Electronic Supplementary Information

Spray-On Omniphobic ZnO Coatings

Nitin K. Neelakantan, Patricia B. Weisensee, John W. Overcash, Eduardo J. Torrealba,

William P. King, and Kenneth S. Suslick**

Table S1. Average height (S_a), Maximum feature height (S_z), Root-mean-squared gradient (S_{dq}) and Roughness (r) of ZnO:PDMS coated samples.[a]

Sample (ZnO:PDMS)	S_a (average height) [µm]	S_z (maximum feature height) [µm]	S_{dq} (rms gradient)[b]	r = A/A_{flat}[c]
1:2 – as-is	6.6	75	1.3	1.2
1:2 – Teflon	9.6	115	2.3	1.4
1:1 – as-is	32.5	255	11.1	3.3
1:1 – Teflon	33.1	239	11.0	3.3
2:1 – as-is	27.4	224	10.0	3.0
2:1 – Teflon	18.9	151	7.9	2.6
2:1 – Silane	18.2	146	4.7	2.3
2:1 – Silane[d]	10.3	92	3.2	2.0
ZnO only	10.0	83	3.8	2.0
PDMS only[e]	~0.1	~12	~0.1	~1.0

[a]Numbers represent the roughness values for an area of 0.58x1.04 mm² on each sample. Given the method of sample fabrication by random spraying, the roughness at other points of the sample might deviate from the reported values by up to ± 20%. The general trend between the samples, however, remains the same.

[b]S_{dq} refers to the root means squared change in slope of the area of the sample scanned.

[c]A / A_{flat} is the total area A of the rough sample divided by the projected area A_{flat}, (i.e. that of a flat silicon wafer).

[d]Plasma-oxidized before silanization.

[e]Surface values of pure PDMS are based on very few data points, image acquisition was not possible due to high sample reflectance and very high flatness.

