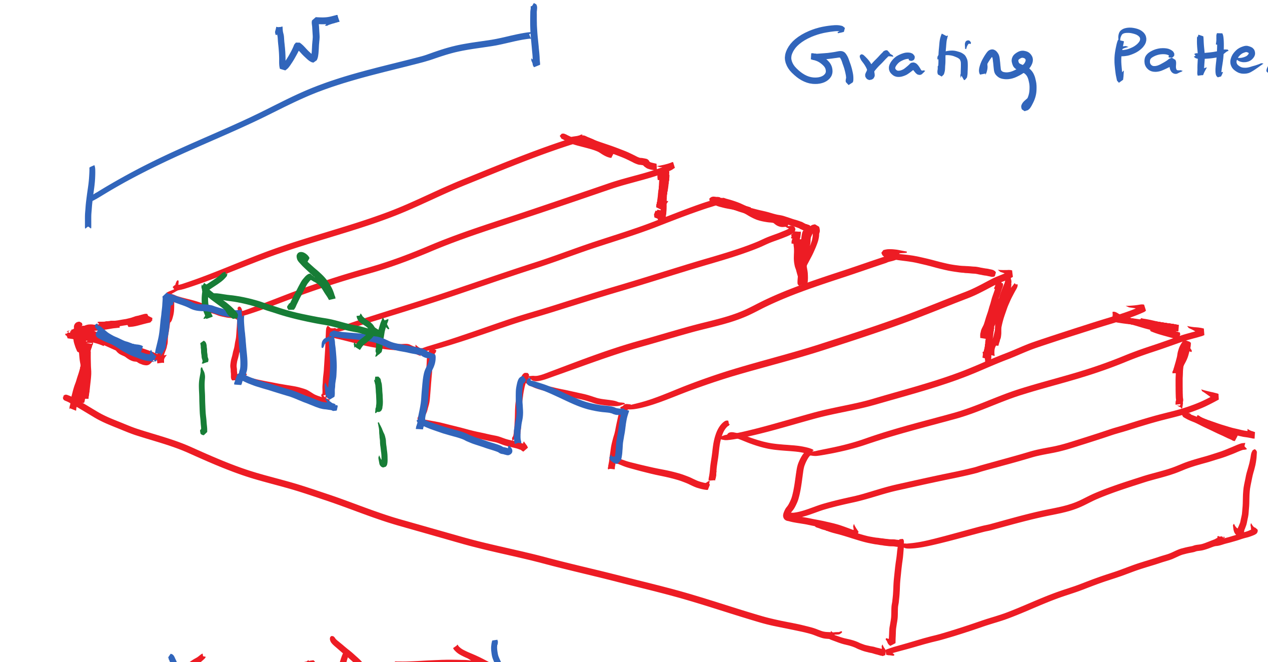
Topographic Patterns

03.02.2022

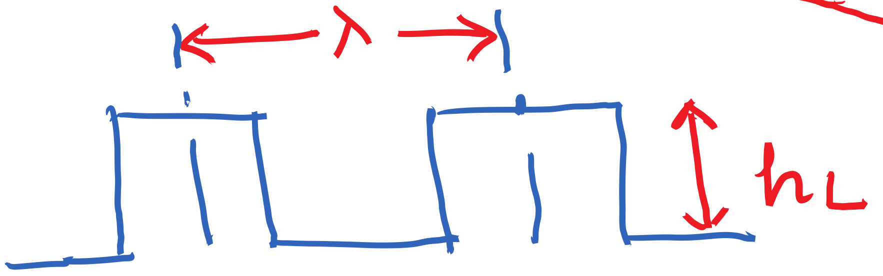
Lecture - 11

Grating Patterned Surface

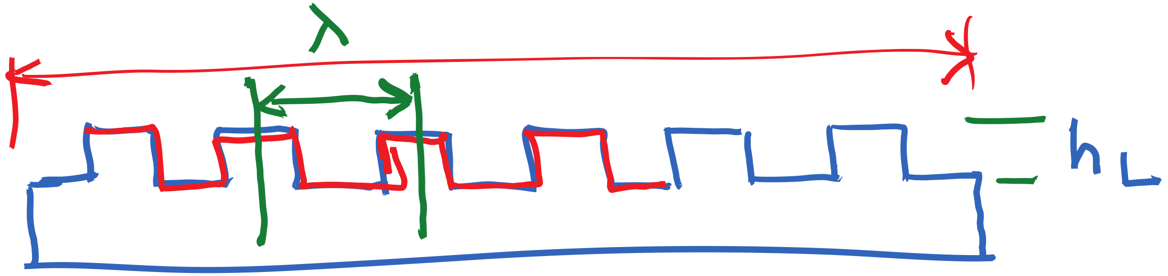


Line and Grating -

Optical Grating.

