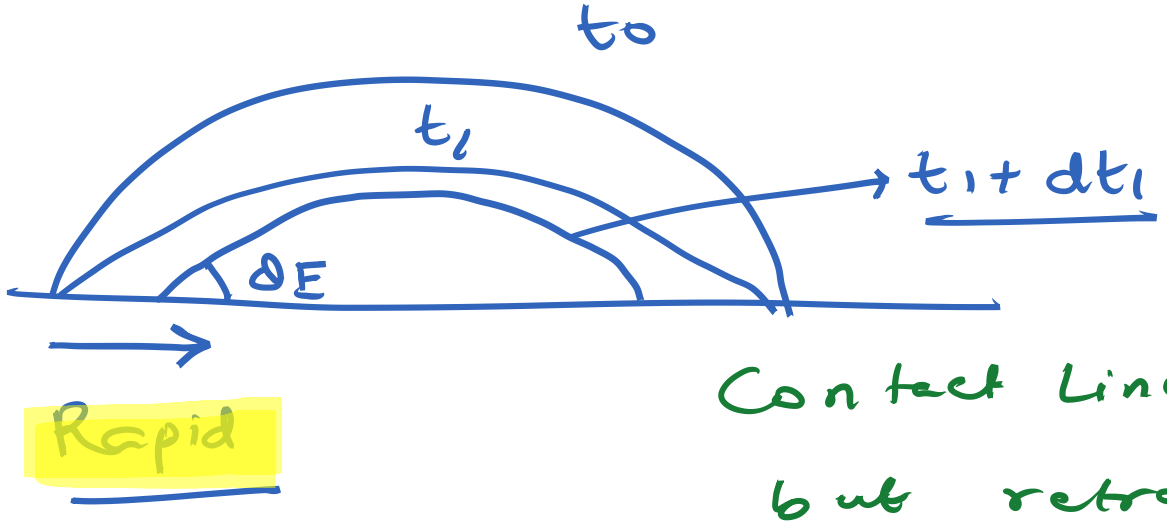
Ininitially Pinned → followed by rapid retraction.

→ till $\theta_i \approx \theta_E$ again → Again Pinning → Followed by Rapid retraction.

Mixed Mode of Evaporation



Sequential Pinning and depinning →

Contact Line is not retracting uniformly but retracts in bursts.

Motion of the Contact Line → Stick Slip Motion

↓ When it is pinned

↳ Rapid retraction

Evap of a Pure Liquid →

There will be nothing.

02.02.2022

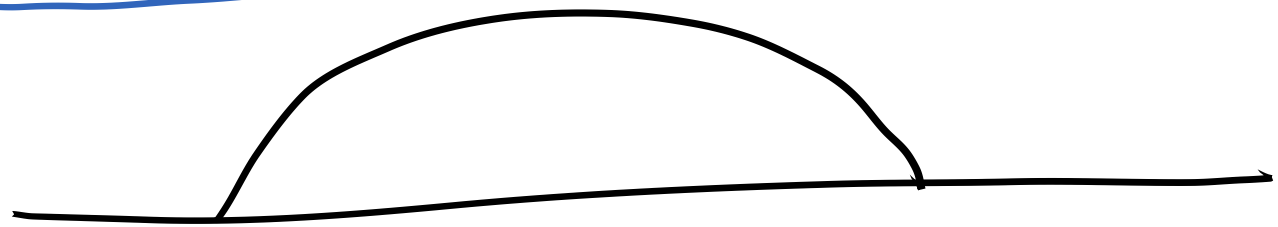
2.2.22

Lecture 10

Drop of a Solution → Solution or → Dispersion (Colloidal Dispersion)

*→ Liquid (Solvent) will evaporate, Solute will NOT evaporate.

Most Real Surfaces Exhibit Some Pinning.