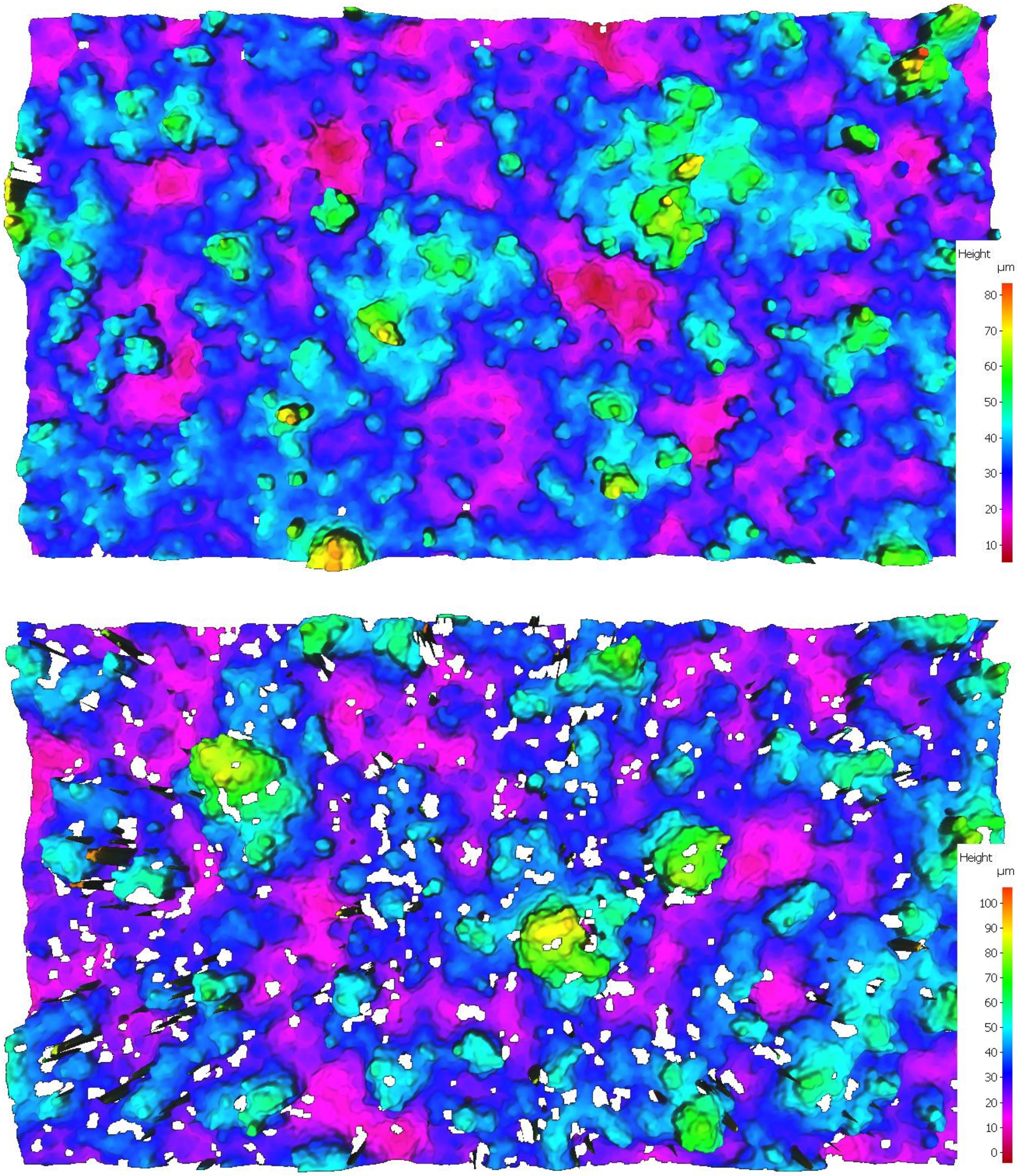

Figure S1a. Topographical images taken with the Alicona 3D microscope of samples with a ratio of 1:2 ZnO:PDMS (top) and 1:2 ZnO:PDMS, Teflon overcoated (bottom). The white areas in the bottom image are data points that could not be picked up by the lens. These do not significantly affect the average roughness measurements given in Table S1.