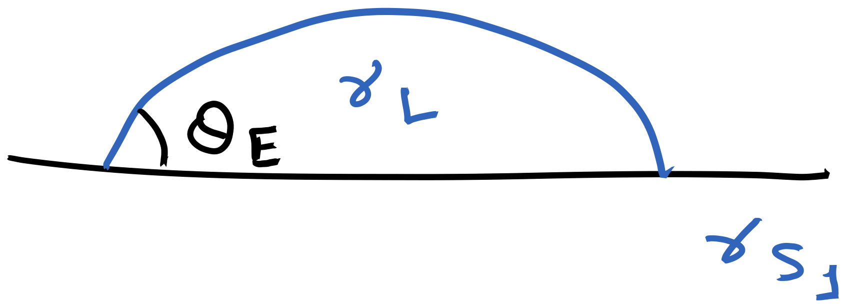


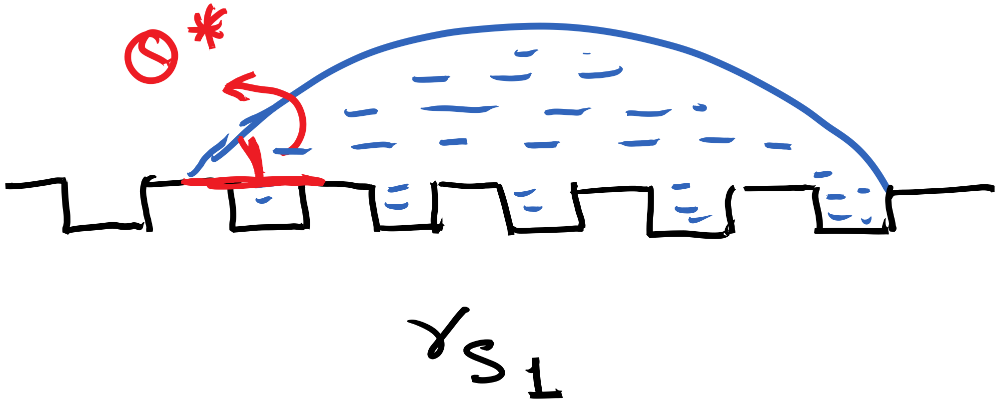
A liquid Drop on a Topographically Patterned Surface



