M.Sc. IV Semester
Electrochemistry
Unit IV

# Piezoelectric Effect And Material

This is also an electromechanical phenomenon. Crystals e.g. quartz, Rochelle salt, tourmaline become electrically polarized (charges appear on their surfaces) when a stress is applied to them. This phenomenon of polarisation of a solid (crystal) on which forces are acting is Piezoelectric effect. For reasonable forces the polarisation is proportional to the magnitude of the applied force. If the external force is reversed in sign, the polarisation changes in sign. The relationship between P and F. For particularly simple geometries is

$$P = \text{Constant} \cdot F$$

or

$$P \propto F$$

The piezoelectric effect has an inverse, i.e a dimensional change (a strain) is produced in a crystal when it is placed in an electric field — called inverse piezoelectric effect. Piezoelectric strains are very small and the corresponding electric field are very large. For example, in quartz, a field of 1000 V/cm produces a strain of the order of $10^{-7}$. Conversely, small strain can produce large electric fields. Thus piezoelectricity is characterised by a one-to-one corresponding of direct and inverse effect.

The origin of piezoelectric effect can be understood as follows:

(i) If a crystal has a centre of symmetry and is electrically neutral, a mechanical deformation alone does not, bring about electric dipoles. In such crystals, though, On applying stress, charges are displaced but distribution of charges still maintains its symmetry and they exhibit no net polarisation. Hence no piezoelectric effect is observed.

(ii) In piezoelectric crystals, those having no centre of symmetry, displacement due to stress distorts the original charge distribution is such a way that it is no longer symmetrical. A net polarization results in such crystals and we observe piezoelectric effect.

(iii) It follows, therefore, that the piezoelectricity is related to crystal symmetry. The symmetry element involved is essentially the centre of inversion. A crystal can exhibit piezoelectricity only if its unit cell lacks a centre of inversion.
In fig 1(a) crystal has no centre of inversion but if fig 1(b) the . is. That is why in fig 1(a)

Charge distribution is distorted so as to produce polarization where as in fig 1(b) no charge distortion.

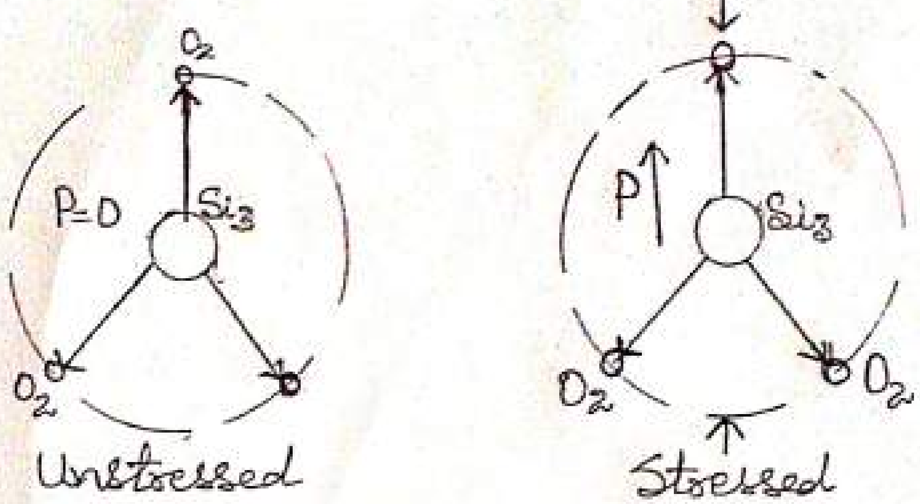


Fig 1(a) Piezoelectricity and Crystal Symmetry

quartz Crystal having lack of Centre of Inversion Shows piezo electricity.

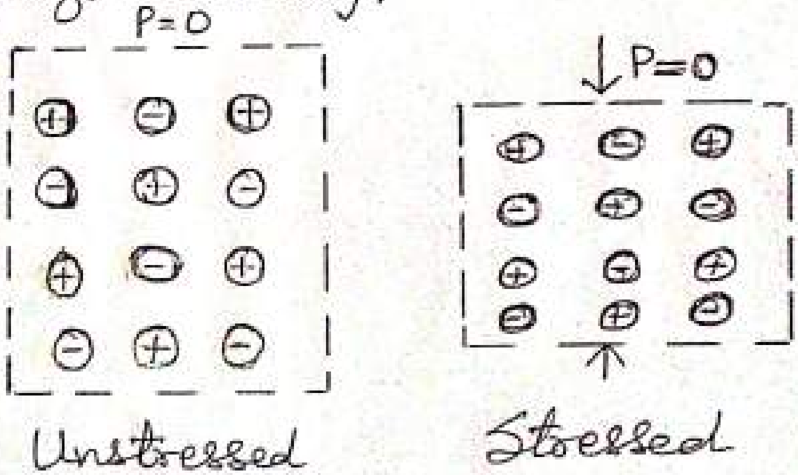


Fig.1(b) A Crystal with Centre of inversion Shows no piezoelectricity.

Piezoelectricity is thus exhibited by only non-Centrosymmetric systems 21 out of 32 Crystal classes are non-Centrosymmetric. The absence of Centre of Symmetry makes it possible for Crystals in these classes to have one or more directions of polarisation under Stress.

Piezoelectric effect is extensively used to convert electrical energy into mechanical energy and vice versa i.e piezoelectric substances are used as electro-mechanical transducers. Another important application of piezoelectricity is their use as highly stable oscillators for frequency Control.

Among Crystals showing the piezoelectric effect, some, such as tourmaline and Crystallised quartz, show a futher phenomenon called Pyroelectricity. When these Crystals are heated, they becomes positively charged on one side and negatively charged on the other and when they cooled off, they shown electrification opposite in sign from that when heated. Crystals which

Show pyroelectricity have "bad symmetry" and possess a permanent dipole even in ordinary state. Out of 32, eleven crystalline symmetries have the capability of being pyroelectric. Ferroelectric substances are one kind of substance which exhibits pyroelectric phenomenon. We can define a ferroelectric crystals as a pyroelectric crystal with reversible polarization.