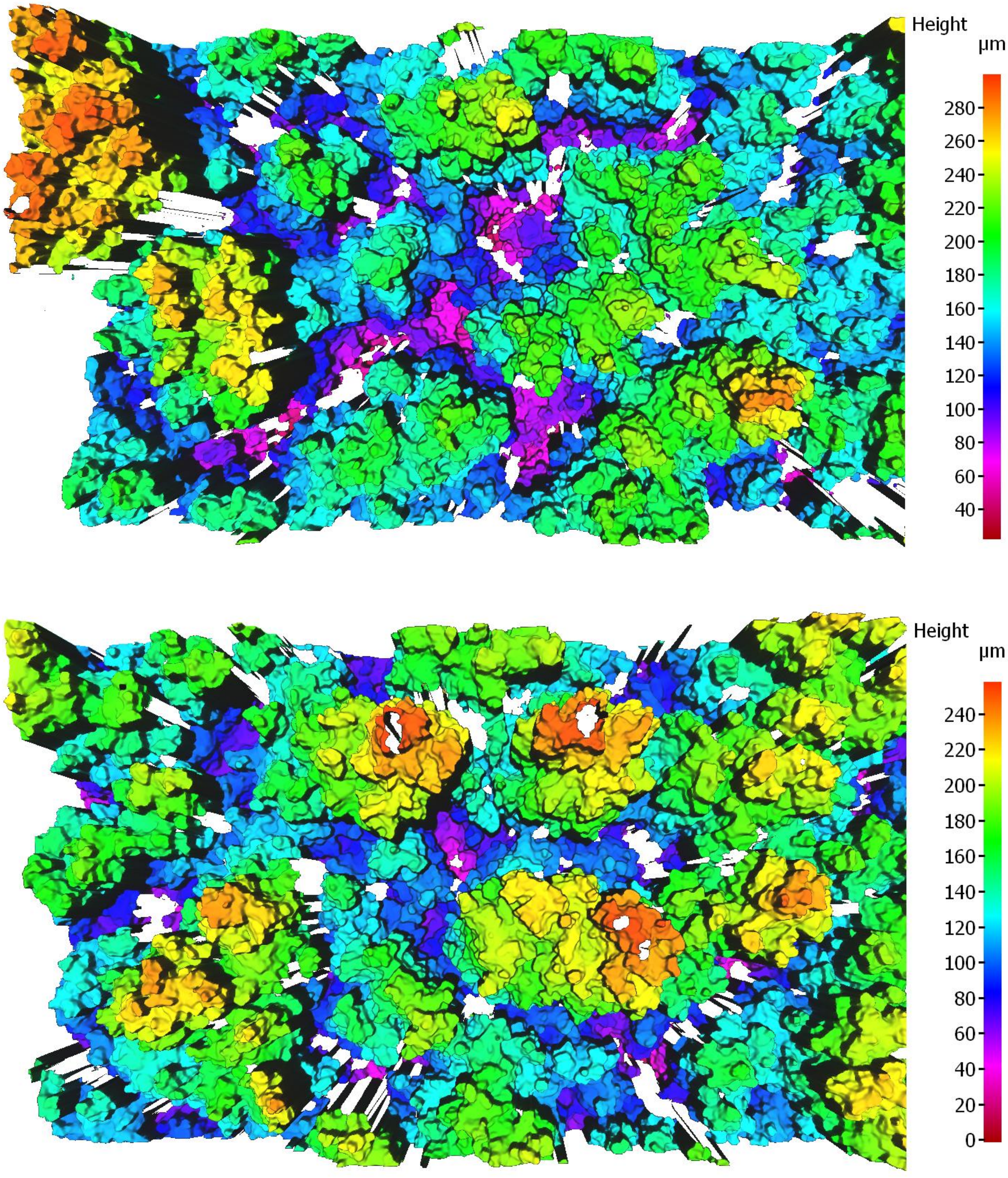

Figure S1b. Topographical images taken with the Alicona 3D microscope of samples with a ratio of 1:1 ZnO:PDMS (top) and 1:1 ZnO:PDMS, Teflon overcoated (bottom). The white areas in the images are data points that could not be picked up by the lens. These do not significantly affect the average roughness measurements given in Table S1.