$$r_f = \frac{\lambda + 2h_L}{\lambda}$$

WENSEL STATE OF WETTING





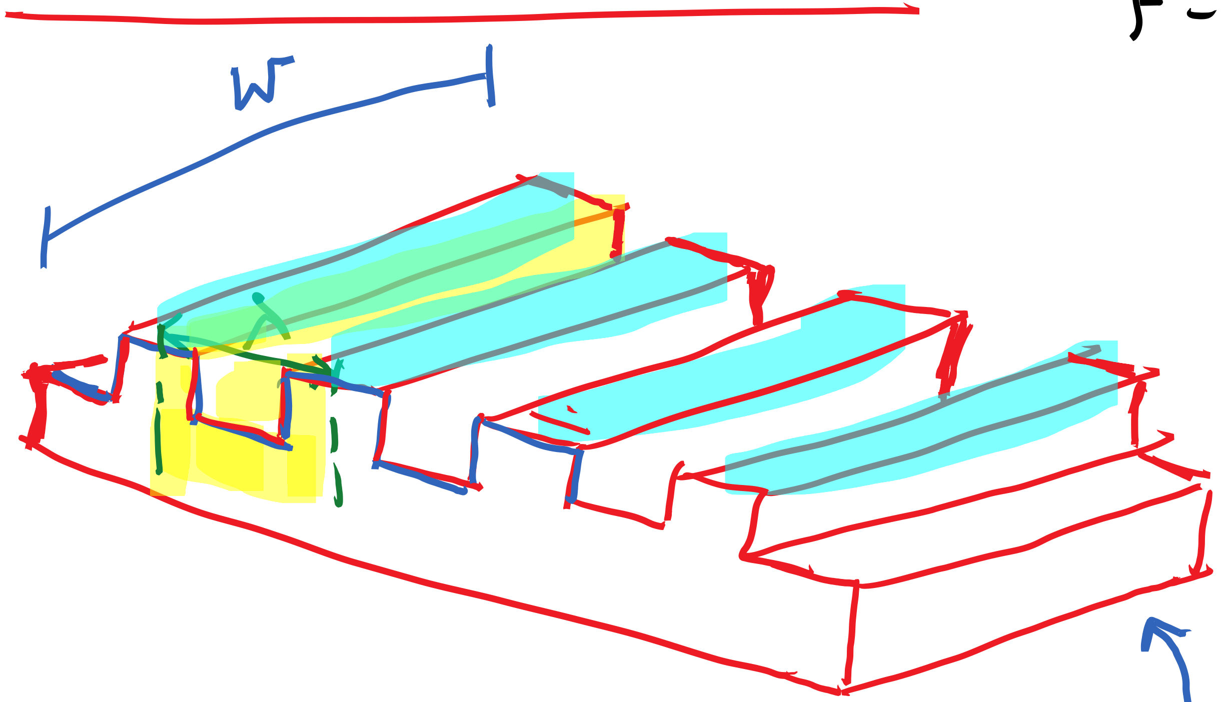
(1) γ_L and γ_S are same

θ^* is different than θ_E

$$\boxed{\cos\theta^* = r_f \cdot \cos\theta_E}$$

r_f = Line Roughness

$$= \frac{\text{Wetted area}}{\text{Projected area}} = \frac{\text{Wetted Perimeter}}{\text{Project Perimeter}}.$$

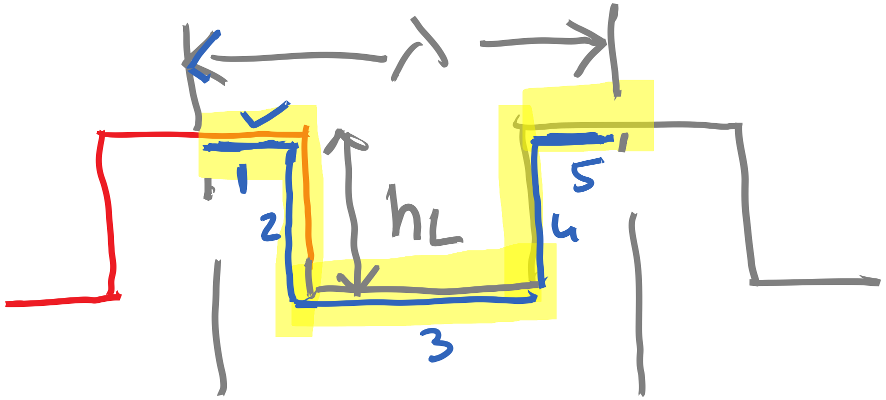


$$\gamma_f = \text{Line Roughness}$$

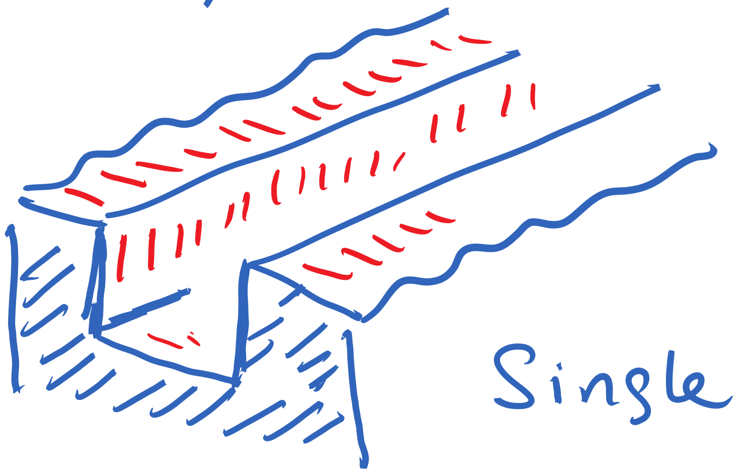
$$= \frac{\text{Wetted Area}}{\text{Projected Area}}$$

$$= \frac{(\lambda + 2h_L)\cancel{W}\cancel{n}}{(\lambda \cdot \cancel{W} \cdot \cancel{n})} = \frac{\lambda + 2h_L}{\lambda}$$

Keep n such features Side by Side → You get the surface.



