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ELECTROWETTING ON SUPERHYDROPHOBIC SU-8 PATTERNED SURFACES

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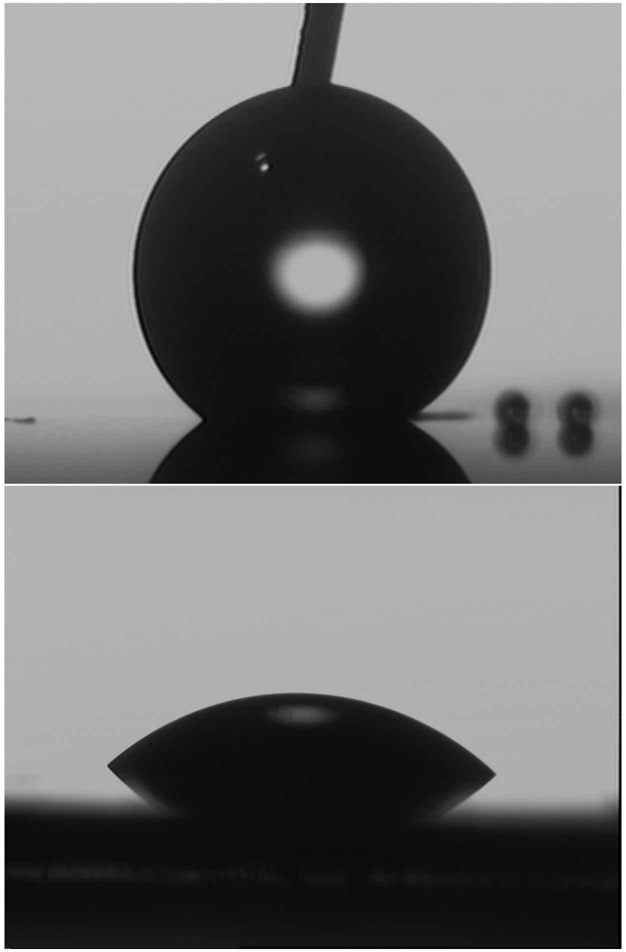
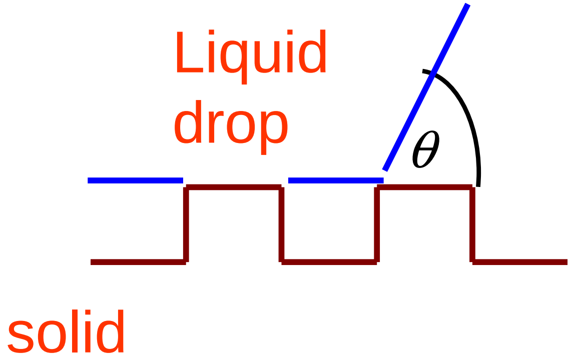
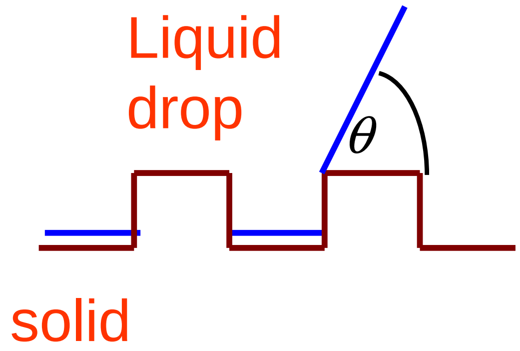
Introduction



- A small droplet of a liquid deposited on a surface either forms a spherical cap shape or it spreads across the surface until it forms a wetting film.

