Electronic Supplementary Material (ESI) for Nanoscale.
This journal is © The Royal Society of Chemistry 2014

Electronic Supplementary Information (ESI)

Hierarchically nanotextured surfaces maintaining superhydrophobicity under severely adverse conditions

Tanmoy Maitra,[a] Carlo Antonini,[a] Matthias Auf der Mauer,[a] Christos Stamatopoulos,[a] Manish K. Tiwari[ζ] and Dimos Poulikakos[a]*

Contact angles on intermediate surfaces

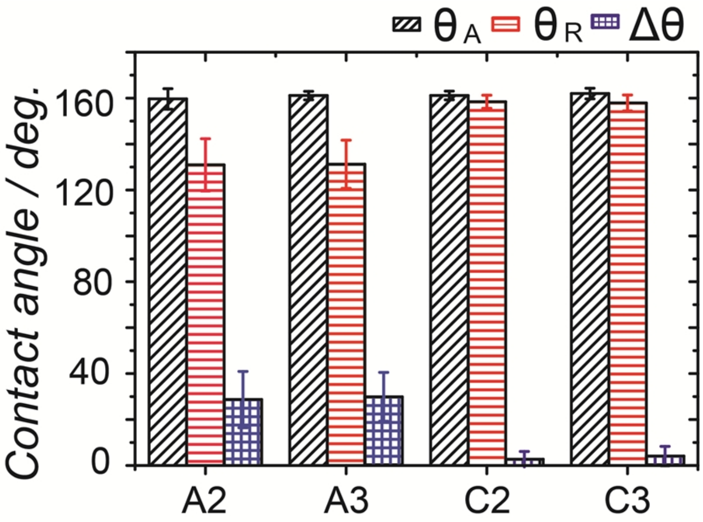

Fig. S1 The advancing θ_A , and receding θ_R contact angles and contact angle hysteresis $\Delta\theta$ of intermediate surfaces A2, A3, C2 and C3 (see in process schematic in Fig. 2 of the main manuscript).

The contact angle values (advancing and receding contact angles and contact angle hysteresis) of intermediate surfaces, namely A2, A3, C2 and C3 (see details of surface fabrication process in Fig. 2 of the main paper) are shown in Fig. S1. The contact angle hysteresis is particularly low for surfaces C2 and C3. This can be attributed to the presence of rounded microspherulites (see schematic in Fig. 2 in main manuscript) on sharp pits due to aluminum dislocation etching. The morphology of spherical iron particles resembles the lotus leaf texture, which excels at minimizing hysteresis. Although the presence of sharp pits is sufficient to establish a Cassie-Baxter wetting state after coating with low energy molecules (i.e. FDTS and PDMS), as is evident from the high values of advancing and receding contact angles on A2 and A3, the contact angle hysteresis remains relatively high, ~30^{o}, likely due to the presence of sharp edges which are known to cause partial/local pinning of the moving contact line. Differently, on surfaces C2 and C3 the presence of rounded microstructures, i.e. spherical iron particles enhances superhydrophobicity, with a strong reduction of contact angle hysteresis.

PDMS film thickness change with n-hexane immersion

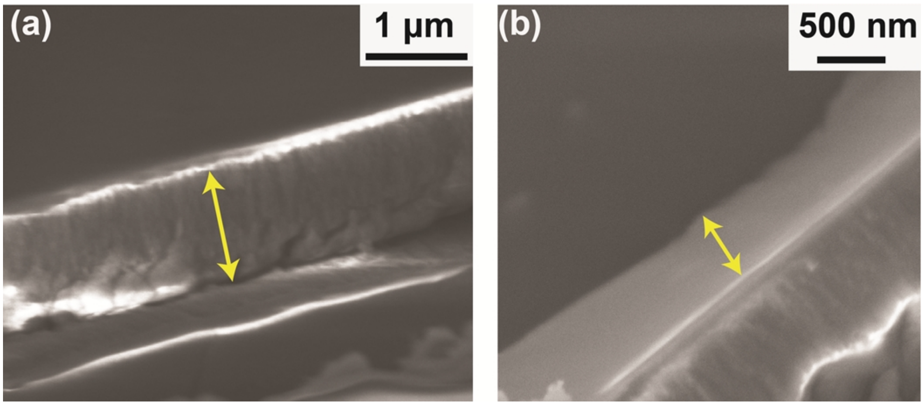

Fig. S2 SEM images of a PDMS film coated on a smooth aluminum substrate (a) before and (b) after immersion in n-hexane for 13 hours. (Yellow arrows in the images indicate the thickness of the PDMS film).

The Fig. S2 shows the SEM images of a PDMS film on a smooth aluminum substrate, dip coated at a speed of 5 µm/s, before and after submersion in n-hexane for 13 hours. Tests were performed to check the integrity of the PDMS layer after immersion in n-hexane, which is used for the MTS functionalization step. The images in Fig. S2 were used to estimate the PDMS film thickness. The average thickness was 1.171 ± 0.069 µm initially and was reduced to 0.533 ± 0.070 µm after the immersion in n-hexane for 13 hours, as was expected due to the solubility of PDMS in h-hexane. However, the layer is still present on the surface and remains thick enough to impart the desired functionality.