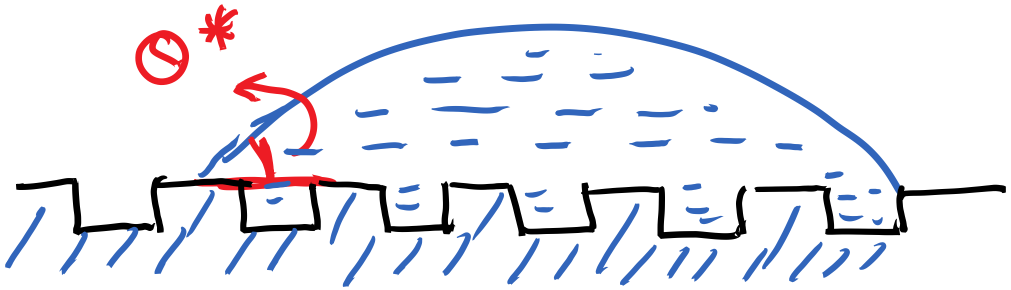
$\Rightarrow (\lambda + 2h_L)\, W$



Single Feature

Wetted Area for this Single Feature

WENSEL STATE OF WETTING

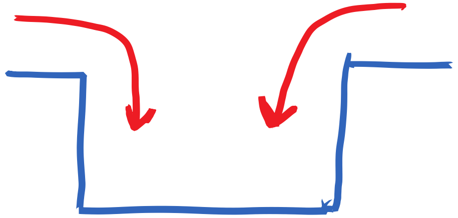


$\theta^* \rightarrow$ Effective Contact Angle

$$\boxed{\cos\theta^* = \gamma_f \cdot \cos\theta_E}$$

$$\gamma_f = \frac{\lambda + 2h_L}{\lambda}$$

Liquid Enters within the features



$$\gamma_f > 1$$

① $\theta_E < 90^\circ$

$$(\gamma_f \cdot \cos\theta_E) > (\cos\theta_E)$$

$\cos\theta^* > \cos\theta \rightarrow \theta^* < \theta_E$

② $\theta_E > 90^\circ \rightarrow \theta^* > \theta_E$

