Pinning Effect of Triple Contact Lines at the Edges of Square Pillars of Microstructured Surfaces

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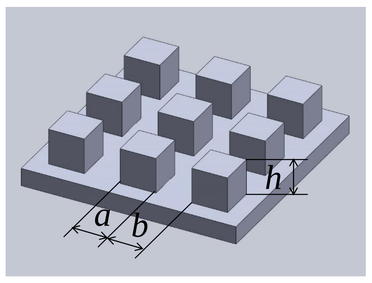
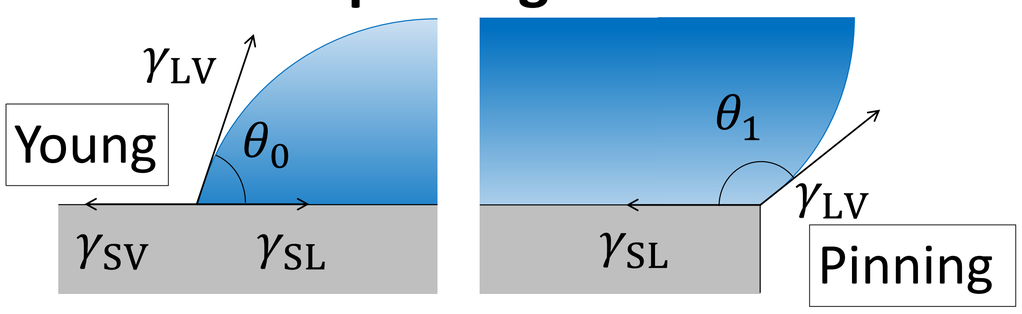
- There are a number of experimental data that agree with neither Cassie–Baxter model nor Wenzel mode.



- It is suggested in some theories that the free energy of bottom interface of a droplet does not affect the apparent contact angle.
- Pinning effect has remarkable influence on the apparent contact angle.

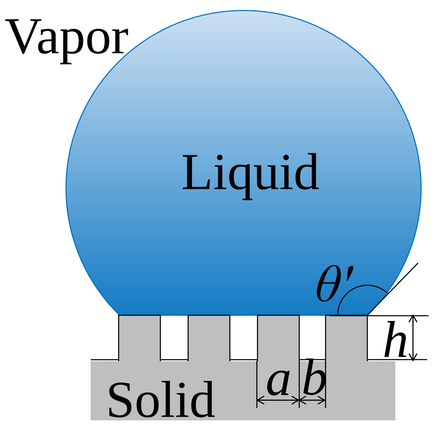
Base model of pinning effect

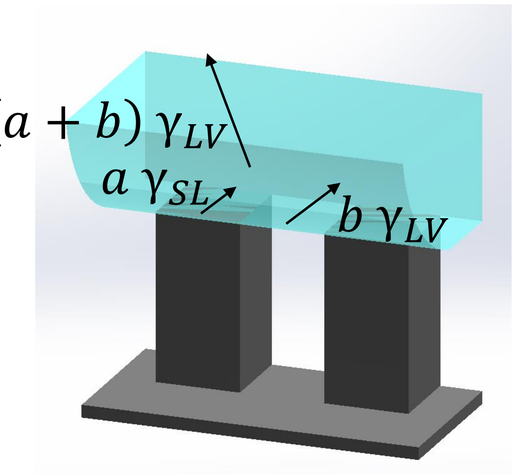


$$\cos\theta_0 = \frac{\gamma_{SV} - \gamma_{SL}}{\gamma_{LV}} \qquad \cos\theta_1 = -\frac{\gamma_{SL}}{\gamma_{LV}}$$

Model for top–edge pinning

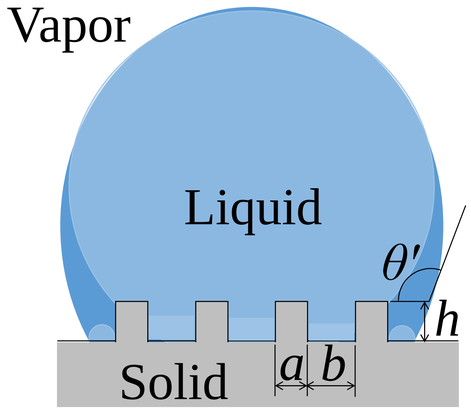
$$\cos\theta' = \frac{a}{a+b}\cos\theta_1 - \frac{b}{a+b} \qquad (1)$$

