

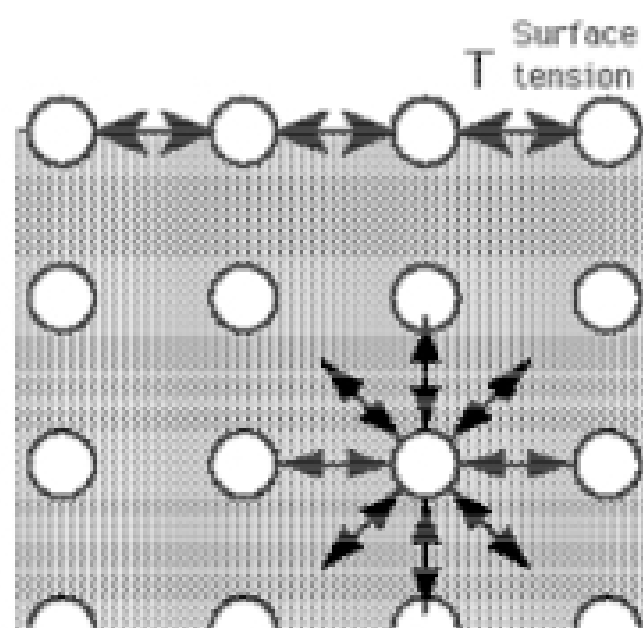
# Introduction to Fluidics

- Today:
  - Surface Tension
  - Squeeze-Film Damping
  - Electrokinetic Effects
    - Electroosmotic flow
    - Electrophoresis

📖 Reading: Senturia, Chapter 13, p.332-349

## ● Physics

- Molecules at surface experience different forces than moles in bulk and are energetically at higher energy
- Distributed force called 'surface tension' tends to minimize free surface and attain energy minimum
  - suspended liquid tends to form spherical drop (lowest surface/volume ratio)



- Physics

- Surface tension,  $T=[N/m]=[J/m^2]$

$$\frac{\text{Surface energy}}{\text{volume}} = \frac{(4\pi r^2)T}{\left(\frac{4\pi r^3}{3}\right)} = \frac{3T}{r}$$

- smaller bubbles are energetically less favorable
- large forces associated with formation and collapse (cavitation) of bubbles

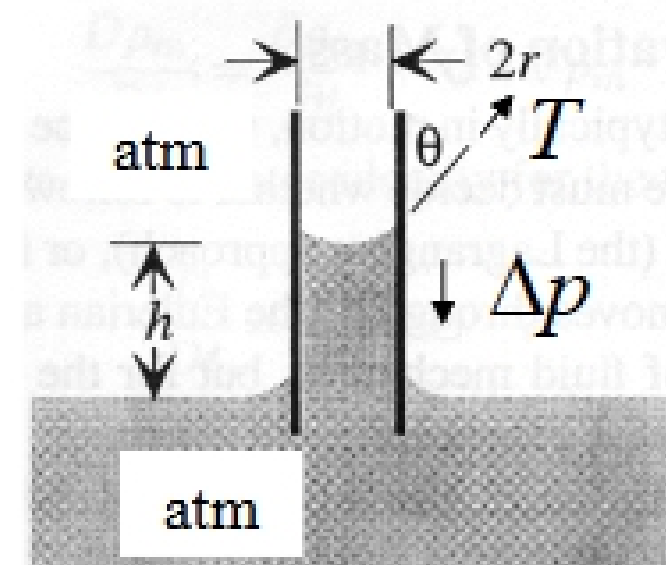
- Capillary force

- contact angle,  $\theta$
- $\theta$  depends on liquid, surface roughness, contamination, roughness, etc.

At equilibrium, total force on fluid in capillary is zero.

$$\Rightarrow F_{\text{surface tension}} = F_{\text{gravitational}}$$

$$\Rightarrow T(2\pi r) \cos \theta = \rho(\pi r^2 h)g \quad \Rightarrow \quad h = \frac{2T \cos \theta}{\rho g r}$$



Ref. Senturia, *Microsystem Design*, p.321