Conductivity and Mobility in Semiconductors

Conductivity (σ): Conductivity is a measure of a material's ability to conduct electric current. In semiconductors, conductivity is influenced by the concentration of charge carriers (electrons and holes) and their mobility. It is defined by the equation:

$$\Sigma = q(n\mu_n + p\mu_p)$$

where:

q is the charge of the carriers,

n is the concentration of electrons,

p is the concentration of holes,

μ_n is the mobility of electrons,

μ_p is the mobility of holes.

In intrinsic (pure) semiconductors, the number of electrons equals the number of holes, leading to n = p. In extrinsic (doped) semiconductors, the conductivity can vary significantly based on the type and concentration of dopants.

Mobility (µ): Mobility refers to how quickly charge carriers can move through a semiconductor when an electric field is applied. It is defined as:

$$M = \frac{v_d}{E}$$

where:

v_d is the drift velocity of the charge carriers,

E is the electric field strength.

Mobility is affected by various factors, including temperature and the presence of impurities or defects within the semiconductor lattice. Generally, as temperature increases, mobility decreases due to increased scattering events among charge carriers.

Key Points

Charge Carrier Types: Electrons (negative charge carriers) and holes (positive charge carriers) contribute to conductivity.

Temperature Dependence: Higher temperatures can increase intrinsic carrier concentration but reduce mobility due to scattering.

Doping Effects: Doping can significantly enhance conductivity by increasing the number of charge carriers, while also impacting mobility depending on the dopant type.

Applications: Understanding conductivity and mobility is crucial for the design and optimization of semiconductor devices like diodes, transistors and solar cells.