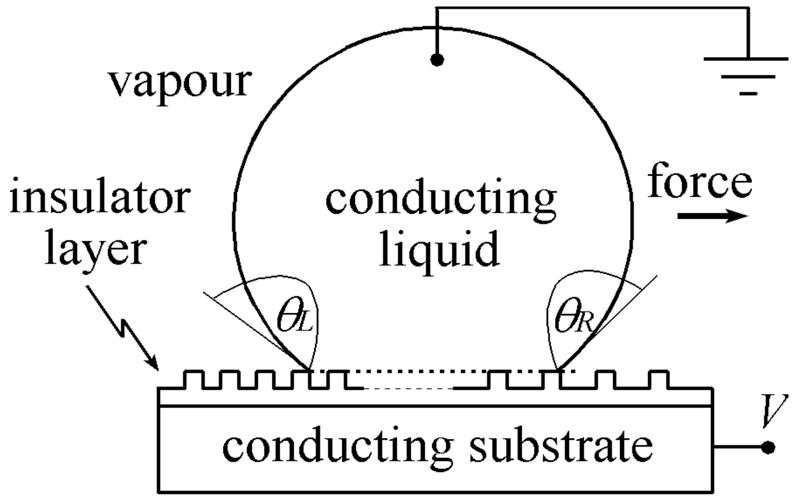


Cassie-Baxter equation,
$\cos\theta r = f \cos\theta e - (1-f)$



Wenzel's equation,
$\cos\theta r = r \cos\theta e$

- Super-hydrophobicity and electrowetting both modify the effective contact angle.



Experimental arrangement for electrowetting

When a voltage is applied to the drop the surface free energy is altered.

This decreases the contact angle of the droplet
- reduction in hydrophobicity occurs.

Report studies of electrowetting on superhydrophobic surfaces.

Experimental

SU-8 is an epoxy based negative photo-resist
Strong, stiff and chemically resistant after processing.

The patterned SU-8 was spin coated with amorphous fluropolymer Teflon® AF 1600 (DuPont Polymers).

Cylindrical pillars of diameter 7.0 height 6.5 and separation of 15μm

- confirmed by scanning electron microscope images.

Droplets of deionised water with 0.01M KCl.
The profile was captured using a Kruss DSA-1 contact angle meter.
A dc voltage was applied using a Keithley 2410 source/meter.

A drop of water immediately after deposition,

At the maximum voltage applied of 130V,

and at zero volts after the bias had been removed.

One feature that is clearly observed is the high hysteresis in the contact angle.