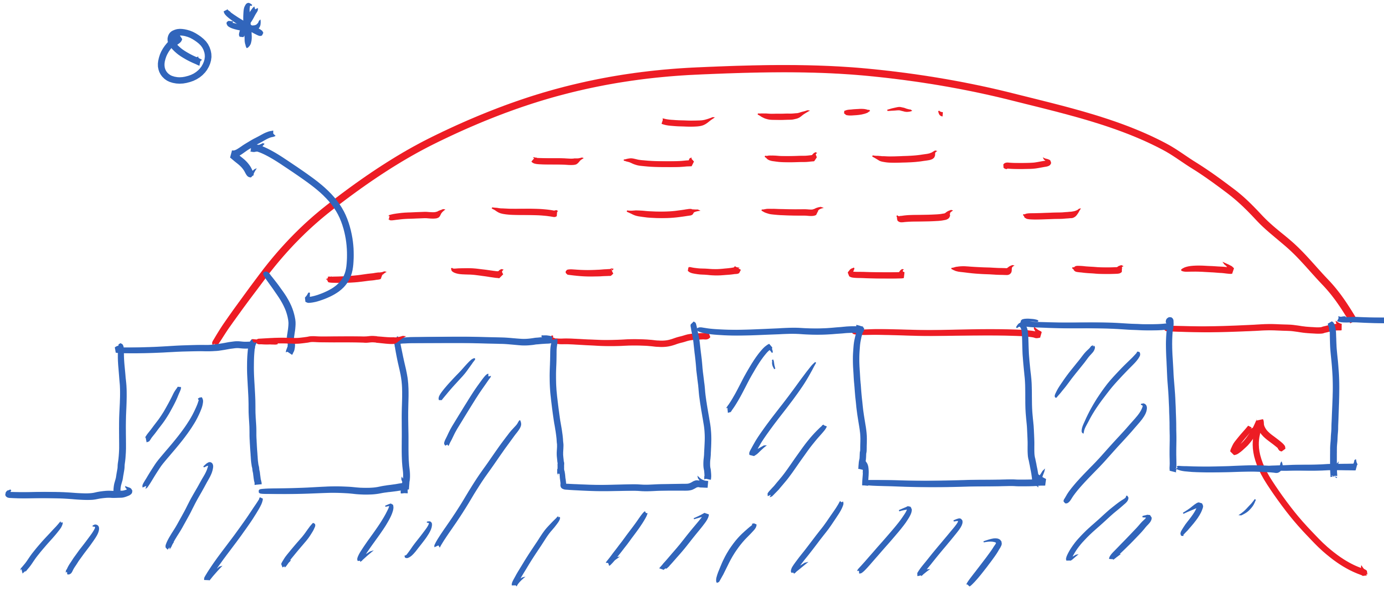
Surface 1: 88°

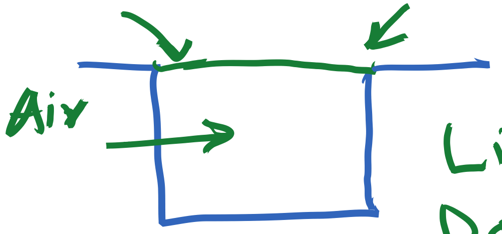
Surface 2: 92°

(Difference amplified when patterned) $\Rightarrow$

CASSE STATE OF WETTING

Liquid does not penetrate within the grooves.



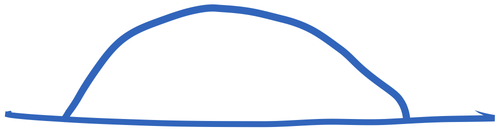


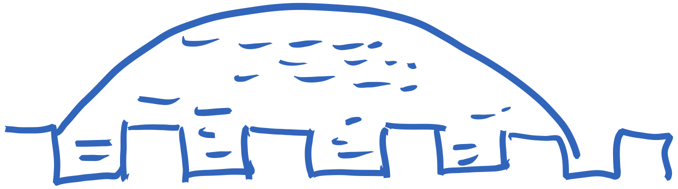
Liquid DOES NOT ENTER within the features

Entrapped Air. (Below the liquid)

Liquid Fails to remove the air within the features

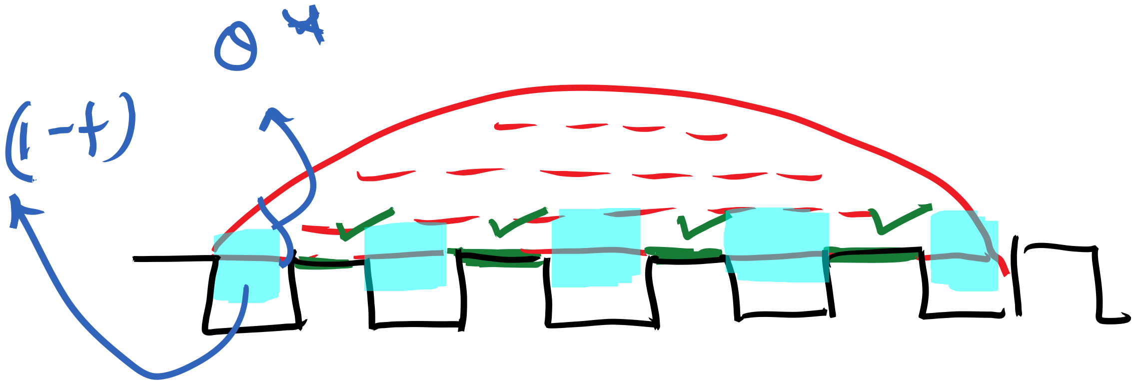
Composite Contact Area: Comprising of S-L and Solid-Air Interfaces





