6.9: Pyroelectricity

Pyroelectricity is the property presented by certain materials that exhibit an electric polarization P_i when a temperature variation $\delta\Theta$ is applied uniformly:

$$P_i = p_i^T \, \delta\Theta$$

where p_i^T is the pyroelectric coefficient at constant stress. Pyroelectric crystals actually have a spontaneous polarization, but the pyroelectric effect can only be observed during a temperature change. If the polarization can be reversed by the application of an electric field, the crystal is ferroelectric.

If the crystal is also piezoelectric, the polarization due to an applied temperature variation is also partly due to the piezoelectric effect. The coefficient describing the pure pyroelectric effect is the pyroelectric coefficient at constant strain, p_i^S. The two coefficients are related by:

$$p_i^T = c_{ijkl} d_{kln} \alpha_{jn} + p_i^S$$

where the c_{ijkl} are the elastic stiffnesses, the d_{kln} the piezoelectric coefficients and the α_{jn} the linear thermal expansion coefficients.

The converse effect is the electrocaloric effect. If a pyroelectric crystal is submitted to an electric field, it will undergo a change of entropy $\Delta\sigma$:

$\Delta\sigma = p_i \, E^i$

and will release or absorb a quantity of heat given by $\Theta \, V \, \Delta\sigma$ where Θ is the temperature of the specimen and V its volume.