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

The static dielectric constant for gases

$$P = \varepsilon_o \chi_e E = \varepsilon_o(\varepsilon_r - 1)E \xrightarrow{1}$$

$$P = NP_{induced} = N\alpha_e E_{local} = N\alpha_e E \xrightarrow{2}$$

From 1 and 2

$$\varepsilon_r = 1 + \frac{N\alpha_e}{\varepsilon_o}$$

The static dielectric constant for solid

$$P = \varepsilon_o \chi_e E = \varepsilon_o(\varepsilon_r - 1)E \xrightarrow{1}$$

$$P = NP_{induced} = N\alpha_e E_{local} = N\alpha_e \left[E + \frac{P}{3\varepsilon_o} \right] \xrightarrow{2}$$

From 1 and 2

$$\varepsilon_r = 1 + \frac{\frac{N\alpha_e}{\varepsilon_o}}{1 - \frac{N\alpha_e}{3\varepsilon_o}}$$

The static dielectric constant for solid

$$\frac{\varepsilon_r - 1}{\varepsilon_r + 2} = \frac{N\alpha_e}{3\varepsilon_o}$$

Clausis Mossiti Relation

$$\rho = \frac{\text{mass}}{\text{volume}} = \frac{NM}{N_A}$$

ρ : mass density

N_A : Avogadro's number

N : no. of atoms/volume

M : atomic weight

Molar Polarizability

$$\frac{M\left(\varepsilon_r - 1\right)}{\rho\left(\varepsilon_r + 2\right)} = \frac{N_A \alpha_e}{3\varepsilon_o}$$

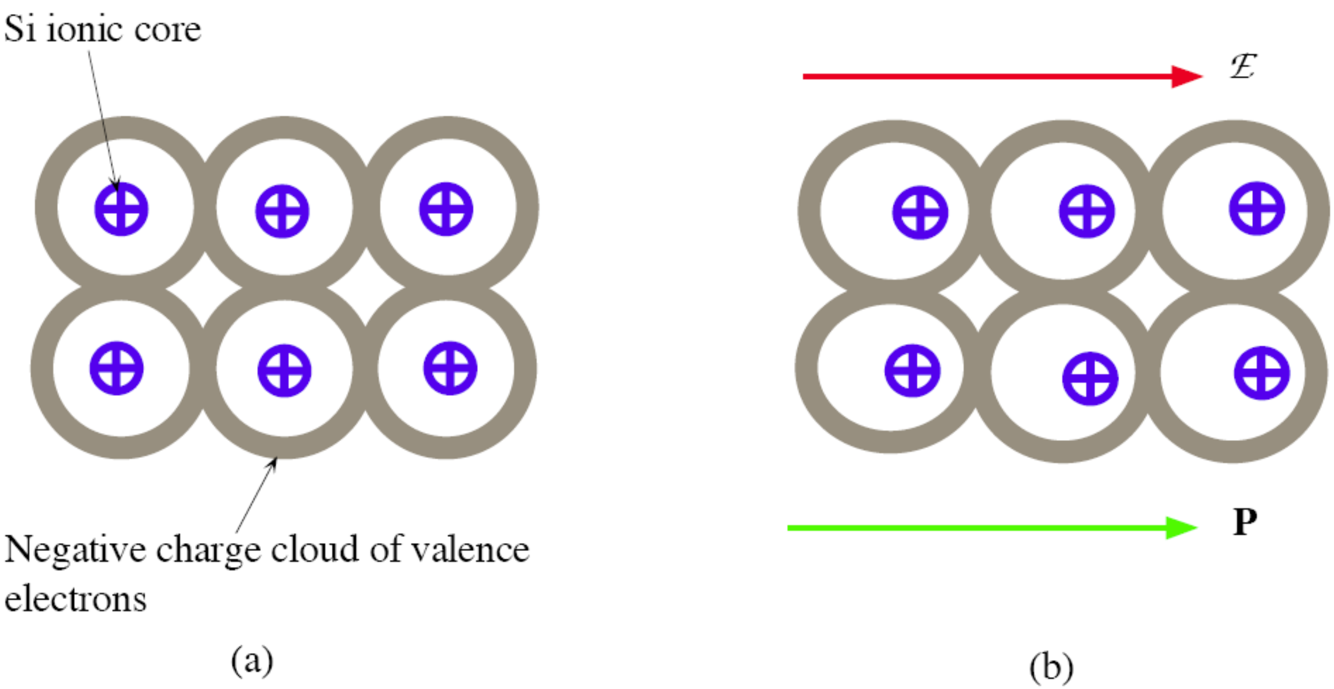
Types of Polarization

1-Electronic

2-Ionic

3-Dipolar

1-Electronic polarization



(a) Valence electrons in covalent bonds in the absence of an applied field.