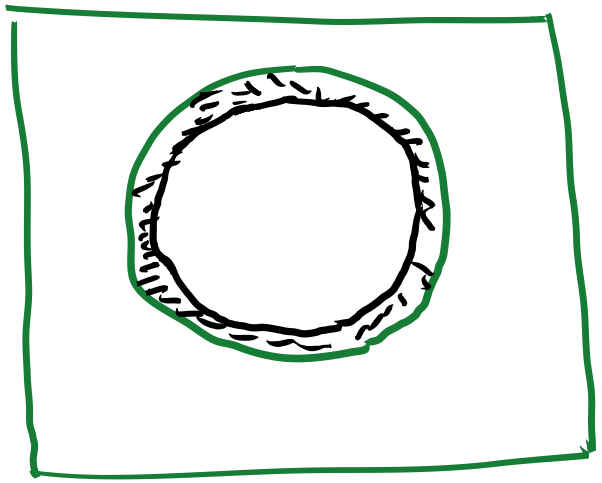
Coffee stain / Coffee Ring Effect

Deposited Solute

Along the Edges

1997

Deegan "Nature"



✓ (1) Uniform Deposition

(2) 

More deposition towards the centre

(3) 

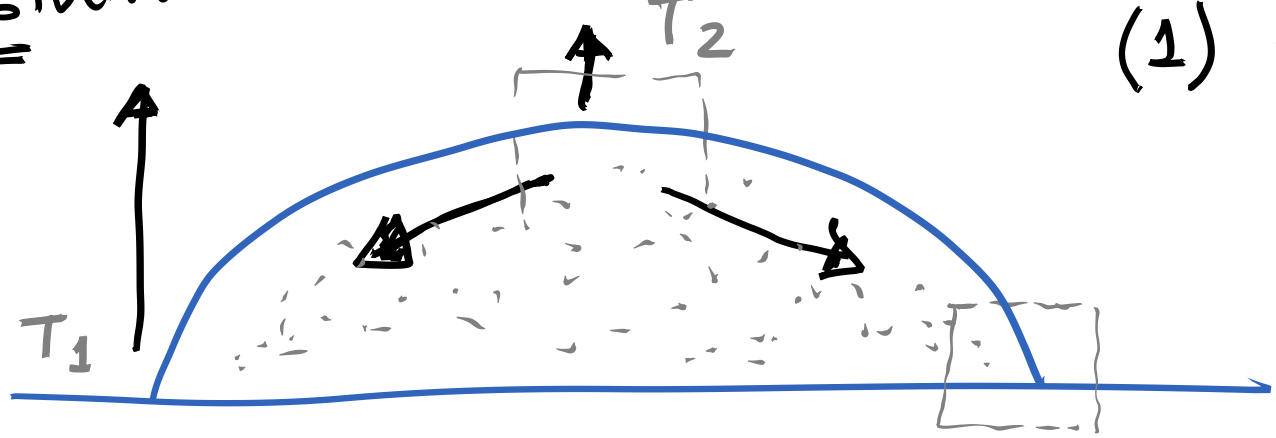
CCA mode → More of an ideal Situation
(Zero pinning)

∴ Most practical/real Surfaces → Mixed mode/CCR mode.

There is more loss of solvent

① $T_1 < T_2$

② Solute Rich Zone



Drop has a Curvature

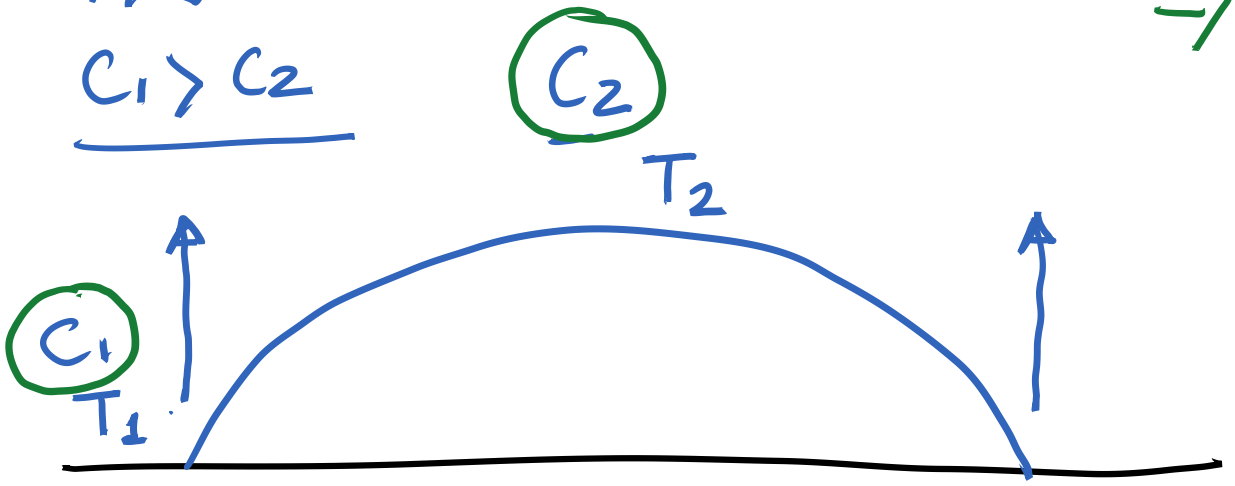
(1) Rate of Evaporation is higher along the periphery, than bulk

① As there is more loss of Solvent → Convective Flow is set up within the drop → (Solvent Replinishment).