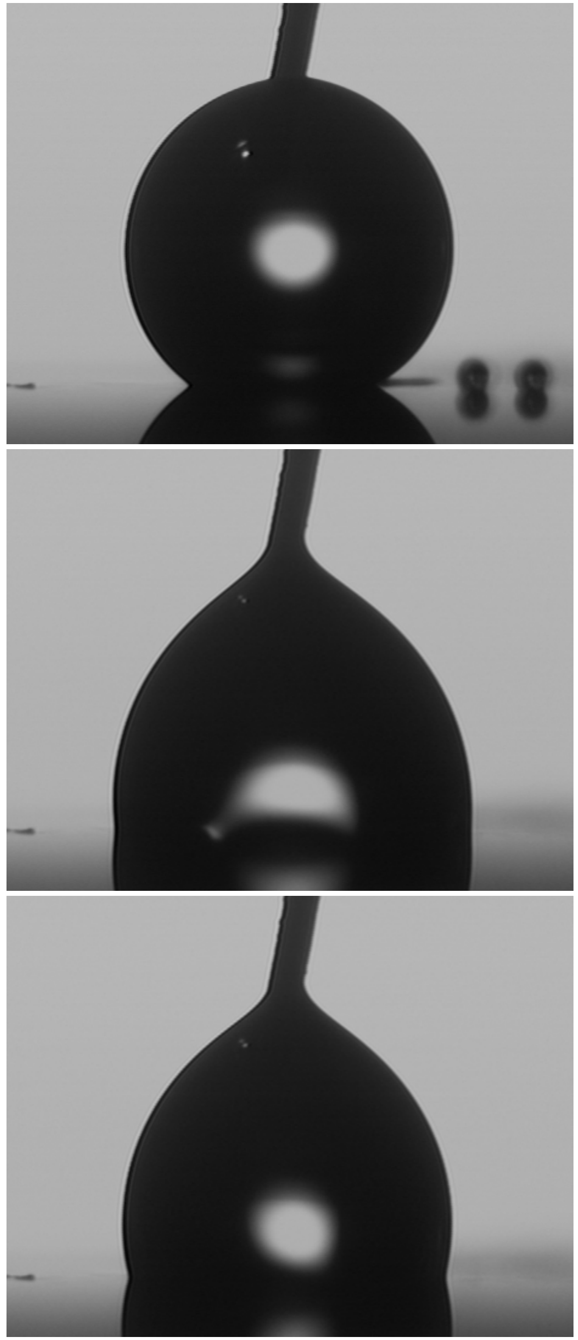
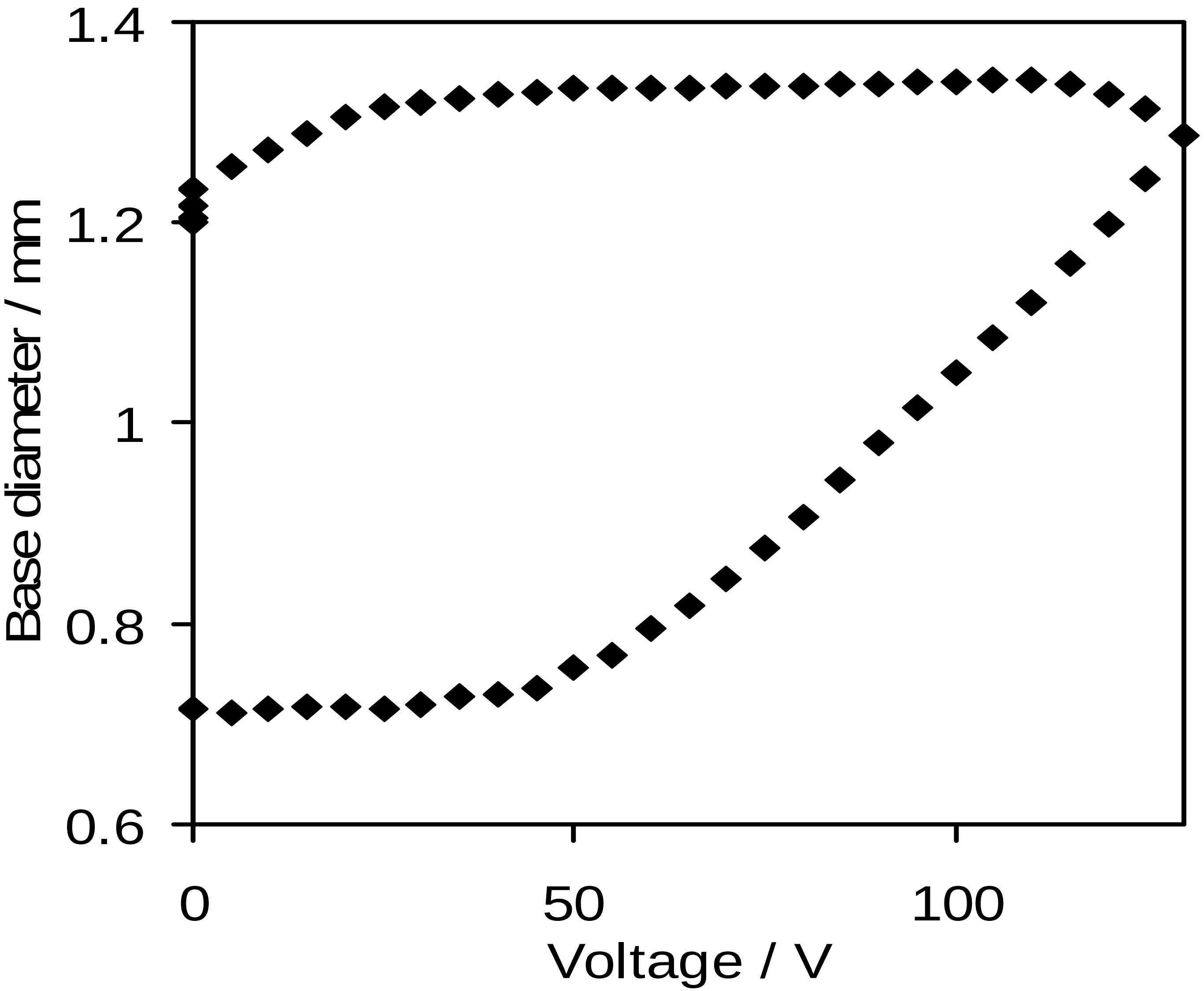


