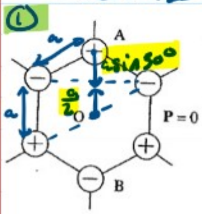
Piezoelectric & Ferroelectrics

Saturday, December 5, 2020 2:38 PM

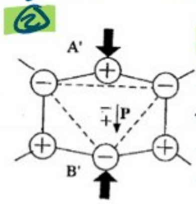
Piezoelectricity

- Direct: Apply force or displacement → generates charge & voltage
- Indirect: Apply Voltage or charge → generates displacement or force
- Non-centrosymmetric (no center of symmetry)
  ↳ can be polarized when charge applied

①



②



① Dipole moment $p = qd$

Top (−): $-2q(\frac{a}{2}) = -qa$

Top (+): $q(\frac{a}{2} + a\sin(30°)) = qa$

↳ cancel ∴ no net dipole moment

② Dipole moment $p = qd$

Top (−): $-2q(\frac{a}{2}) = -qa$

Top (+): $q(\frac{a}{2} + a\sin(<30°)) < qa$

↳ (−) Net dipole moment

- Direct Piezoelectric Equation: Polarization → $P_x = d_x T_x$ → d = piezoelectric coeff.
  ↳ ($\hat{x}$ dir) T = applied stress/Force/A

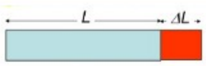
$P_y = d_{yx} T_x$ → d_{yx} = coeff. of polarization in $\hat{y}$ by Force in $\hat{x}$

Polarization, Piezoelectric Coefficients, Stress

$$\begin{bmatrix} P_x \\ P_y \\ P_z \end{bmatrix} = \begin{bmatrix} d_{xx} & d_{xy} & d_{xz} \\ d_{xy} & d_{yy} & d_{yz} \\ d_{xz} & d_{yz} & d_{zz} \end{bmatrix} \begin{bmatrix} T_x \\ T_y \\ T_z \end{bmatrix}$$

- Application of pressure → surface charge $\sigma_b = P\cdot\hat{n}$ → $\hat{n}$ = normal vector
- Field from σ_b: $E = \frac{\sigma}{\varepsilon_0} = \frac{P}{\varepsilon_0}$, @ surface: $E = \frac{P\cdot\hat{n}}{\varepsilon_0}$
- Voltage Induced: $V = -Ea$ → a = material thickness

- Inverse/Converse Piezoelectric Equation: Strain → $S_x = d_{xx} E_x$
  ↳ Strain = change in length



$S = \frac{\Delta L}{L}$

$$\begin{bmatrix} S_x \\ S_y \\ S_z \end{bmatrix} = \begin{bmatrix} d_{xx} & d_{xy} & d_{xz} \\ d_{xy} & d_{yy} & d_{yz} \\ d_{xz} & d_{yz} & d_{zz} \end{bmatrix} \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix}$$

- k^2 = EM coupling factor: $k^2 = \frac{\text{Mech energy out}}{\text{Elec energy in}}$