



A brief note on dielectric materials

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DESCRIPTION

Materials are categorized as conductors, insulators and semiconductors based on their electrical conducting properties. Every material is made up of molecules which in turn made up of atoms. When subjected to electric field these atoms in the material undergoes certain displacements and changes in properties. In October 1745, an experiment done by Ewald Georg von Kleist of Germany by connecting a high voltage electrostatic generator to a volume of water collected in a handheld jar using a wire showed that charge can be stored. Using this phenomenon, Pieter van Musschenbroek invented the first capacitor called "Leyden Jar". The new material property that backed this invention was "Dielectric".

Every material is made up of atoms. Atoms contain both negatively and positively charged particles. The central nucleus of the atom is positively charged. In any material, the atoms are arranged as dipoles represented with a positive and negative charge on its end. When these materials are subjected to electric field dipole moment takes place. A conductor material starts conducting when electricity is applied. An insulator opposes the flow of electricity as it does not have any free moving electrons in its structure. But Dielectric is a special type of insulator that does not conduct electricity but gets polarized when subjected to electricity.

Polarization in Dielectric

In Dielectric materials, when subjected to the electric field the positive charges present in the material gets displaced in the direction of the applied electric field.

The negative charges are shifted in the direction opposite to the applied electric field. This leads to Dielectric polarization (Yang et al., 2020). In dielectric material, electric charges do not flow through the material. Polarization reduces the overall field of the dielectric.

Properties of Dielectric

The term Dielectric was first introduced by William Whewell. It is the combination of two words 'Dia' and 'electric'. The electrical conductivity of a perfect dielectric is zero (Xia et al., 2017). A dielectric stores and dissipates the electrical energy similar to an ideal capacitor. Some of the main properties of a Dielectric material are Electric Susceptibility, Dielectric polarization, Dielectric dispersion, Dielectric relaxation, Tunability,

How easily a dielectric material can be polarized when subjected to an electric field is measured by the electric susceptibility. This quantity also determines the electric permeability of the material. The electric dipole moment is a measure of the separation of negative and positive charges in a system. The relationship between the dipole moment (M) and the electric field (E) leads to the properties of the dielectric. When the applied electric field is removed, the atom returns to its original state. This happens in a way of exponential decay. The time it takes for an atom to return to its original state is called relaxation time. There are two factors that decide the polarization of dielectric. They are the formation of dipole moment and their orientation relative to the electric field. Based on the elementary dipole type there can be either electronic polarization or ionic polarization (Bedrov et al., 2019). Electronic polarization P_e occurs when the dielectric molecules forming the dipole moment are composed of neutral particles.

Ionic polarization P_i and digital polarization each are unbiased of temperature. Permanent dipole moments are produced within side the molecules whilst there may be an asymmetrical distribution of price among one of a kind atoms. In such cases, orientation polarization P_o is determined. If a unfastened price is gift with inside the dielectric fabric it'd cause the Space price polarization P_s . The general polarization of dielectric includes these types of mechanisms. Thus the whole polarization of the dielectric fabric is written as:

$$P_{\text{Total}} = P_i + P_e + P_o + P_s$$

Dielectric Dispersion

When P is the most polarization attained through the dielectric, τ is the rest time for a specific polarization method, the dielectric polarization method may be expressed as:

$$P(t) = P[1 - \exp(-t/\tau)]$$

The rest time varies for one of a kind polarization processes. Electronic polarization may be very fast observed through ionic polarization. Orientation polarization is slower than ionic polarization. Space price polarization may be very slow. When better electric powered fields are implemented, the insulator begins off evolved accomplishing and behaves as a conductor (Zotos et al., 1996). In such conditions, dielectric substances lose their dielectric properties. This phenomenon is called Dielectric Breakdown. It is an irreversible method. This results in the failure of dielectric substances.

Types of Dielectric Material

Dielectrics are categorized primarily based totally at the sort of molecule gift within the fabric. There are sorts of dielectrics-Polar dielectrics and Non-polar dielectrics.

Polar dielectrics: In polar dielectrics, the middle of mass of high-quality debris does now no longer coincide with the middle of mass of bad debris. Here the dipole second exists. The molecules are asymmetrical in shape (Zhang et al., 2021). When the electrical subject is implemented the molecules align themselves with the electrical subject. When the electrical subject is eliminated random dipole second is determined and the internet dipole second within the molecules turns into zero. Examples are H_2O , CO_2 .

Non-polar dielectrics: In the non-polar dielectrics, the middle of mass of high-quality debris and bad debris coincide. There isn't any dipole second in those molecules. These molecules are symmetrical in shape. Examples of non-polar dielectrics are H_2 , N_2 , O_2 .

Applications of Dielectric Material

Some of the programs of dielectrics are as follows:

- These are used for strength garage in capacitors;
- To decorate the overall performance of a semiconductor device, excessive permittivity dielectric substances are used;
- Dielectrics are utilized in Liquid Crystal Displays;
- Ceramic dielectric is utilized in Dielectric Resonator Oscillator;
- Barium Strontium Titanate skinny movies are dielectric which can be utilized in microwave tunable gadgets supplying excessive tunability and coffee leakage current;
- Parylene is utilized in commercial coatings acts as a barrier among the substrate and the outside environment;
- In electric transformers, mineral oils are used as a liquid dielectric and that they help withinside the cooling method.
- Castor oil is utilized in excessive-voltage capacitors to boom its capacitance value;
- Electrets, a mainly processed dielectric fabric acts as electrostatic equal to magnets.

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