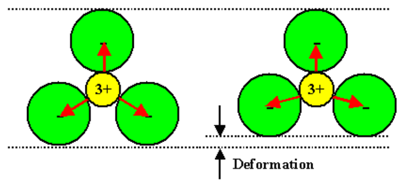
3.6.3 Summary to: Special Dielectrics

- Polarization ***P*** of a dielectric material can also be induced by mechanical deformation ***e*** or by other means.
  - *Piezo electric materials* are anisotropic crystals meeting certain symmetry conditions like crystalline quartz (**SiO_2**): the effect is linear.
  - The effect also works in reverse: Electrical fields induce mechanical deformation
  - Piezo electric materials have many uses, most prominent are quartz oscillators and, recently, fuel injectors for Diesel engines.

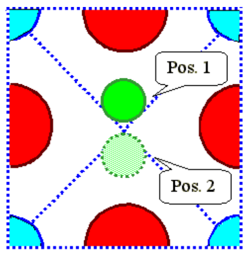


$$P = \text{const.} \cdot e$$

- *Electrostriction* also couples polarization and mechanical deformation, but in a quadratic way and only in the direction "electrical fields induce (very small) deformations".
  - The effect has little uses so far; it can be used to control very small movements, e.g. for manipulations in the **nm** region. Since it is coupled to electronic polarization, many materials show this effect.

$$e = \frac{\Delta l}{l} = \text{const} \cdot E^2$$

- *Ferro electric materials* posses a permanent dipole moment in any elementary cell that, moreover, are all aligned (below a critical temperature).
  - There are strong parallels to ferromagnetic materials (hence the strange name).
  - Ferroelectric materials have large or even very large (**$\epsilon_r > 1.000$**) dielectric constants and thus are to be found inside capacitors with high capacities (but not-so-good high frequency performance)



$BaTiO_3$ unit cell

- *Pyro electricity* couples polarization to temperature changes; *electrets* are materials with permanent polarization, ... There are more "curiosities" along these lines, some of which have been made useful recently, or might be made useful - as material science and engineering progresses.

Questionaire

Multiple Choice questions to all of 3.6