② As evap more from edge → Temp drops more at the edge.

$T_1 < T_2$

$C_1 > C_2$



$\Rightarrow$

Solution →

1) Solute is dissolved in the solvent

2) When does the solute deposition on the surface → start ?

→ When the intrinsic Solute Conc. ≈ Saturation Concentration. (C_s)

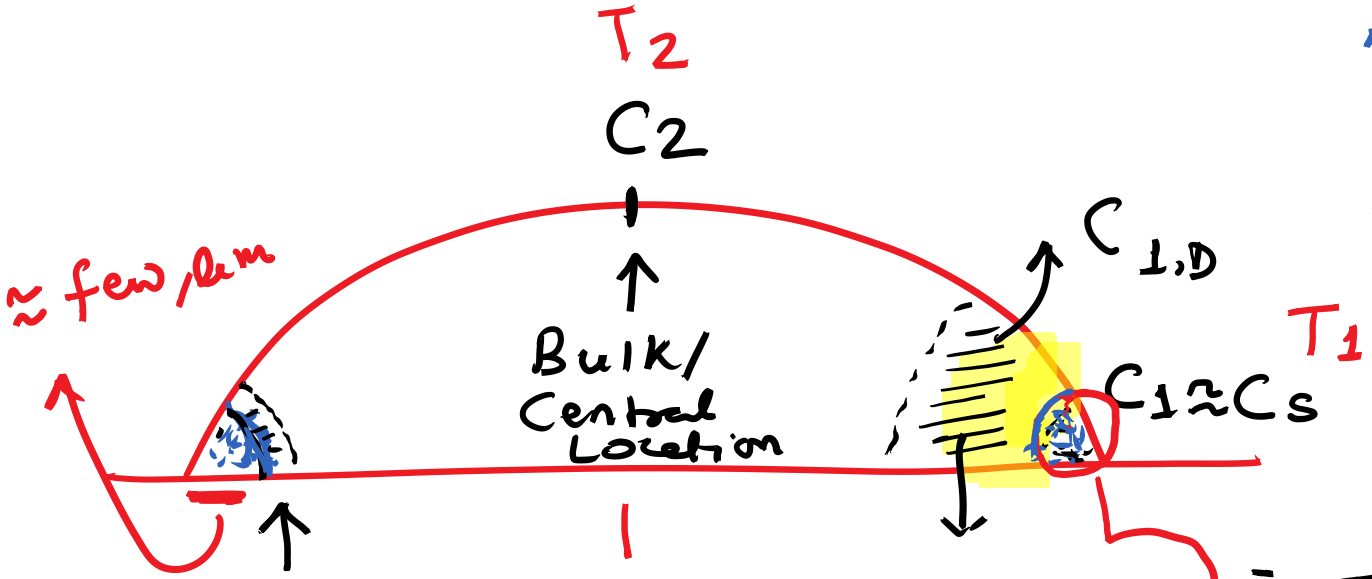
(1) There is initial pinning.

(2) Rate of Evaporation at the edge is higher than the bulk.

(3) Local Solute Conc. at the edge is higher.

(4) As rate of solvent Evap at the edge is higher, The local Temp at the Edge is lower.

(5) Local Conc. at the periphery attains C_s, while it is not attained at the bulk.



Along the periphery, the Solute attains saturation faster →

Depletion Zone.

Depletion Zone

$T_1 < T_2$

$C_{1D} < C_2$

$\gamma_{Edge} \neq \gamma_{Bulk}$

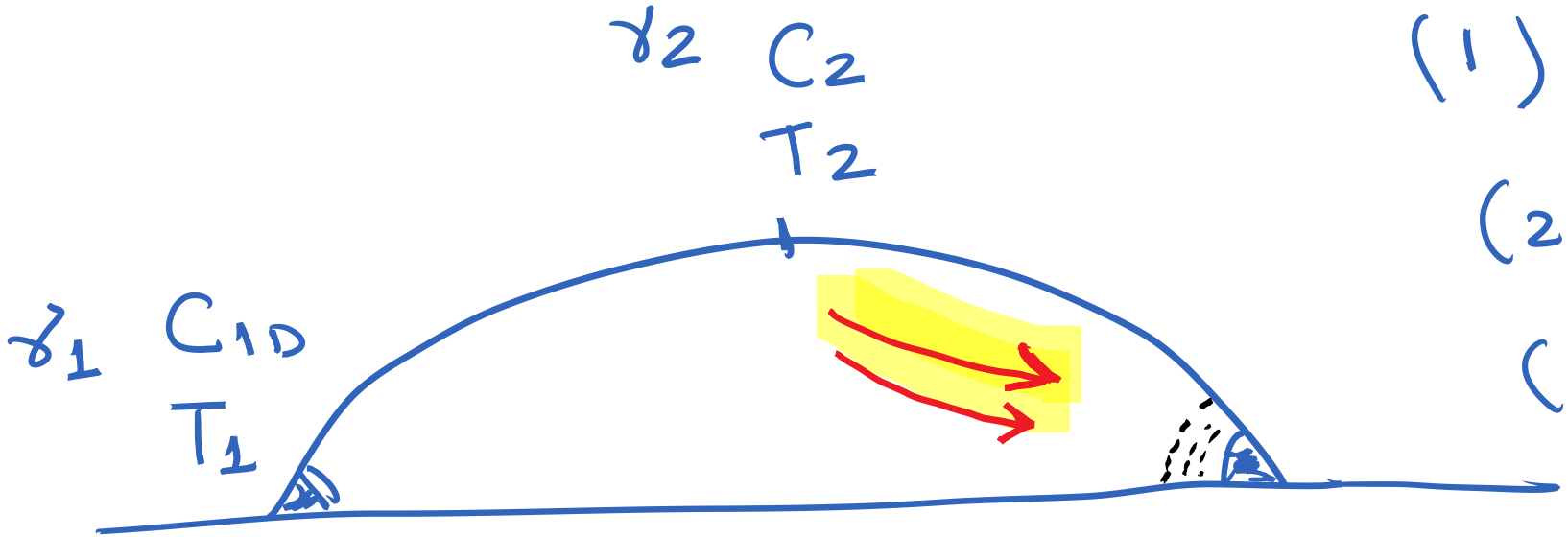
Now that there is Deposition Zone around the droplet → This deposition helps further in pinning of the Contact line.

(2) As the periphery has higher amount of Solute deposition as comp to bulk.

Local Surface Tension?

Central Part
Surface Tension $\approx \gamma_L$

Ridge → Surface tension $\approx \gamma_S$



(1) $T_1 < T_2$

(2) $C_{1D} < C_2$

(3) $\gamma_1 \neq \gamma_2$

(4) Pinning Favored.

$\Rightarrow$ Flow due to Surface Tension Gradient $\rightarrow$ Marangoni Flow.

Flow from The bulk to the periphery

✓ (1) Temp gradient Induced convection.

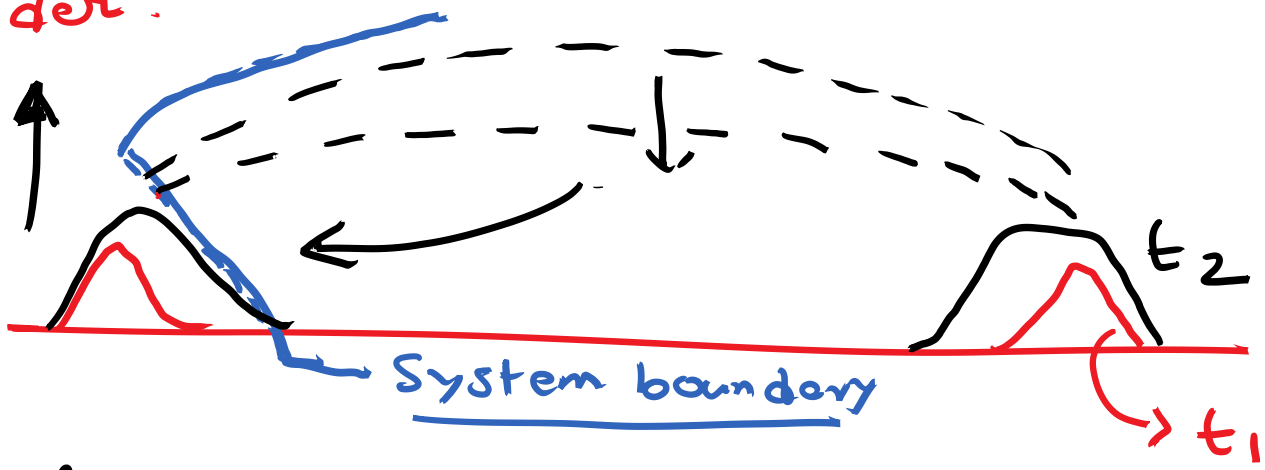
✓ (2) Conc. gradient Induced Diffusion.