Image of a water drops on a SU-8 patterned surface

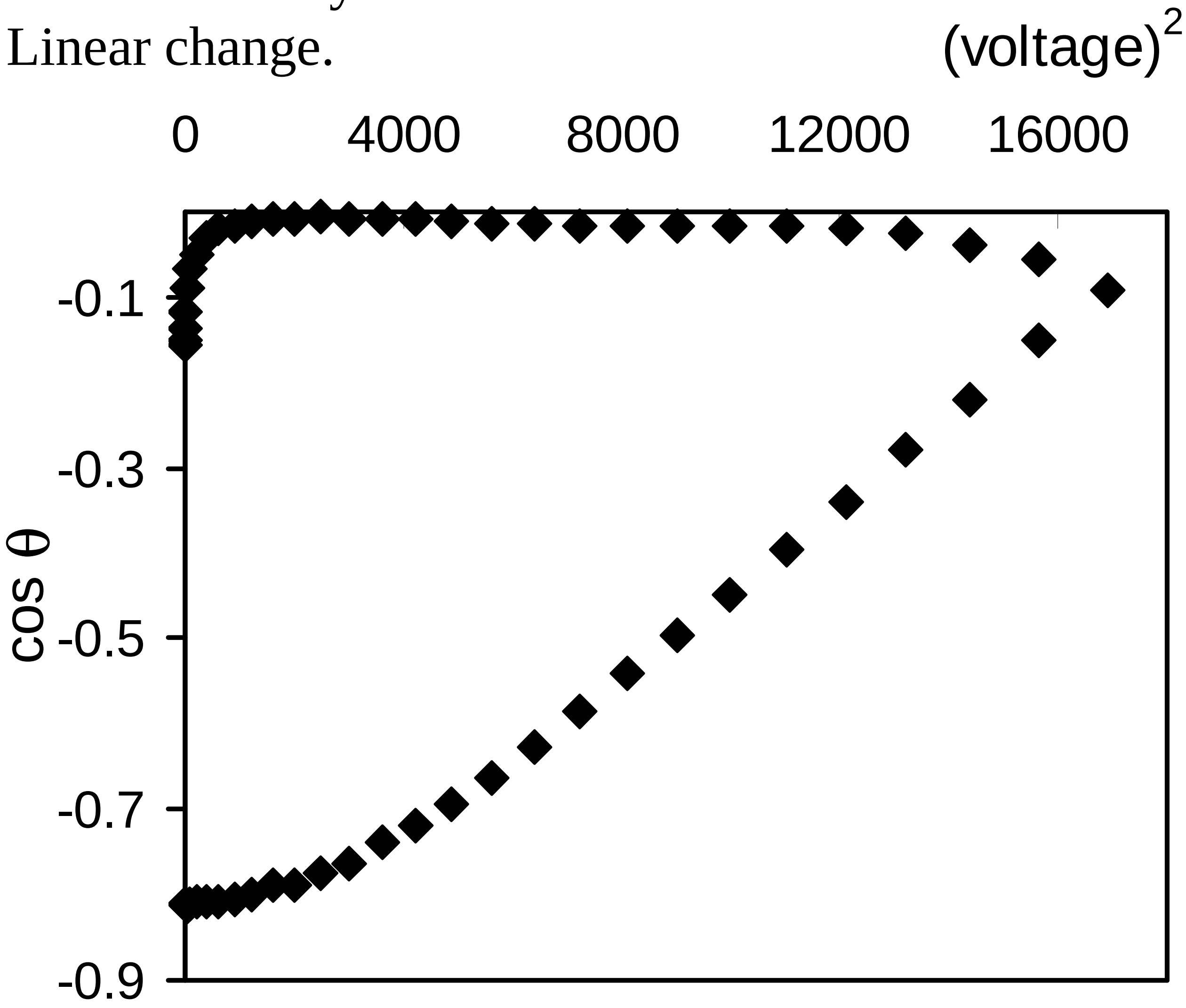
The change in base diameter as a function of applied voltage.
For values of bias up to 45V little change is observed in the base diameter.