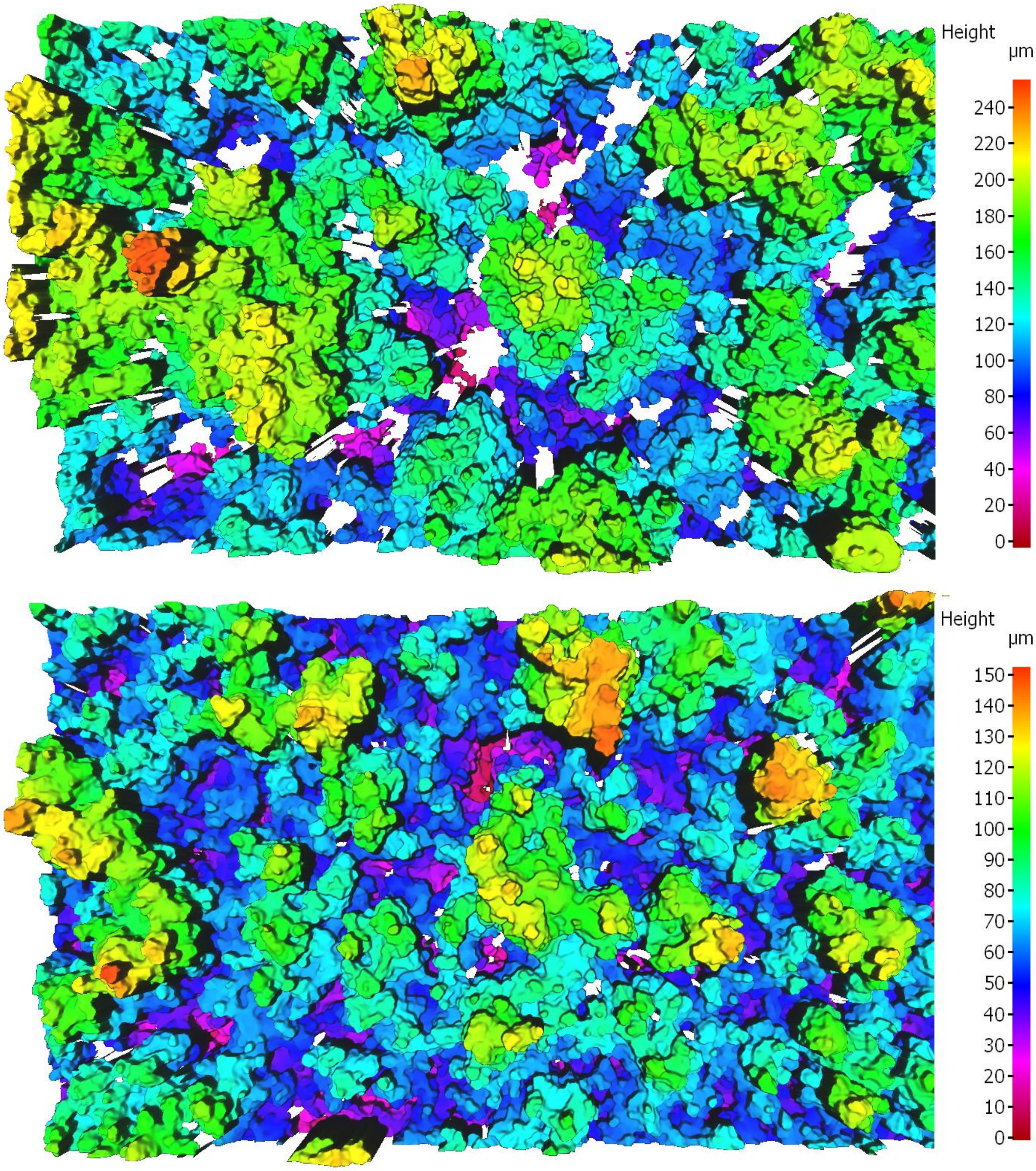

Figure S1c. Topographical images taken with the Alicona 3D microscope of samples with a ratio of 2:1 ZnO:PDMS (top) and 2:1 ZnO:PDMS, Teflon overcoated (bottom). The white areas in the images are data points that could not be picked up by the lens. These do not significantly affect the average roughness measurements given in Table S1.