(3) Might be Supported by Surface Tension Gradient also. (Depends on relative value of γs.

Direction of Marangoni Flow:

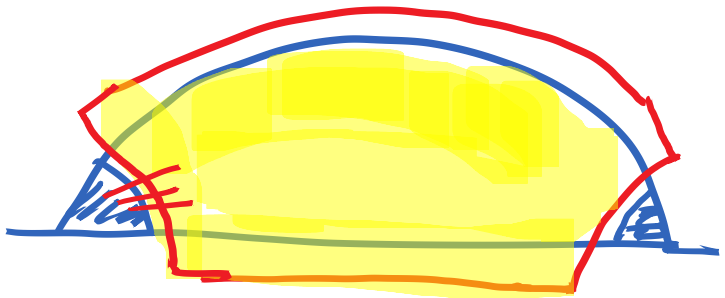
$\gamma_{low} \rightarrow$ High γ.

As a consequence, the ring becomes thicker and wider.

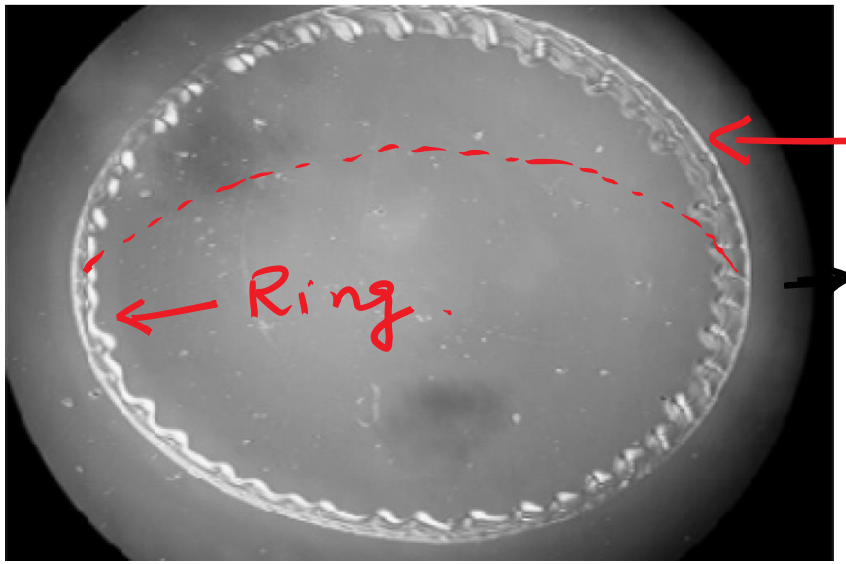


With time → Widening of the rings

Essentially from Evaporation stand point, Such drops Evaporate in the CCR mode.



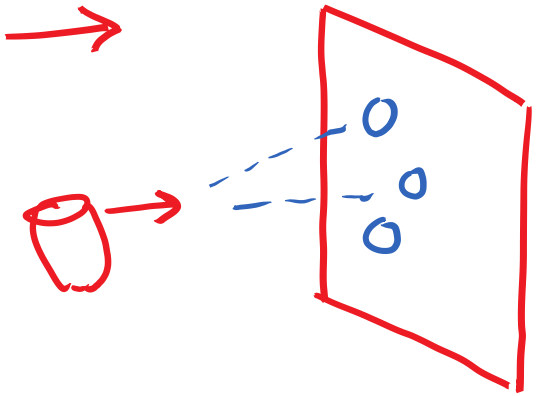
Deposited Solute Ring has entrapped Liquid?

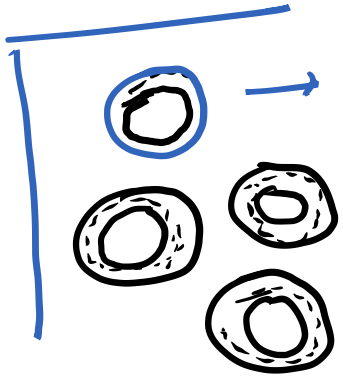


Ring deposit

Is it desirable?