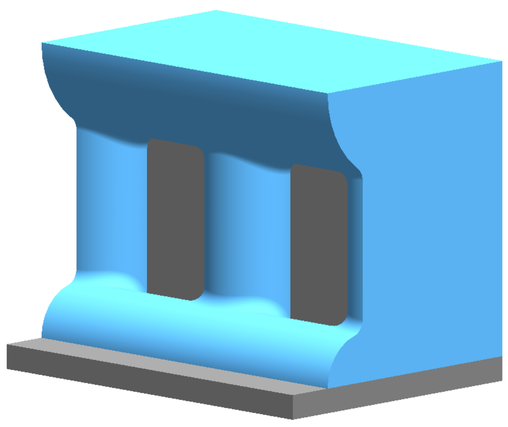




Model for side–edge pinning

$$\cos\theta' = \frac{a+2h}{a+b}\cos\theta_1 + \cos\theta_0 \qquad (2)$$

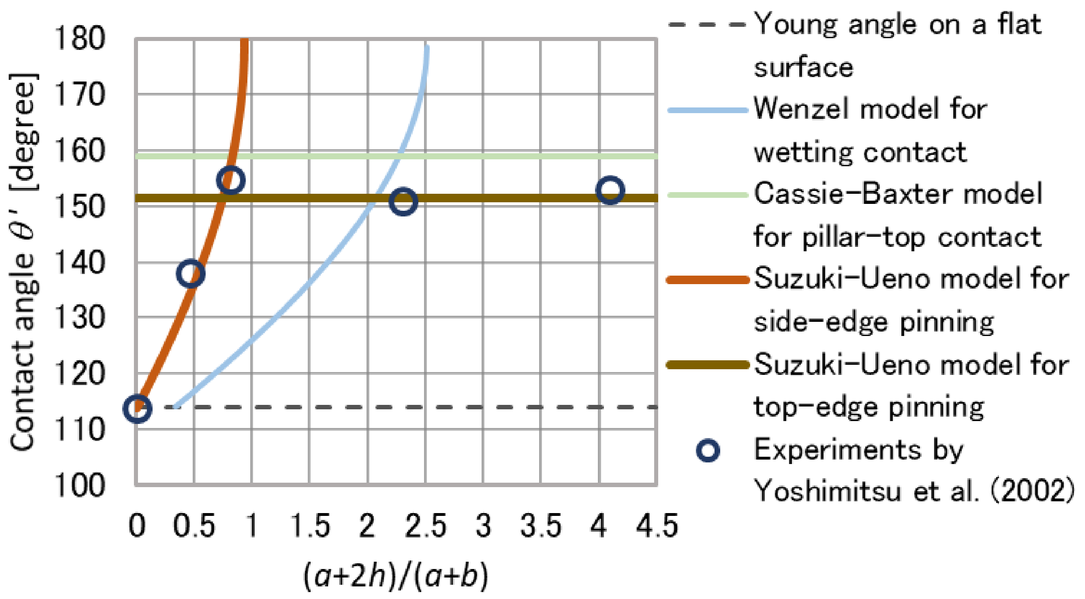




Conclusion

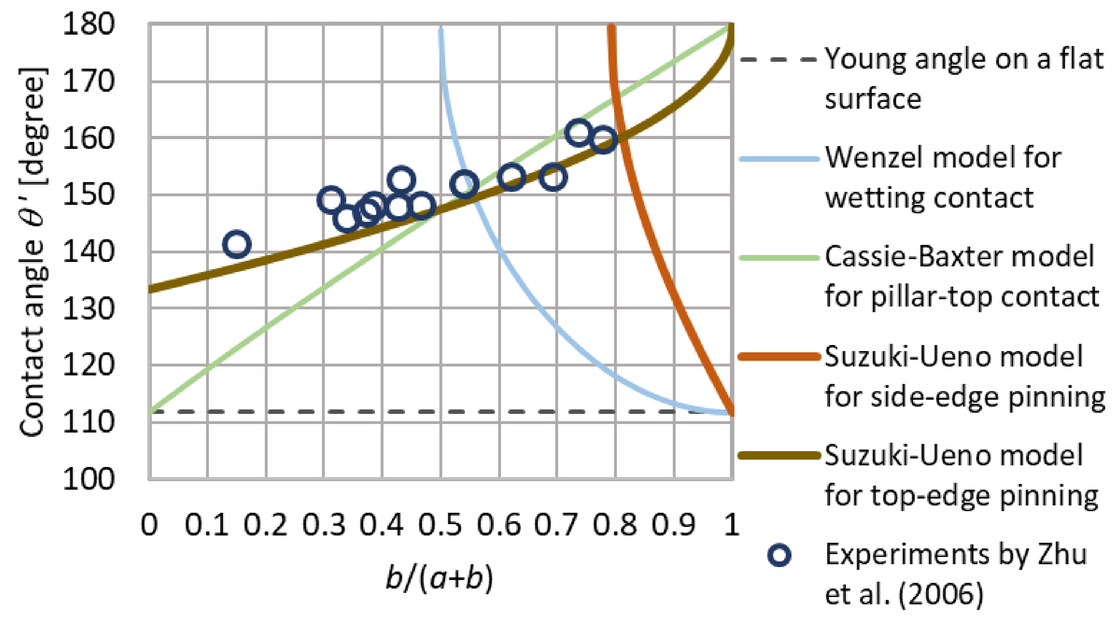
Models for top and side–edge pinning agree reasonably well with experimental values of apparent contact angle of a droplet on microstructured surfaces with square pillars.