- This suggests that under the effect of the applied bias, liquid is being drawn into the pattern and that the drop is changing from the Cassie-Baxter to the Wenzel regime.

- $\cos\theta_r = r \cos\theta_e$

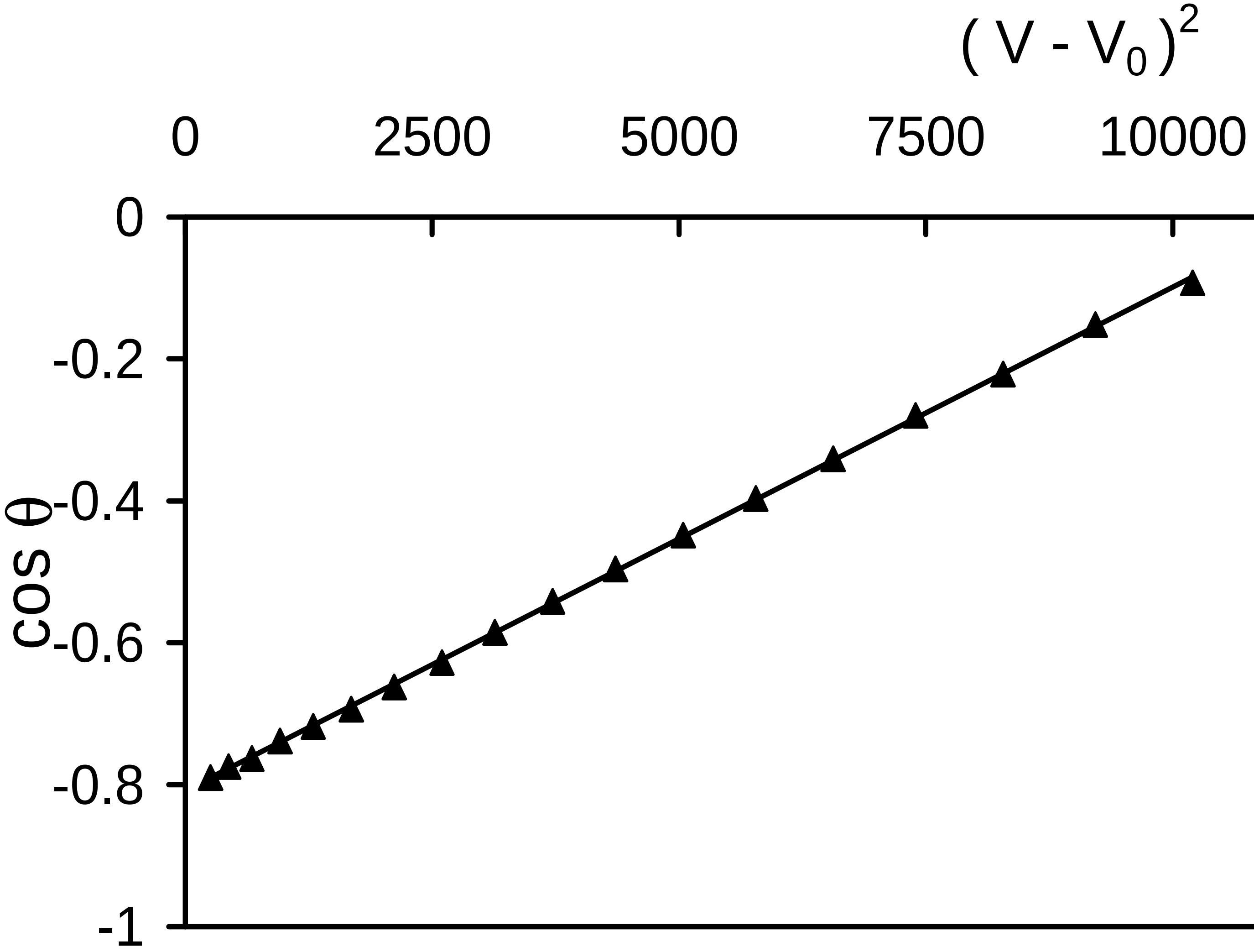
- No reversibility
- Linear change.