Spray Painting →





Droplets hits the Surface →

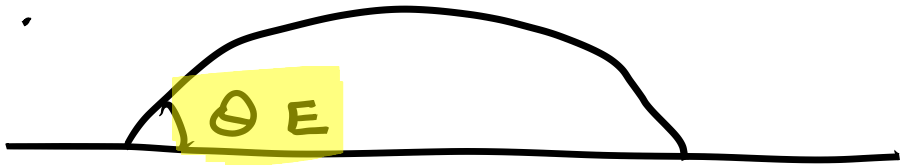
↓

Coffee Ring Deposition is NOT desirable.

⇒ There is Significant Research on Suppressing Coffee Ring Formation.

⇒ Strategy ? ⇒ Modulate the Surface Tension.

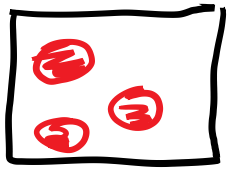
⇒ | Marangoni flow | VS | Convective Diffusive Flow |



Young's Configuration
(Flat Surface)

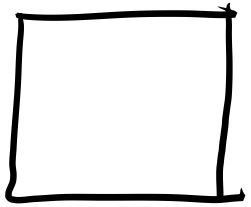
Patterned Surface →

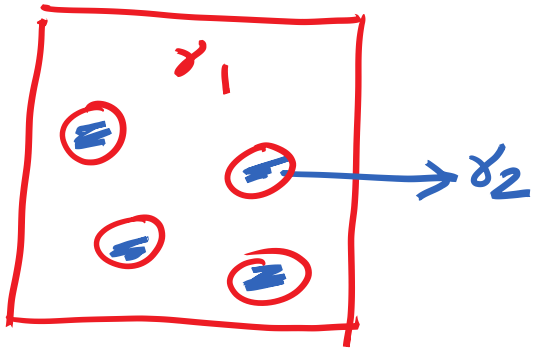
Chemical Patterns



Smooth Surface Where there are diff. Chemical Domains

Physical or Topographic Patterns.





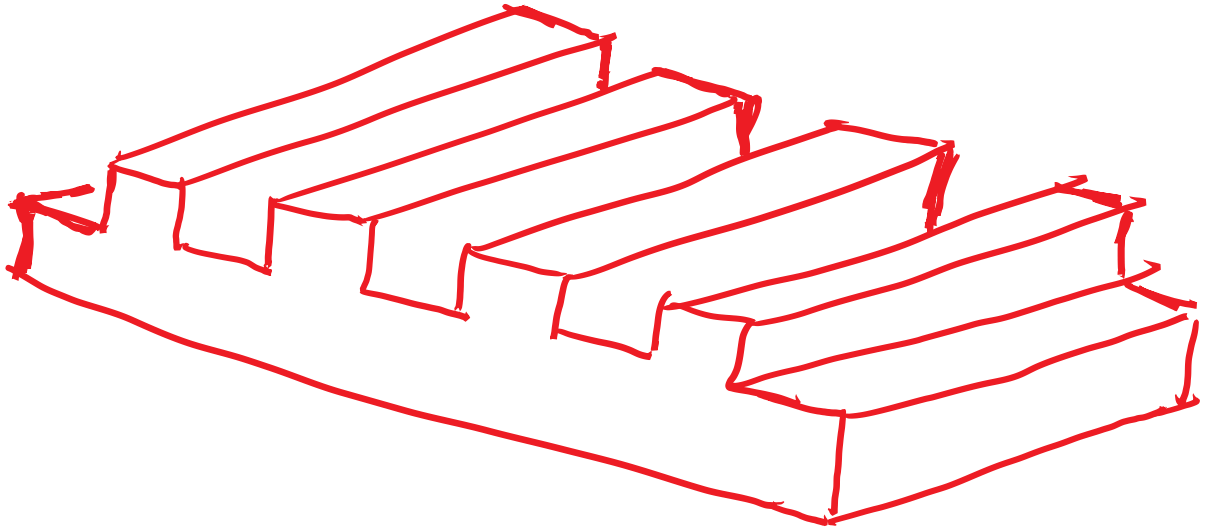
Different Wettability Domains.

Ruled Sheet

Check Board

Topographic Patterns

Grating Patterned Surface



Line and Grating -

Optical Grating.

A liquid Drop on a Topographically Patterned Surface