Lecture 28

Stimulated Emission:

↳ many orders less efficient than absorption.

↳ introducing traps enhances emission.

↳ increasing minority charge carrier concentration in p-n junctions.

↳ The material determines the colour of light emitted.

LASER:

↳ must have population inversion.

* We can have weak lasers and strong LED's hence general idea of Laser > LED is wrong.

↳ LASER is coherent source (in phase)

LED is monochromatic.

Eg: He-Ne laser:

→ In practical laser systems, we have 3 energy states for recombination.

Other Dielectrics: {Peizo-electric, ferro-electric, Pyro-electric}.

$$\{P = N\alpha E = \varepsilon_0(\chi - 1)E\}$$

N: no. of moments, α: polarizability

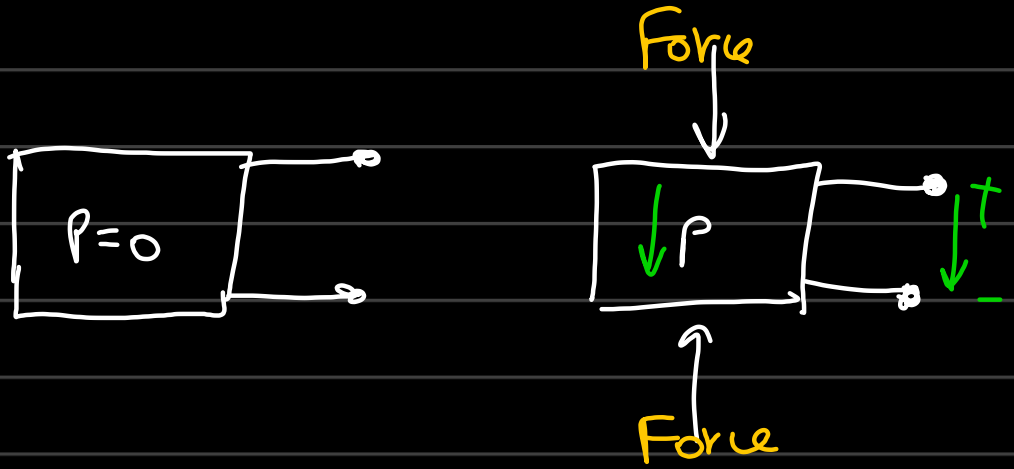
* Piezo ≡ pressure → relates stress into electric signals.

  eg: crystal oscillators. ⇒ quartz crystal.

* ferro ≡ permanence. → has a permanent inherent electric/magnetic dipole moment.

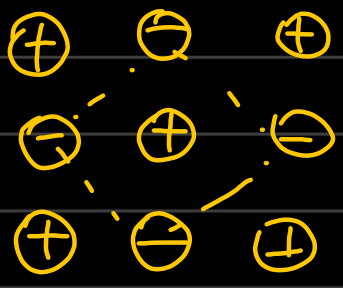
* pyro = heat

* Best, most common peizoelectric: Human bone.

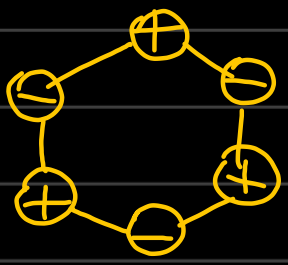


Origin of Polarization:

→ crystals with no center of symmetry are peizoelectrics.



has center of symmetry



no center of symmetry.

→ Constitutive Relations:

↳ T_i is applied pressure along direction i

↳ P_j is polarization obtained along j.

$$\boxed{T_i = d_{ij} P_j}$$

d_{ij} → piezoelectric coefficient

K → electro-mechanical coupling coefficient.

Eg: Quartz, Rochelle salt, PZT {Lead-Zironate-Titanate}

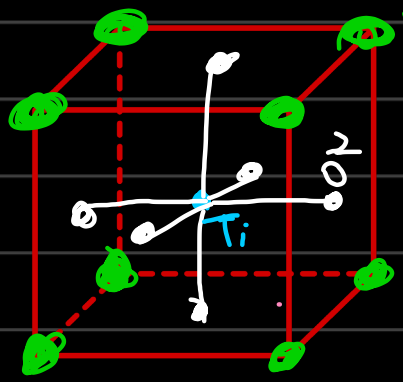
↓ earliest piezoelectric

Barium Titanate: ($BaTiO_3$)

paraelectric (no net dipole moment)

↓

($T > 130°C$)



Cubic at higher temperatures

↳ Tetragonal at room temp.

→ In tetragonal (at RT) → Ti shifts away from centre, leading to a inherent permanent dipole moment.

↳ Ti no longer at BCC.

↳ Hence a ferro-electric material.

* ferro-electricity originates due to minor deviation in crystal symmetry.

* Temperature at which transition from ferroelectric to paraelectric ⇒ Curie temperatures.

* In ferroelectric system, the unit cell has net dipole moment,

↳ However in clusters or bulk, we can have net dipole moment to be zero.

Hysterisis in Ferroelectrics: