EEEM
3RD SEMESTER
ELECTRICAL

Conducting range	Material	Conductivity, σ ($\Omega^{-1} \cdot m^{-1}$)
Conductors	Aluminum (annealed)	35.36×10^6
	Copper (annealed standard)	58.00×10^6
	Iron (99.99 + %)	10.30×10^6
	Steel (wire)	$5.71–9.35 \times 10^6$
Semiconductors	Germanium (high purity)	2.0
	Silicon (high purity)	0.40×10^{-3}
	Lead sulfide (high purity)	38.4
Insulators	Aluminum oxide	$10^{-10}–10^{-12}$
	Borosilicate glass	10^{-13}
	Polyethylene	$10^{-13}–10^{-15}$
	Nylon 66	$10^{-12}–10^{-13}$

Source: Data from C. A. Harper, Ed., *Handbook of Materials and Processes for Electronics*, McGraw-Hill Book Company, NY, 1970; and J. K. Stanley, *Electrical and Magnetic Properties of Metals*, American Society for M

Introduction to Materials Science for Engineers, Sixth Edition by James F. Shackelford.
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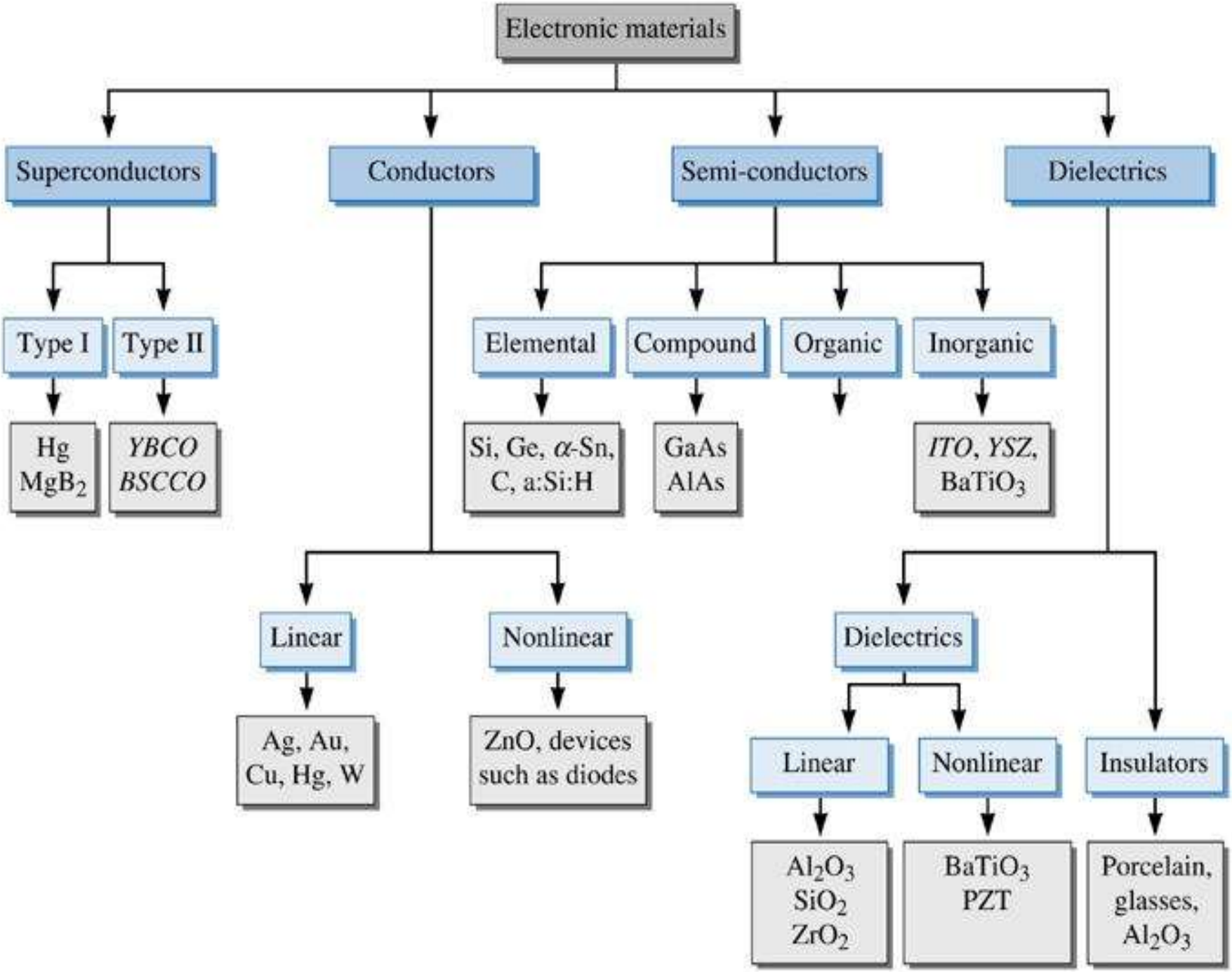
TABLE 18-1 ■ ***Electrical conductivity of selected materials at*** **T = 300 *K****

