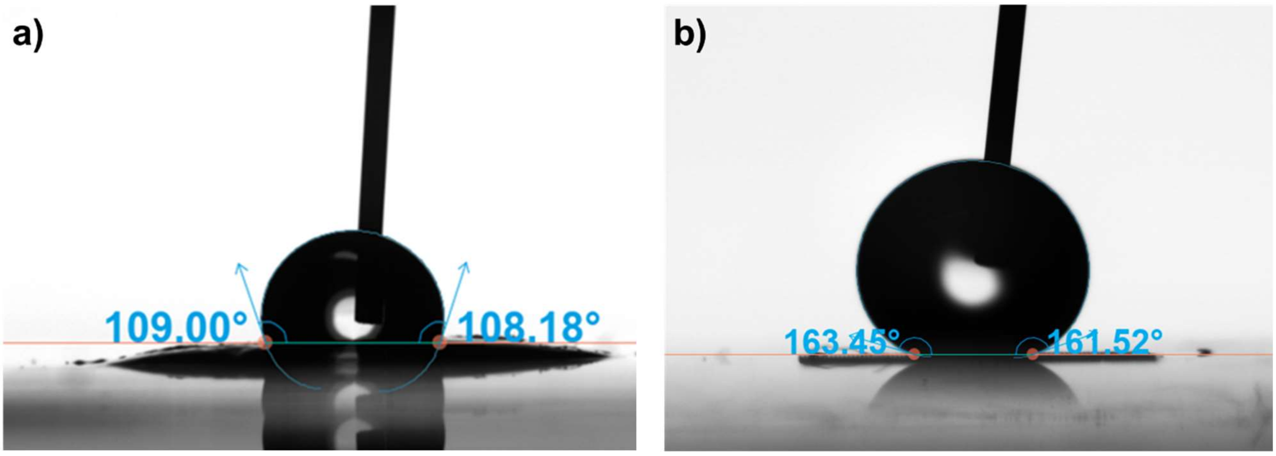

Figure 3. Optical microscopy image showing a static contact angle measurement for water on (a) a flat and contiguous IP-PDMS surface and (b) a patterned IP-PDMS surface consisting of a hexagonal array of structures with a top diameter Φ_{top} of 30 µm and a lattice constant L of 100 µm.