4.7.4 Ferro electricity and its applications

When a dielectric material exhibits electric polarization even in the absence of external field, it is known as ferroelectricity and these materials are termed as ferroelectrics.Ferroelectrics are anisotropic crystals which exhibit spontaneous polarization.

Examples:

- Rochelle salt
- Potassium phosphate
- Barium titanate
- Potassium niobate
- Lithium niobate
- Lithium tantalate etc.

Properties:

1. The dielectric constant of these ferroelectric materials is above 2000.
2. It will not vary with respect to temperature.
3. The dielectric constant reaches maximum value only at a particular temperature called Curie temperature.
4. The polarization does not varies linearly with respect to electric field.
5. Ferro electrics exhibits electric polarization very easily, even in the absence of external electric field
6. They exhibit domain structure similar to that of ferromagnetic material.
7. Ferro electric materials also exhibitshysteresis.
8. Ferro electric materials exhibit piezo electricity and pyro electricity.
    - Piezo electricity means the creation of electric polarization by mechanical stress.

- Pyro electricity means the creation of electric polarization by thermal stress.

Hysteresis of Ferroelectric Materials

The ferroelectrics are known as non-linear dielectrics. Such materials exhibit hysteresis curve similar to that of ferromagnetic materials. The lagging of polarization 'P' behind the applied electric field E is called dielectric hysteresis.

When a ferroelectric material is subjected to external electric field (*E*) the polarization (*P*) increases with respect to the field applied and it reaches the maximum value '*OA*'. If now the applied electric field is reduced, the polarization also decreases from a, and when E becomes zero a small amount of polarization exists in the material is called spontaneous (or) residual polarization.

In order to reduce the value of polarization to zero, a reversing electric field '*OC*' should be applied. This field is known as coercive field. Thus the variation of '*P*' with respect to '*E*' traced along the closed path 'ABCDEFA' in one full cycle of polarization and depolarization is called hysteresis or the hysteresis curve.

Applications

1. Ferro electric materials are used to produce ultrasonic
2. Ferro electrics are also used in SONAR, Strain gauges etc.
3. Ferroelectrics are used to measure and control the temperature.
4. They are also used as frequency stabilizers and crystal controlled oscillators.
5. Electrects are the type of ferroelectric material used in the production of capacitor, microphones, gas filters etc.

6. Electrects bandages are used over the fractured bones to speed up the healing process.
7. In optical communication the ferroelectric crystals are used for optical modulation.

8. Piezo electric materials are used to make pressure transducers, ultrasonic transducers and microphones
9. Pyroelectric materials are used to make high sensitive infra-red detectors.

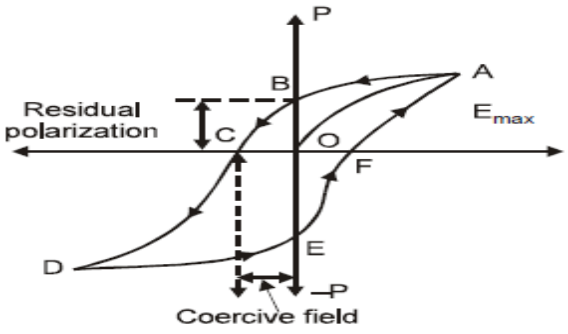

Fig:4.7.4.(i)

Comparison of Type of Polarization

S. N	*Factor*	P_e	P_i	P_o	P_s
1	**Definition**	Electron clouds are shifted from nucleus	Cations and anions are shifted	Regular alignment of random molecules takes place.	Ion diffusion takes place.
2	**Examples**	Inert gases	Ionic crystals	Alcohol, methane, CH_3Cl	Semi conductors, Ferrites.
3	**Temperature dependence**	Independent	Independent	Dependent	Dependent
4	**Relaxation time**	Very fast	Slow	Slower	Slowest
5	**Power loss**	Low	High	Higher	Highest
6	**Frequency range**	10^{15} Hz	10^{13} Hz	10^{6} Hz	10^{5} Hz
7	**Polarisability**	$\alpha_e = \frac{\varepsilon_0 (\varepsilon_r - 1)}{N}$	$\alpha_i = \frac{e^2}{\omega_0^2}\left[\frac{1}{m} + \frac{1}{M}\right]$	$\alpha_o = \frac{\mu^2}{3KT}$	α_s is negligible