Material	Conductivity ($ohm^{-1} \cdot cm^{-1}$)
Superconductors	
Hg, Nb_3Sn, $YBa_2Cu_3O_{7-x}$, MgB_2	Infinite (under certain conditions such as low temperatures)
Metals	
Alkali metals:	
Na	2.13×10^5
K	1.64×10^5
Alkali earth metals:	
Mg	2.25×10^5
Ca	3.16×10^5
Group 3B metals:	
Al	3.77×10^5
Ga	0.66×10^5
Transition metals:	
Fe	1.00×10^5
Ni	1.46×10^5
Group 1B metals:	
Cu	5.98×10^5
Ag	6.80×10^5
Au	4.26×10^5

Material	Conductivity ($ohm^{-1} \cdot cm^{-1}$)
Semiconductors	
Group 4B elements:	
Si	5×10^{-6}
Ge	0.02
α-Sn	0.9×10^{5}
Compound semiconductors	
GaAs	2.5×10^{-9}
AlAs	0.1
SiC	10^{-10}
Ionic Conductors	
Indium tin oxide (*ITO*)	
Yttria-stabilized zirconia (*YSZ*)	
Insulators, Linear and Nonlinear Dielectrics	
Polymers:	
Polyethylene	10^{-15}
Polytetrafluorethylene	10^{-18}
Polystyrene	10^{-17} to 10^{-19}
Epoxy	10^{-12} to 10^{-17}
Ceramics:	
Alumina (Al_2O_3)	10^{-14}
Silicate glasses	10^{-17}
Boron nitride (BN)	10^{-13}
Barium titanate ($BaTiO_3$)	10^{-14}
C (diamond)	$<10^{-18}$

** Unless specified otherwise, assumes high purity material.*



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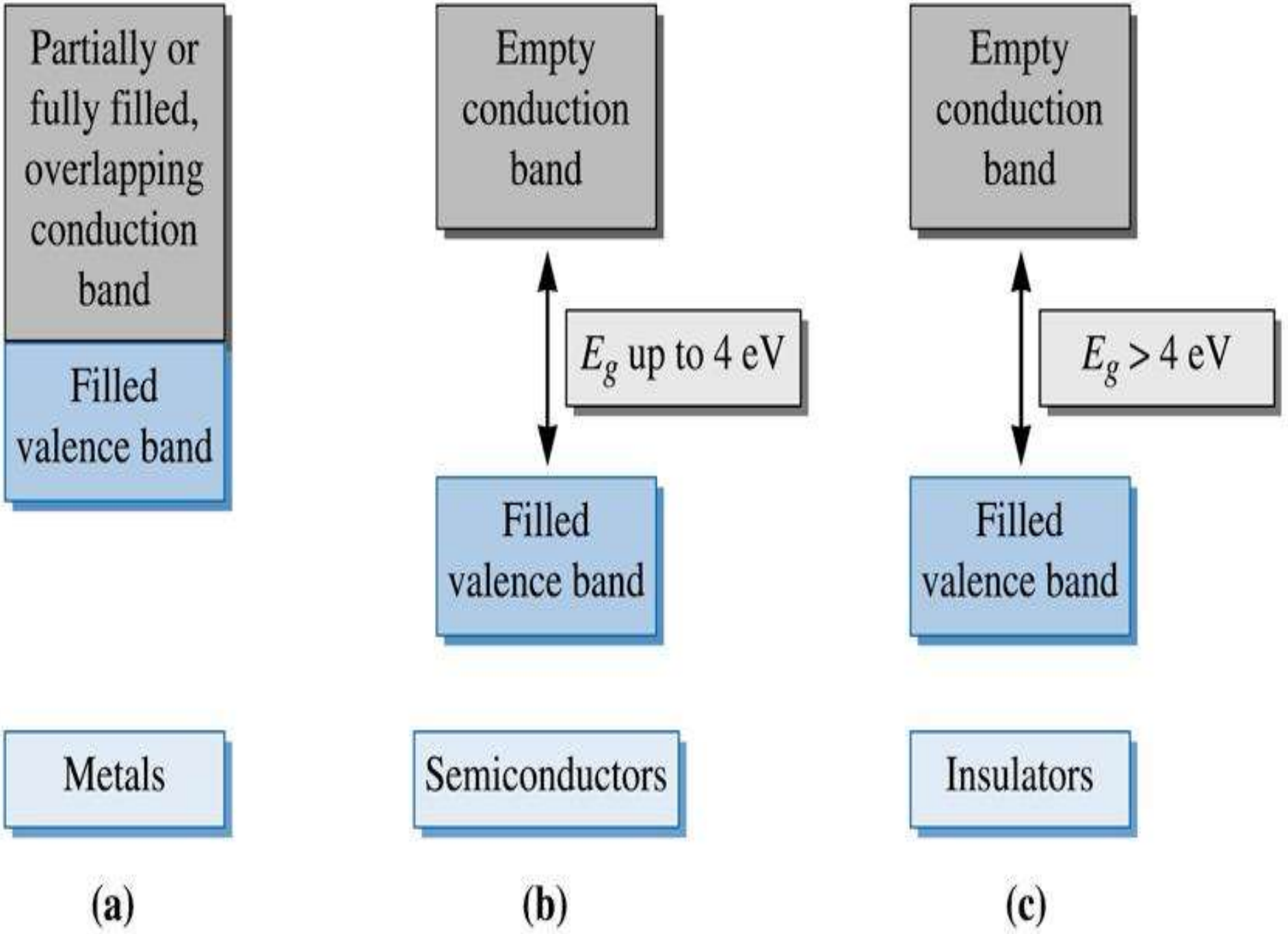
- **Drift velocity - The average rate at which electrons or other charge carriers move through a material under the influence of an electric or magnetic field.**
- **Mobility - The ease with which a charge carrier moves through a material.**