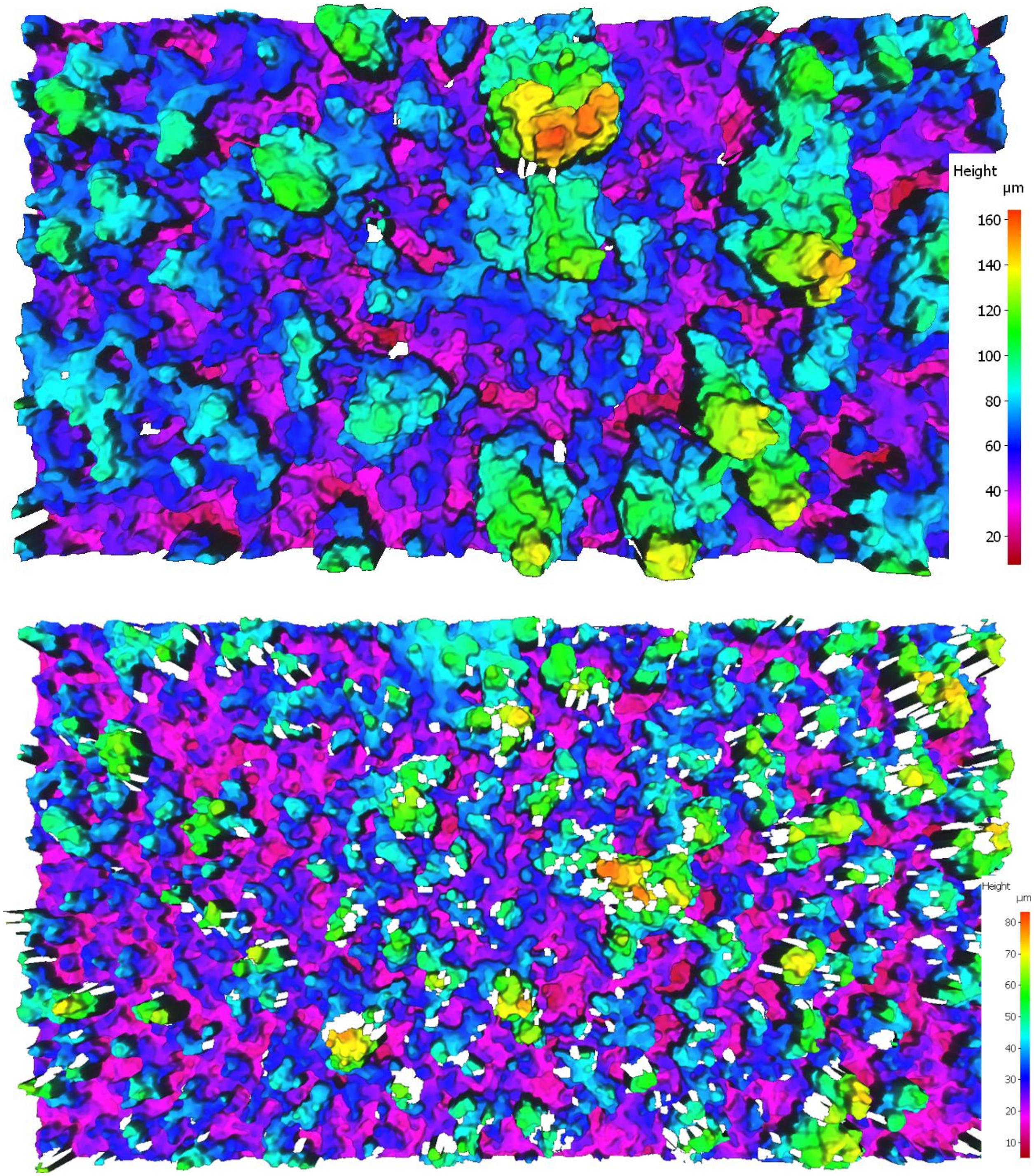

Figure S1d. Topographical images taken with the Alicona 3D microscope of silanized samples with a ratio of 2:1 ZnO:PDMS, the bottom image was treated with O_2 plasma before silanization. The white areas in the images are data points that could not be picked up by the lens. These do not significantly affect the average roughness measurements given in Table S1.

