Electronic Materials

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Reference: Principles of Electronic Materials and Devices by Safa Kasap

Grading:

10% on the 4th week
20% on the 7th week
10% on the 10th week
20% on the 12th week
40% on the 16th week

We use different tests for materials

Destructive: The material is destroyed after the test.

Done on samples of the material e.g.: cubes of concrete such as break down voltage.

Non destructive: The material is not destroyed after test. Done on finished components e.g.: x-ray test.

Insulators (Dielectric)

- Bad conductions to electricity (high resistivity) e.g.: wood, mika for capacitors, SiO_2 for MOSFET
- At room temperature, valence band completely filled.
- No holes in conduction band.

Dielectric Materials

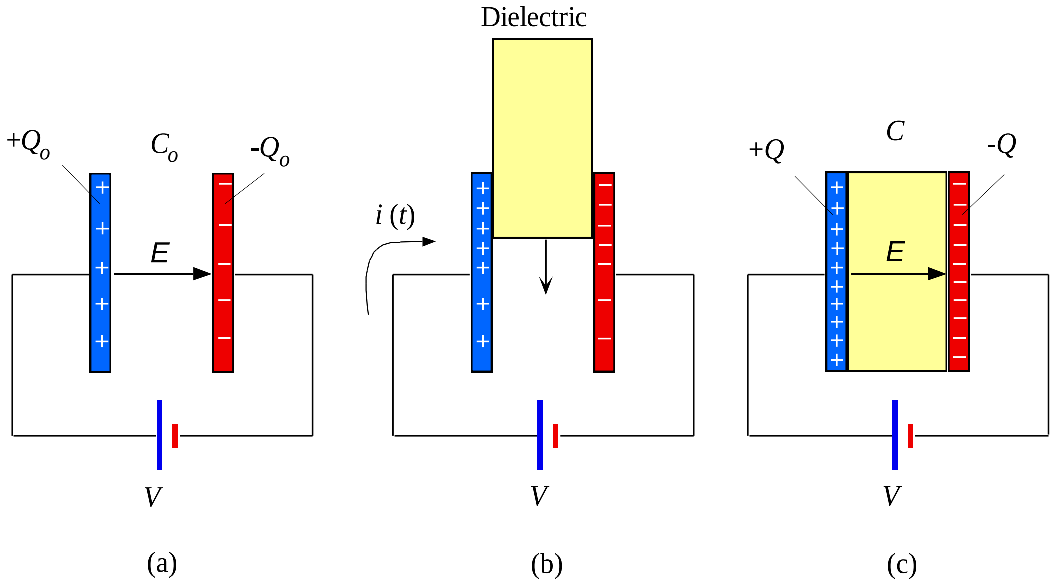

Fig. 7.1: (a) Parallel plate capacitor with free space between plates. (b) As a slab of insulating material is inserted between the plates, there is an external current flow indicating that more charge is stored on the plates. (c) The capacitance has been increased due to the insertion of a medium between the plates. (*E* is the electric field.)

From *Principles of Electronic Materials and Devices, Second Edition*, S.O. Kasap (© McGraw-Hill, 2002)
http://Materials.Usask.Ca

Parallel plates capacitor with air or vacuum

$$C = \frac{\in_o A}{L} = \frac{Q}{V}$$

C : Capacitance : charge stored per unit voltage.

A : Area of plate (m^2)

L : distance between 2 plates (m)

$\in_o$: absolute permittivity (air) $= 8.85 \times 10^{-12}$ F/m

Parallel plate capacitor with dielectric

$$C = \frac{\in A}{L} = \frac{Q}{V}$$

$$\in = \in_r \in_o$$

$\in_r$: relative permittivity (dielectric constant) at air $\in_r = 1$

Relation between different parameters related to dielectric

$$\sigma_d : \text{charge density} = \text{charge per unit area} = \frac{Q}{A}\, c/m^2$$

$$\text{electric field} = \frac{\text{V}}{\text{L}} = V/m \text{ for the same media}$$

$$\vec{\text{D}} = \text{displacement vector} = \in E$$

$\vec{\text{D}}$ vector start from positive free charge and ends on negative free charge

$$\left|\vec{\text{D}}\right| = \sigma_d \; c/m^2$$

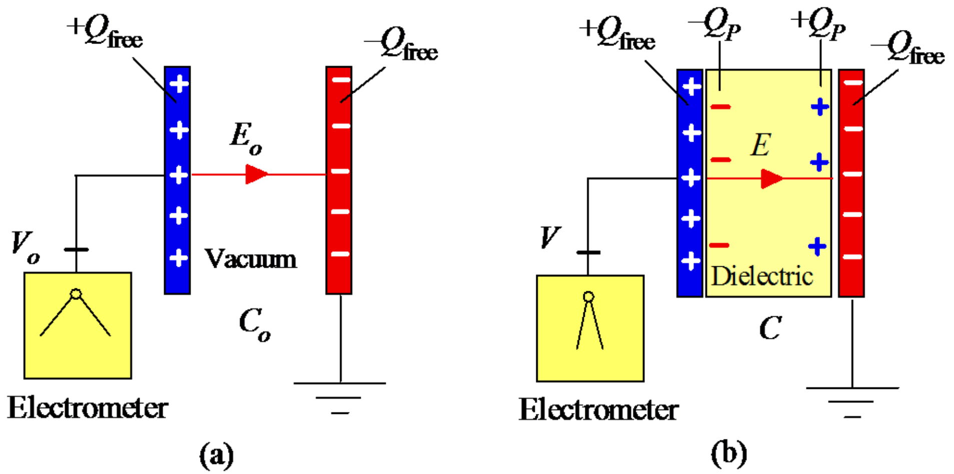

Fig. 7.45: (a) Parallel plate capacitor with free space between plates which has been charged to a voltage V_o. There is no battery to maintain the voltage constant across the capacitor. The electrometer measures the voltage difference across the plates and, in principle, does no affect the measurement. (b) After the insertion of the dielectric, the voltage difference is V, less than V_o and the field in the dielectric is E less than E_o.