The cosine of the contact angle (θ) as a function of the square of the applied voltage (V^2) showing the increasing voltage starting at cos θ = −0.812

- If this is the case then we should expect that the linear region should allow us to predict the roughness factor of the pattern given a known contact angle on a flat surface.

- To take account of the initial bias range where the base diameter is not changing we use a fitting parameter V_0 and plot cosθ as a function of $(V-V_0)^2$ from this the intercept should give the cosine of the Wenzel angle□ θr.



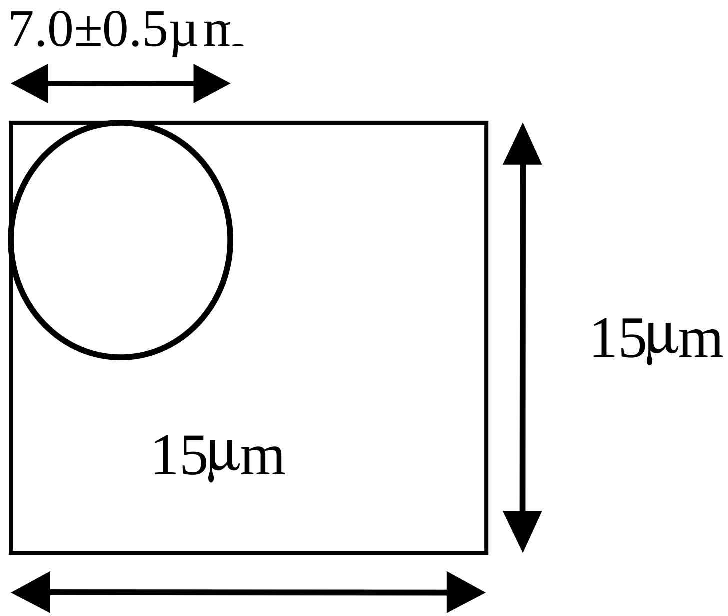
The cosine of the contact angle (θ) as a function of $(V-V_0)^2$ where V is the applied voltage and fitting parameter V_0 = 28 volts.

- From the intercept
  - θr 143.3° ± 0.4°

- Contact angle on a flat surface treated with the Teflon® AF gives
  - θe = 113.9°

- Using Wenzel's equation, this gives a roughness factor of
  - r = 1.92 ± 0.1

- From the model of the pattern and estimated height of 6.5 ± 1.3µm, the roughness factor
  - r = 1.64 ± 0.17



Model for roughness calculation with pillar of height h and diameter d.

The slight difference in these values may be explained from the electron microscope.