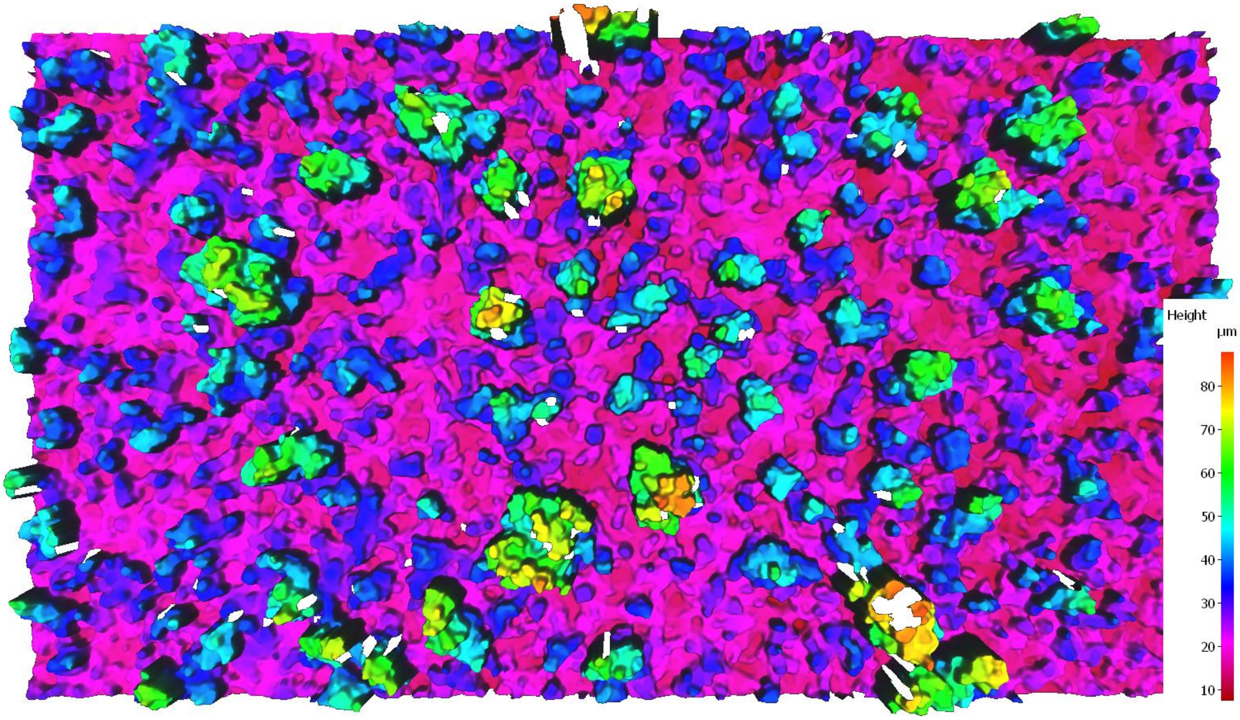

Figure S1e. Topographical images taken with the Alicona 3D microscope of samples sprayed with ZnO nanoparticles only. The white areas in the images are data points that could not be picked up by the lens. These do not significantly affect the average roughness measurements given in Table S1.

Table S2. Relative atomic percentages (at. %) of C, Si and F on the surface of ZnO:PDMS samples, as determined by x-ray photoelectron spectroscopy. O and H components are not accounted for in these analyses.

Sample (ZnO:PDMS)	Top Coat	C (rel. at. %)	Si (rel. at. %)	F (rel. at. %)
1:2	None	68	32	0
1:1	None	68	31	1
2:1	None	73	26	1
1:2	Teflon	53	20	27
1:1	Teflon	44	11	45
2:1	Teflon	43	11	46
2:1	FDTS	54	6	39
2:1	FDTS, plasma-treated	36	3	61

Spectra were obtained using a Kratos Axis ULTRA photoelectron spectrometer using a monochromatic Al Kα source. Survey spectra were collected at a constant pass energy of 160 eV. Spectra of the C(1s), Si(2p), and F(1s) core levels were collected at a pass energy of 40 eV and used to determine the relative atomic percentage of each of those elements.

The ATR-FTIR (attenuated total reflectance Fourier transform infrared) spectra below was collected on a Perkin Elmer 100 IR Spectrometer. Each spectrum is the average of 10 scans. Zn nanoparticles themselves gave no significant absorbance bands in this region of the IR

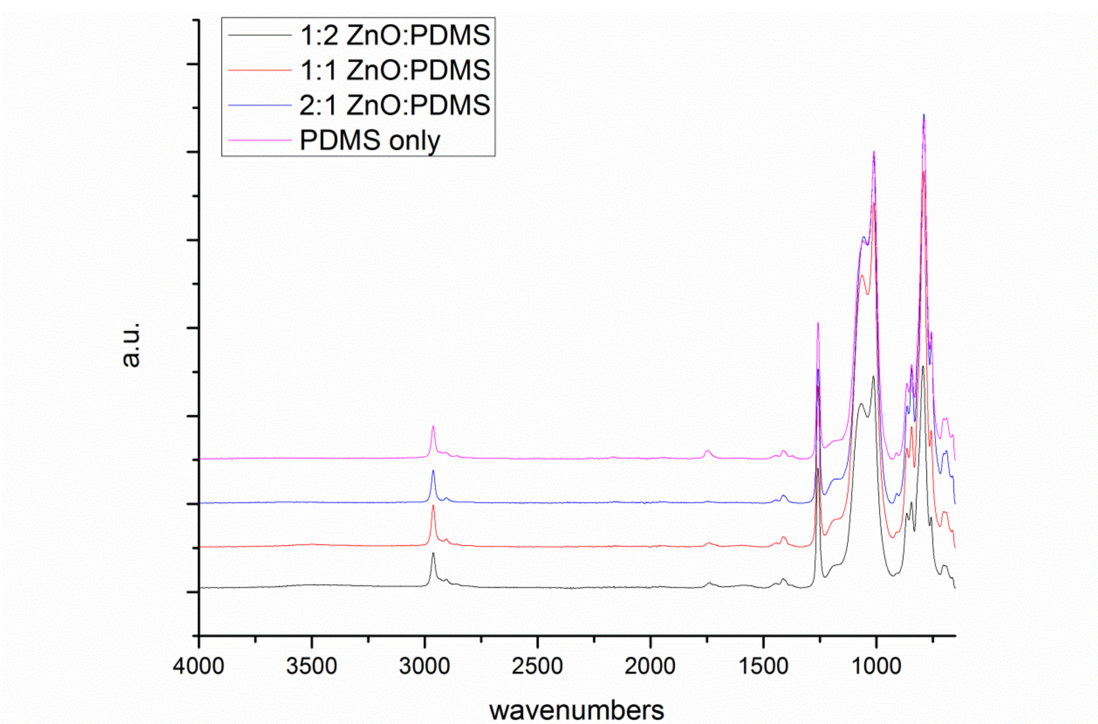

Figure S2a. ATR-IR of ZnO:PDMS coatings and that of PDMS only.

