4.7 PIEZO AND FERROELECTRIC CERAMICS

We know that the piezoelectric crystals undergo a change in polarisation when they are subjected to a stress. The application of compressive stress results in the displacement of charge in one direction while tensile stress leads to the displacement of charge in opposite direction.

Pyroelectric crystal is one which produces spontaneous polarisation due to application of electric field. Further in these crystals, a change in temperature also produces a change in spontaneous polarisation.

On the other hand, if one changes the direction of electric field, the direction of spontaneous polarisation also changes. The crystals exhibiting this additional property are known as *ferroelectrics*.

Therefore, ferroelectric crystal exhibit spontaneous and reversible polarisation. Most of the properties of ferroelectricity and ferromagnetism are common.

The ferroelectric properties disappear at certain temperature T_C (curie temperature). The crystal will be in paraelectric state above T_C, which is analogous to paramagnetism.

The crystal in the paraelectric state obeys Curie-Weiss law. Therefore, the spontaneous polarisation takes place, below T_C.

Examples for the ferroelectric ceramics are Rochelle salt, $BaTiO_3$, $SiTO_3$, $PbTiO_3$, $LiNbO_3$, $NaNbO_3$, $KNbO_3$, $PbTa_2O_3$, etc.

The structure, Curie temperature and Curie constants of ferroelectric ceramics are shown in Table.

Hysteresis

Ferroelectric ceramic materials exhibit the hysteresis behaviour. The hysteresis behaviour exhibited by a single crystal and polycrystalline material is shown in fig. 4.24 and fig. 4.25 respectively.

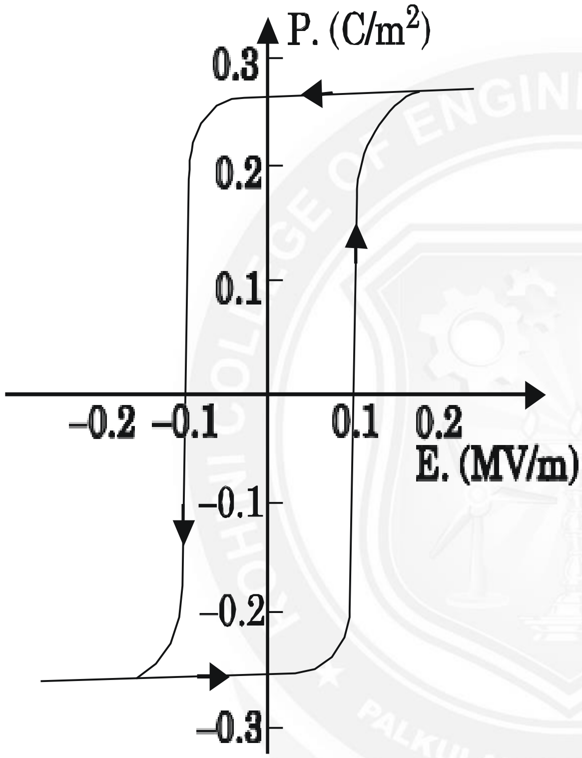

Fig. 4.7.1 Hysteresis loop - single crystal

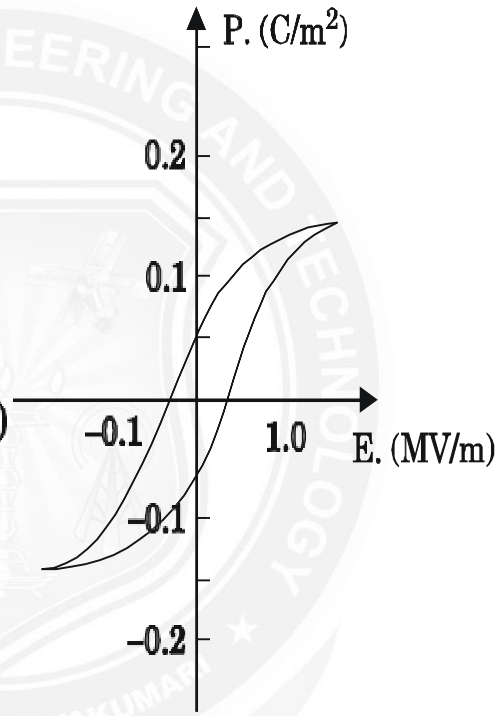

Fig. 4.7.2 Hysteresis loop - polycrystalline

FERROMAGNETIC CERAMICS

We know that soft magnetic (ferro magnetic) materials are easy to magnetise with low value of magnetic field. On the other hand, the hard magnetic materials require larger magnetic field for magnetisation as well as demagnetisation.

Therefore, the coercive field is very high and hence, used to make hard magnets for applications such as recording media and permanent magnet. The soft magnetic ceramics, exhibits similar properties as that of soft magnetic materials (metal counter parts).

However, soft magnetic ceramics are good electrical insulators. The eddy current losses of the soft magnetic ceramics are very low. Therefore, the magnetic ceramic materials are used whenever there is a requirement of reduction in the eddy current losses.The magnetic ceramic materials are classified into three types namely,

- **spinel,**
- **garnets and**
- **hexagonal ferrites.**

Hexagonal Ferrites

Hexagonal ferrites are ferromagnetic materials. The general formula for hexagonal ferrites is $BaO \cdot 6Fe_2 O_3$. The structure of ferrites is in line with magneto plumbite and hence, it is called *magneto ferrites*.

In this structure, all magnetic spins are parallel. Based on the arrangement of grains, hexagonal ferrites are classified as *isotropic* and *anisotropic ferrites*.

The grains are arranged in random manner in isotropic ferrites, while in anisotropy crystals they are aligned in a regular manner. One can obtain the anisotropy by the influence of magnetic field.

Thus, hexagonal ferrites have high anisotropy constants and hence, are used to fabricate hard magnets with high coercive fields.

In view of its low conductivity, high coercive fields, easy manufacturing, etc., hexagonal ferrites is one of the important permanent magnets. It finds wide application like loudspeaker and compact dc motors, where a large field is required.