Chemical stability of surfaces with (C3) and without PDMS film (C2)

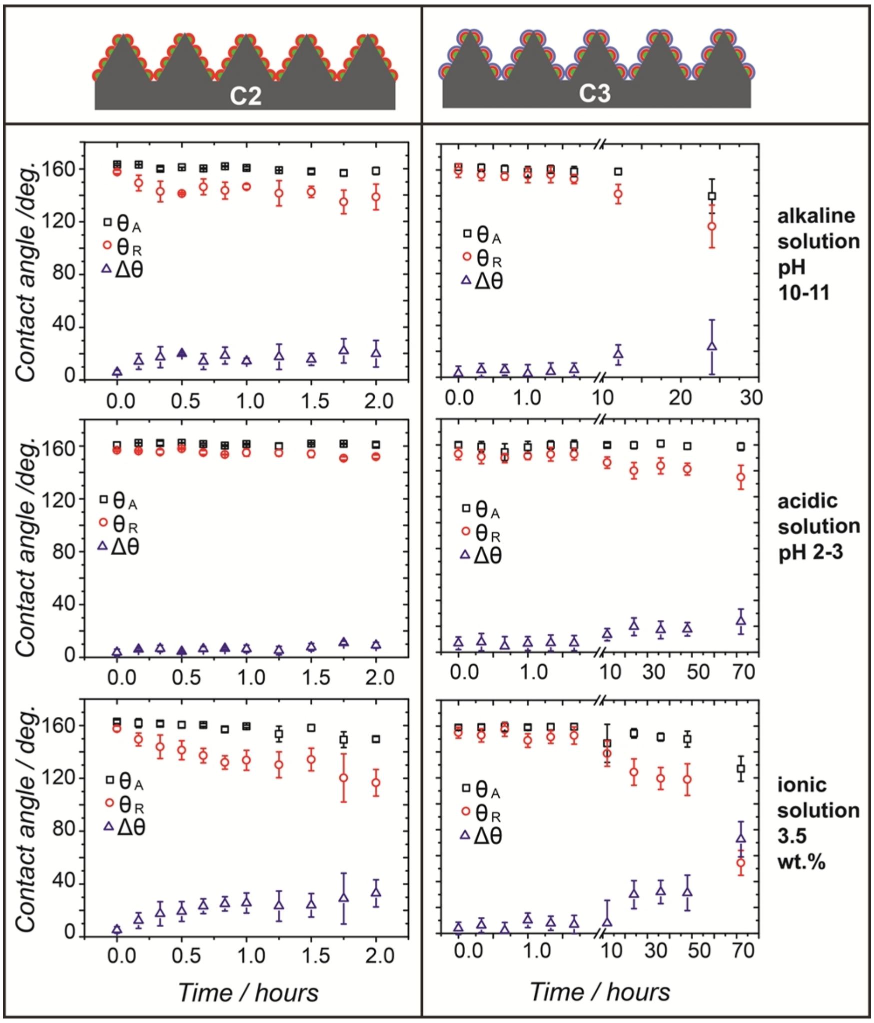

Fig. S3 Chemical stability tests on two different surfaces, C2 and C3, with alkaline (pH 10-11), acidic (pH 2-3) and ionic (3.5 % weight sodium chloride solution) solutions.

The Fig. S3 shows the chemical stability results of surfaces C2 and C3. The tests were performed using alkaline, acidic and ionic solutions as described in the main paper. The surface C2 was coated only with a FDTS layer, whereas the surface C3 was first coated first by FDTS and then by PDMS. It is clear that the surface C2 degrades within two hours in ionic solution compared to surface C3, which survived well up to 48 hours. Additionally, in alkaline and acidic solutions, surface C2 degraded rapidly compared to surface C3. The better resistance of surface C3 over surface C2 in all the chemicals tested is due to the existence of the PDMS layer, which serves as a barrier layer.

Impalement pressure balance

For a drop impacting on surface, the impalement pressure peak is given by,[1]

$$P_{\max} = 0.88\left(\frac{R^7 V^{28} \rho_l^{16}}{\mu^4 \gamma^3}\right)^{\frac{1}{9}} \tag{S1}$$

where R, V, ρ_l, μ and γ are the radius of the impacting drop, velocity of the impacting drop, density of the water, viscosity of air and surface tension of water/air interface, respectively.

It was shown[2] that for drop impalement into a surface texture, leading to local transition of Cassie state to Wenzel state in the area close to impact point, $P_{\max} \propto P_c$. In particular, previous experiments using photolithographically patterned micro-pillar textured surfaces[2] showed that $P_{\max} \approx 80P_c$ at impalement. Thus, by measuring the critical velocity of impalement by drop impact tests, $P_{\max}$ can be computed using Eq. S1, and, in turn, the surface capillary pressure P_c can be estimated.

1. S. Mandre, M. Mani and M. P. Brenner, *Phys. Rev. Lett.*, 2009, **102**.
2. T. Maitra, M. K. Tiwari, C. Antonini, P. Schoch, S. Jung, P. Eberle and D. Poulikakos, *Nano Lett.*, 2014, **14**, 172-182.