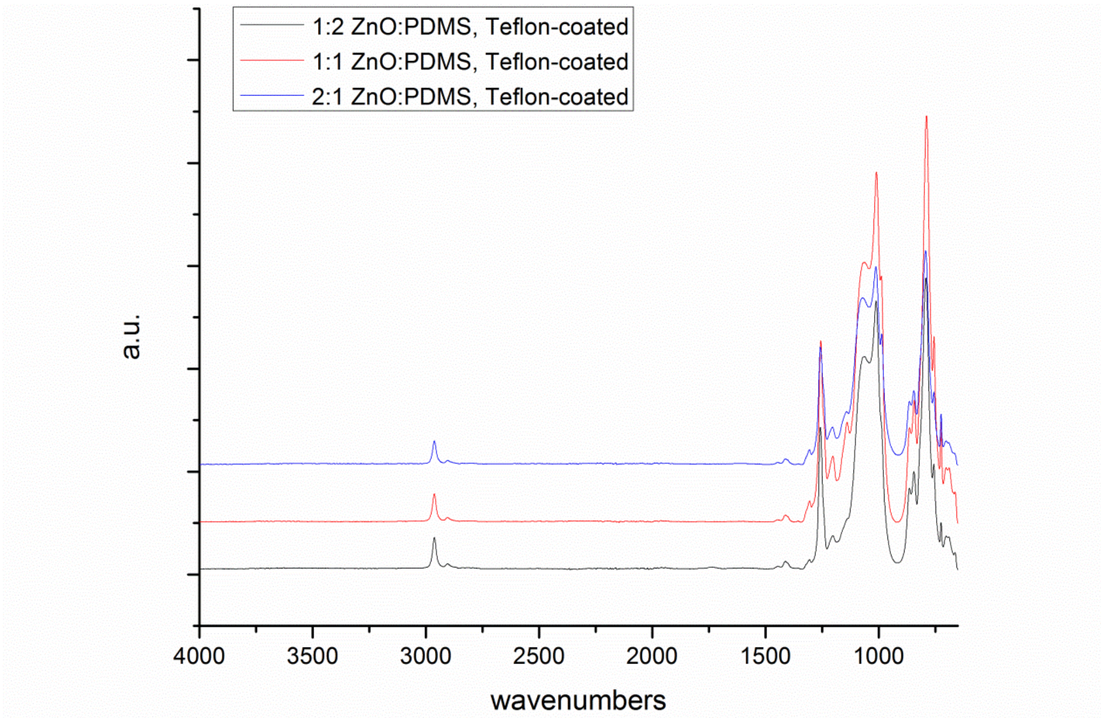

Figure S2b. ATR-IR of ZnO:PDMS coatings that were overcoated with Teflon AF.