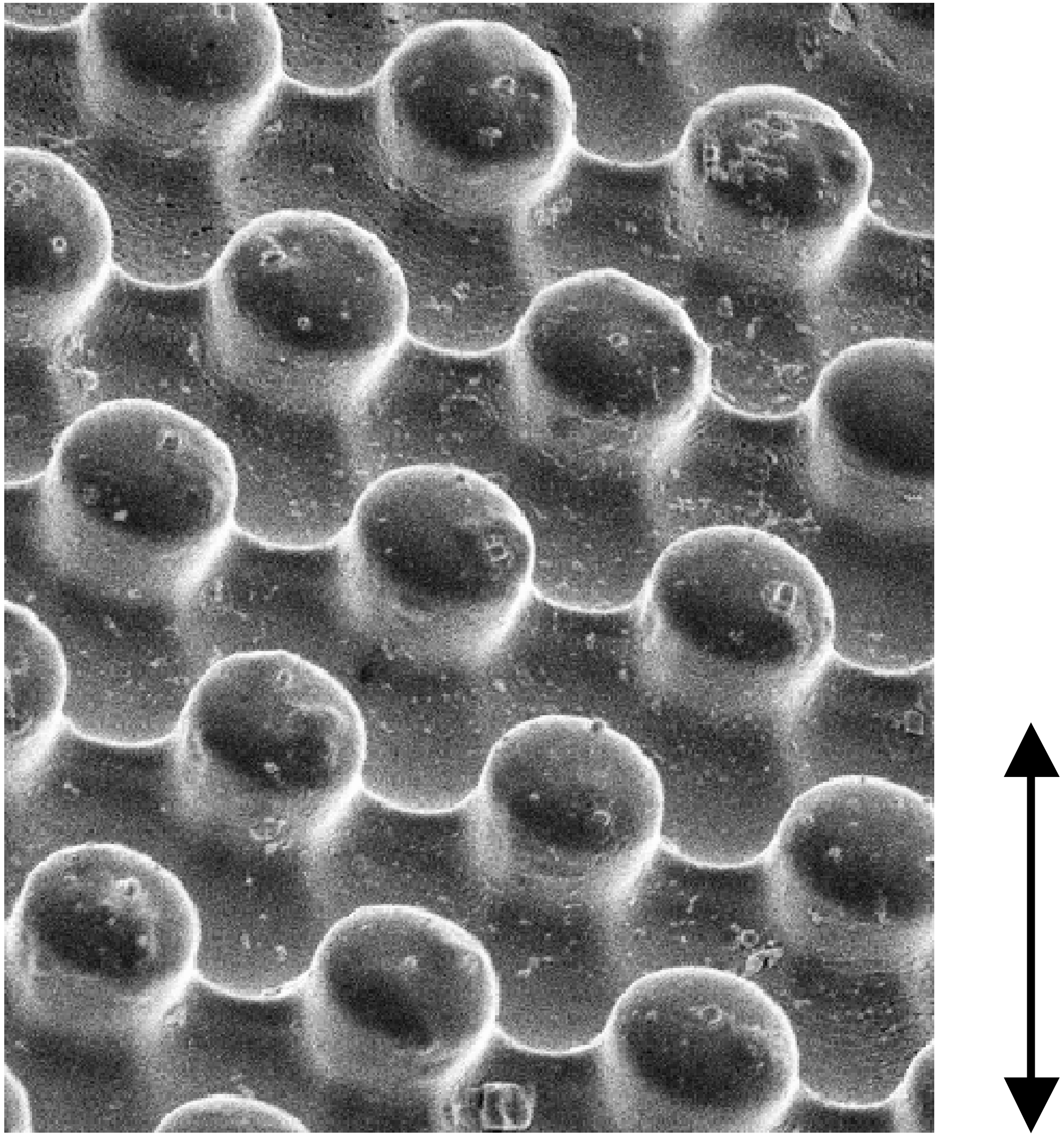


Fig. 6 Scanning electron microscope image of patterned surface with Teflon AF coating.

This clearly shows Teflon® bridges between the pillars.

Extra contribution to the surface roughness.

The arrow in this diagram represents 20μm.