Experiments by Yoshimitsu et al. (2002)



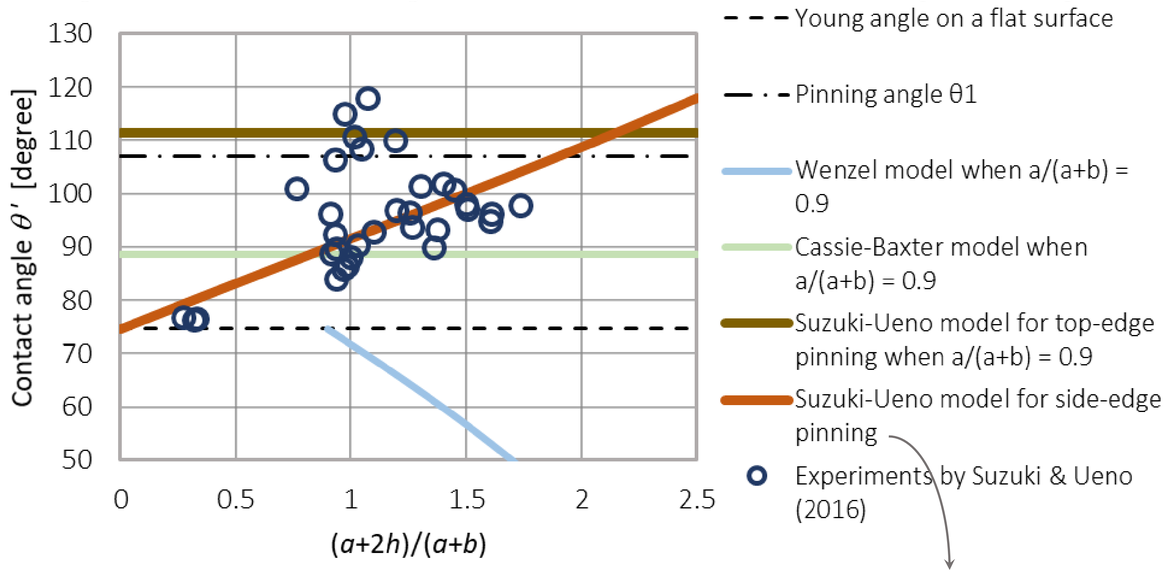
Pillar width $a = 50$ μm, groove width $b = 100$ μm, $\theta_0 = 114°$, $\theta_1 = 129.4°$

Experiments by Zhu et al. (2006)

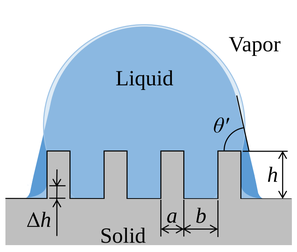


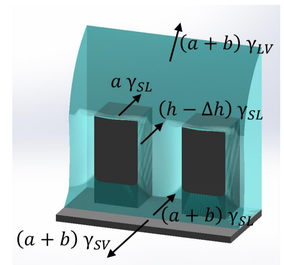
Pillar height $h = 16$ μm, $\theta_0 = 111.8°$, $\theta_1 = 133.3°$

Experiments by Suzuki and Ueno (2016)



Pillar width $a + b = 0.5$–1.0 μm, pillar height $h = 0.01$–0.61 μm, $a/(a+b) = 0.21$–0.92, $\theta_0 = 74.7°$, $\theta_1 = 107.1°$





[1] S. Suzuki and K. Ueno, *Langmuir* **33**, 138-143 (2016).
[2] Z. Yoshimitsu, A. Nakajima, T. Watanabe and K. Hashimoto, *Langmuir* **18**, 5818-5822 (2002).
[3] L. Zhu, Y. Feng, X. Ye and Z. Zhou, *Sensors and Actuators* **130**, 59-600 (2006).