DIELECTRICS

Insulators in between capacitor plate such as vacuum or air do not modify the electric field. Materials such as teflon, paper, glass do. These are called dielectrics. In what way do they modify the electric field ? Their simple effect is to change the capacitance by a factor κ such that $C= \kappa C_0$. This factor is called the dielectric constant.

Since C=Q/V increasing the capacitance implies that dielectrics increase the capacity of the metal plates to store charge. Also since $C_0=\varepsilon_0 A/d$ the permittivity ε_0 gets replaced by ε.κ.

Dielectrics also increase the breakdown voltage across a capacitor. Why ?

Because, $E_{max} = (V_{max}/d)$ is higher for dielectrics.

Parameter	Teflon	Air
κ	2.1	1.00
E_{max}	60×10^6 V/m	3×10^6 V/m

Commercial capacitors come with a voltage rating which depends upon the quality of the dielectric inside in addition to of course the size of the capacitor in farads.

Microscopics of Dielectrics:

Polar molecules and non-polar molecules.

There is an induced field which opposes the applied field E0 to produce a net field Enet which is usually smaller. This Enet is proportional to E0 only if Eind is also proortional to E0.

In terms of charge densities suppose E0 produces a charge density σ on the plates. We have E0=σ/ε0 and Eind=σind/ε0. But Enet = σ/k.ε0 implies that

$$\frac{s}{ke_0} = \frac{s}{e_0} + \frac{(-s_{ind})}{e_0}$$

OR

$$s i_{nd} = s\,(1 - \frac{1}{k}) < s$$

When k >> 1, $\sigma_{ind} = \sigma$.

Piezoelectricity: Strain produces charge. Example of the use of piezoelectric materials are tweeters and microphones.