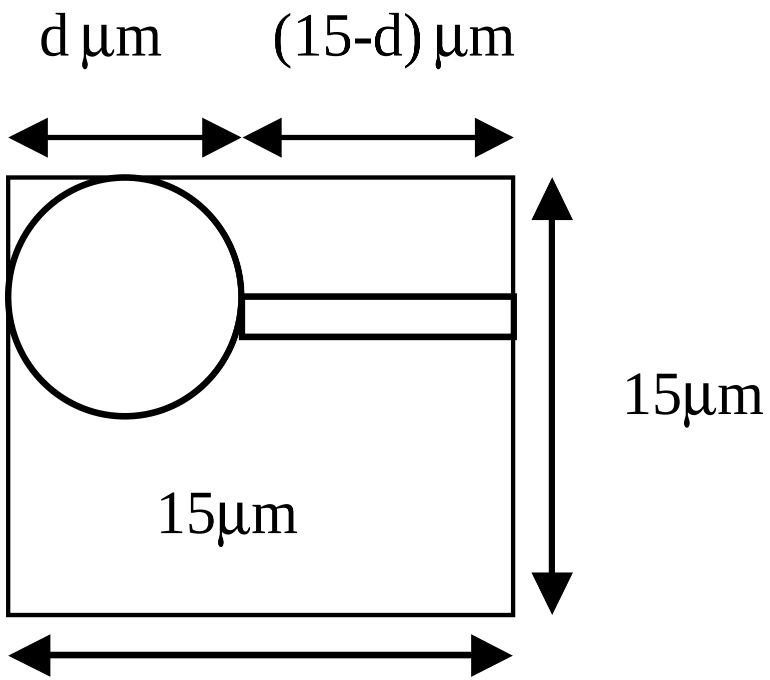


Fig 7. Revised model for roughness calculation with pillar of height h and diameter d and single bridge of height h/2.

- Simple model for the extra surface area introduce.
- If we take the bridge being half the height of the pillar, the new roughness factor becomes
  - $r = 1.87 \pm 0.2$.
- Close agreement with the previous value,
  - $r = 1.92 \pm 0.1$.

Conclusion

Electrowetting on patterned layers of SU8 photoresist with an amorphous Teflon® coating has been observed.

On application of a bias voltage, water is initially drawn into the pattern converting from a Cassie-Baxter to Wenzel regime.

From the intercept of contact angle against voltage squared we can estimate the Wenzel angle and hence deduce an estimate for the surface roughness.

A simple modification to the roughness model to take account of the extra surface area brings the roughness factor in line with the electrowetting data.

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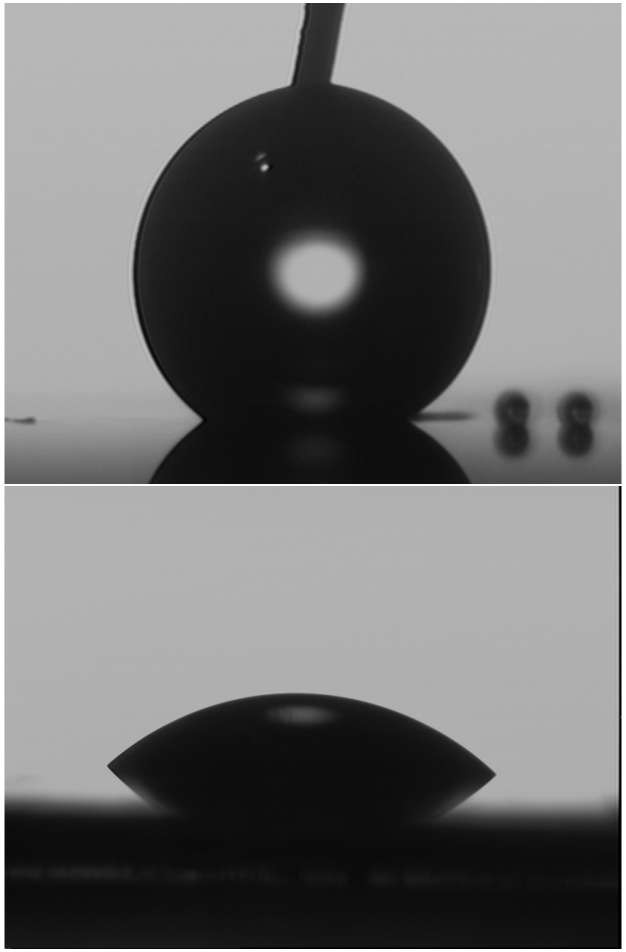
The End



ACKNOWLEDGEMENTS

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