Solid-Liquid Contact

Area below the liquid Had complete



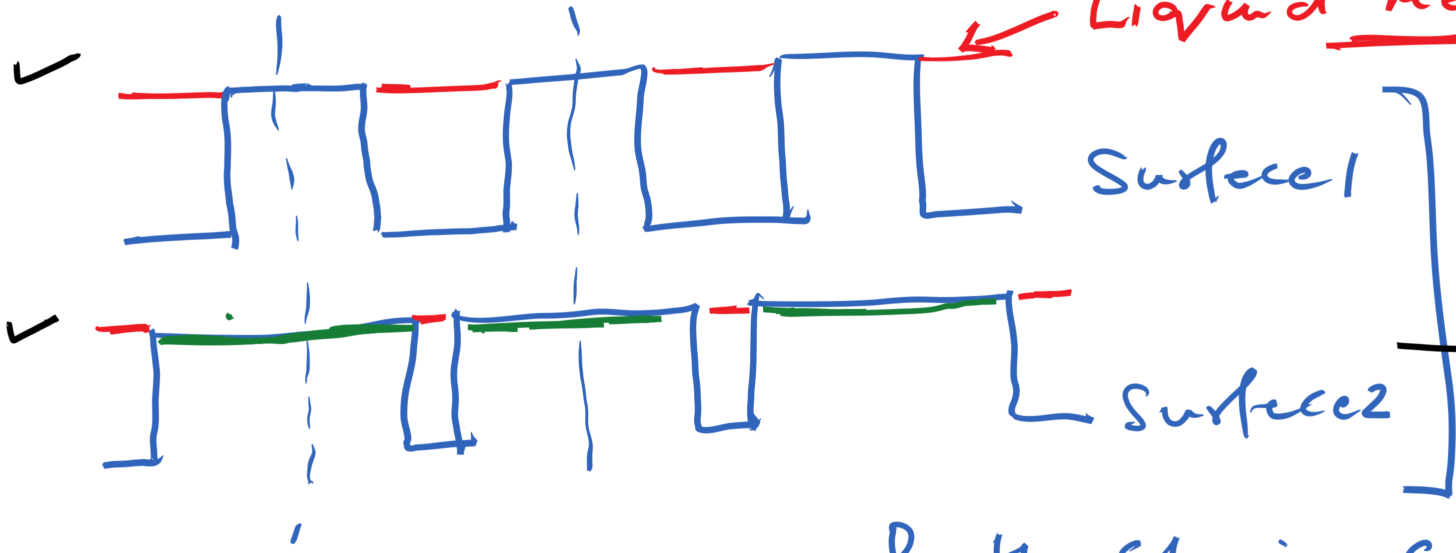
$$\cos\theta^* = r_f \cdot f \cdot \cos\theta_E - (1-f)$$

r_f → Same Line roughness as Wenzel state

$\boxed{f}$ = Ratio of Flat Projection of Solid-liquid Contact area to the total Flat Geometrical area (Projected Area) under the drop.

f → Fraction of Liquid-Solid Contact

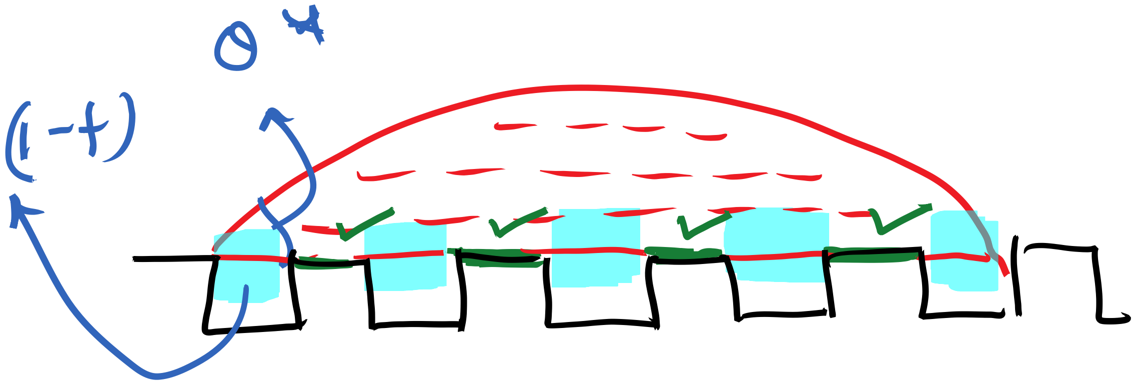
$(1-f)$ →



① Wider Line, narrower grooves.

② Line Tops Come in Contact with Liquid Only.

Both showing Cassie



$$\cos\theta^* = \underbrace{\gamma_f \cdot f \cdot \cos\theta_E}_{\text{Term 1}} - \underbrace{(1-f)}_{\text{Term 2}}$$

$\gamma_f \rightarrow$ Same Line roughness as Wenzel state

$\theta_E < 90^\circ$

$\gamma_f > 1$

$f < 1$

$$\underbrace{\gamma_f \cdot f \cdot \cos\theta_E}_{\text{Term 1}} \rightarrow \text{Higher or Lower than } \cos\theta_E.$$

$(\gamma_f \cdot f) > 1$, Term 1 is trying to reduce θ^* than θ_E

$(\gamma_f \cdot f) < 1 \rightarrow$ trying to increase θ^* than θ_E

$(1-f) > 0$

Depending on the actual geometry It may be possible to achieve effective Hydrophobicity on a Hydrophilic surface, If wetting state is Cassie.