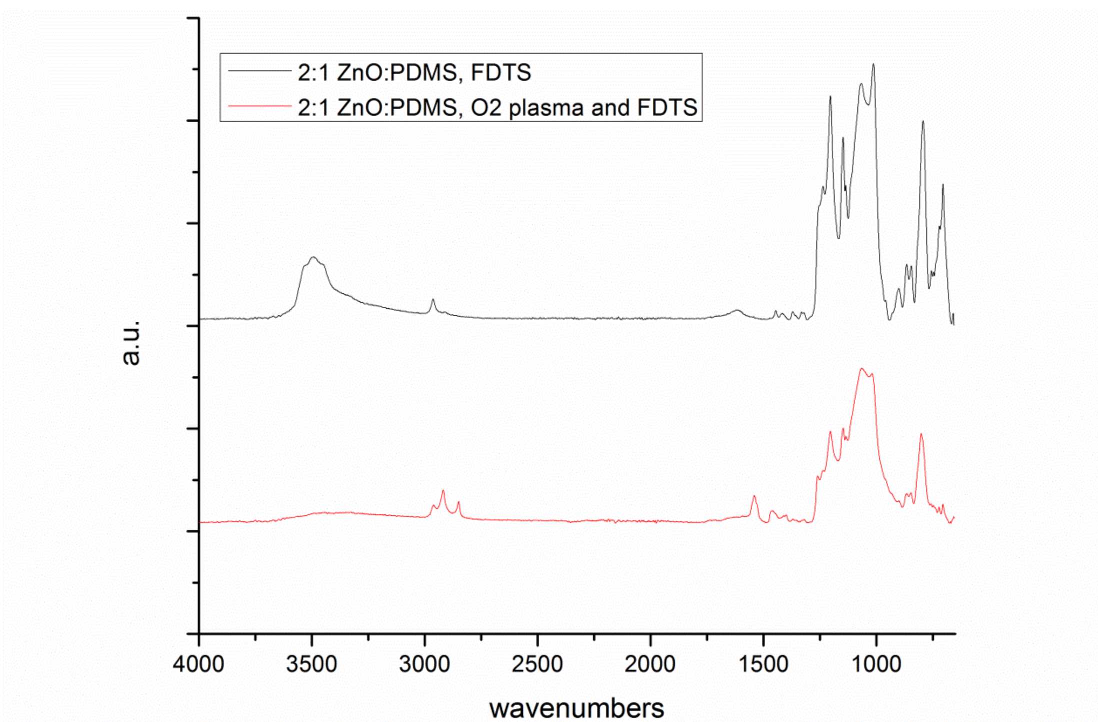

Figure S2c. ATR-IR of ZnO:PDMS coatings and that were overcoated with FDTS.

Table S3. Contact (**θ**) and Sliding (α) Angles of Milk on ZnO:PDMS Samples

Sample (ZnO:PDMS)	**Top Coat**	**θ, Milk[a] (°)**	**α, Milk (°)**
1:2	None	87 ± 5	Pinned
1:1	None	120 ± 2	22
2:1	None	145 ± 4	3
1:2	Teflon	96 ± 6	Pinned
1:1	Teflon	125 ± 3	21
2:1	Teflon	147 ± 5	4
2:1	FDTS[b]	122 ± 15	See note
2:1	FDTS, plasma-treated	148 ± 2	3

[a]1% fat milk; surface tension of milk = 54 mN/m: A. J. Bertsch, *Journal of Dairy Research*, 1983, **50**, 259-267.

[b]This sample produced erratic contact and sliding angles (α =>45, droplets pinned sometimes)

Table S4. Cost Estimate of ZnO:PDMS Sufaces

Material	**Bulk Cost**
filter paper	\$0.50 / m^2
ZnO nanoparticles	\$1800 / ton
PDMS	\$8 / kg

We base our cost estimate on a simple scaling of our spray coating procedure used on a filter paper substrate in this study. Bulk costs were obtained online from alibaba.com. Per m^2 surface of coated paper, the materials costs would be \$0.50 for the paper, \$0.23 for the ZnO, and \$0.52 for PDMS, for a total materials cost of \$1.25/m^2.

video_s1.avi

This video shows a stream of water being repelled on a cellulose filter paper that was spray-coated with a 2:1 ZnO:PDMS solution. The video was recorded with a Canon Rebel T3i and a Sigma 70-300mm at 60 fps, but is played at 15 fps (x0.25 speed).

video_s2.avi

This video shows a stream of water being repelled by an aluminum surface that was spray-coated with a 2:1 ZnO:PDMS solution. Droplets of water bounce off the surface as they impact it. The video was recorded with a Canon Rebel T3i and a Sigma 70-300mm at 60 fps, but is played at 15 fps (x0.25 speed).

video_s3.avi

This video shows an RL-68H droplet (γ = 28 mN/m) sliding across a spray-coated silicon wafer surface (2:1 ZnO:PDMS) that was functionalized with FDTS. The video was recorded with a Canon Rebel T3i and a Sigma 70-300mm at 60 fps, but is played at 15 fps (x0.25 speed). Many meta-stable droplet states can be seen as it moves across the surface. No oily trail or streaking is observed.