(b) When an electric field is applied to a covalent solid, the valence electrons in the covalent bonds are shifted very easily with respect to the positive ionic cores. The whole solid becomes polarized due to the collective shift in the negative charge distribution of the valence electrons.

Fig 7.8

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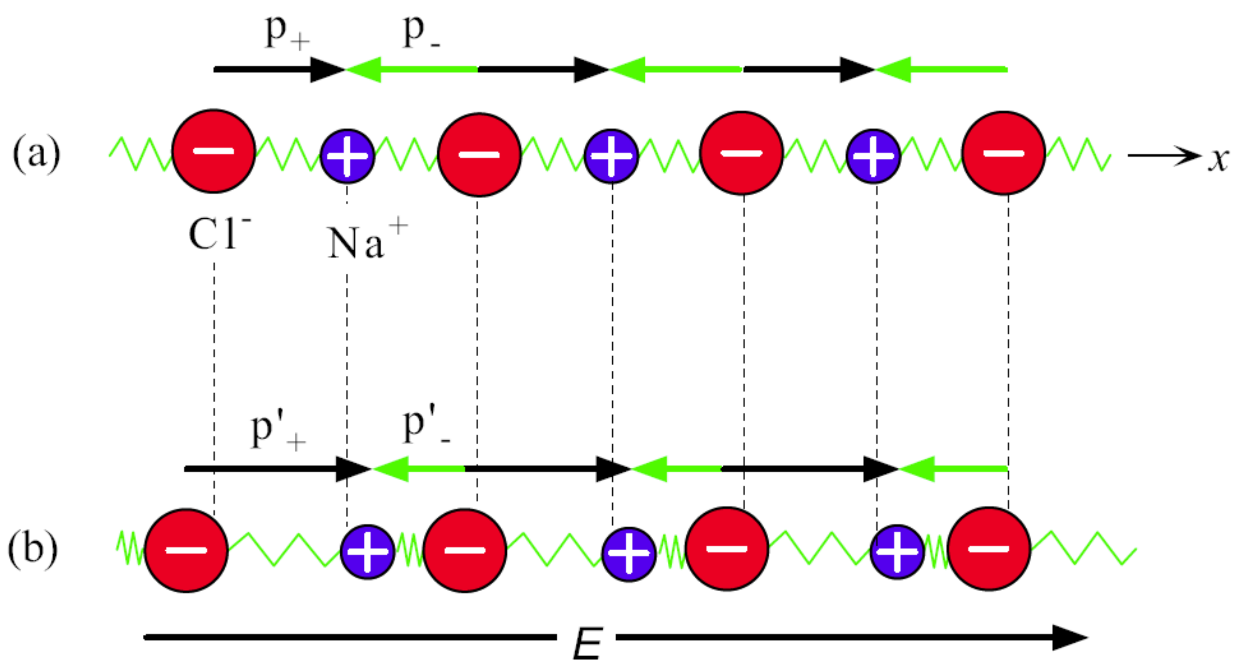
2-Ionic polarization



(a) A NaCl chain in the NaCl crystal without an applied field. Average or net dipole **moment per ion is zero**.

(b) In the presence of an applied field the ions become slightly displaced which leads to **a net average dipole moment per ion.**

Fig 7.9

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Cl

2-Ionic polarization (NaCl)

$$\frac{\varepsilon_r - 1}{\varepsilon_r + 2} = \frac{N_i \alpha_i + N_{e1} \alpha_{e1} + N_{e2} \alpha_{e2}}{3\varepsilon_o}$$

NaCl

Na