- Current density - The current flowing through per unit cross-sectional area.
- Electric field - The voltage gradient or volts per unit length.
- Drift velocity - The average rate at which electrons or other charge carriers move through a material under the influence of an electric or magnetic field.
- Mobility - The ease with which a charge carrier moves through a material.
- Dielectric constant - The ratio of the permittivity of a material to the permittivity of a vacuum, thus describing the relative ability of a material to polarize and store a charge; the same as relative permittivity.

- **Valence band - The energy levels filled by electrons in their lowest energy states.**
- **Conduction band - The unfilled energy levels into which electrons can be excited to provide conductivity.**
- **Energy gap (Bandgap) - The energy between the top of the valence band and the bottom of the conduction band that a charge carrier must obtain before it can transfer a charge.**



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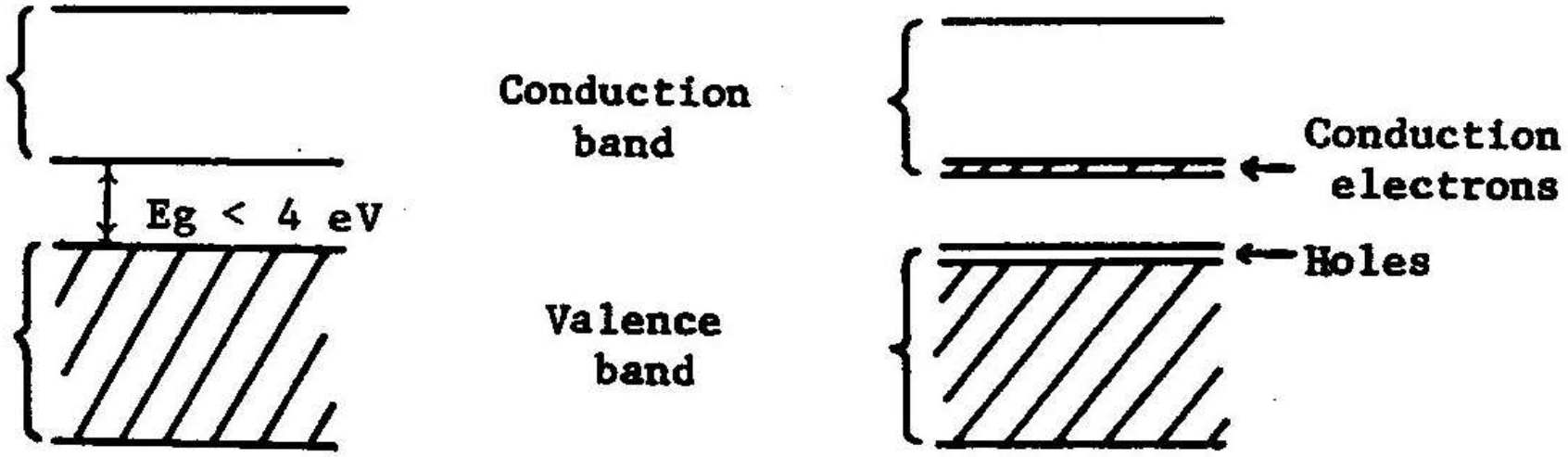
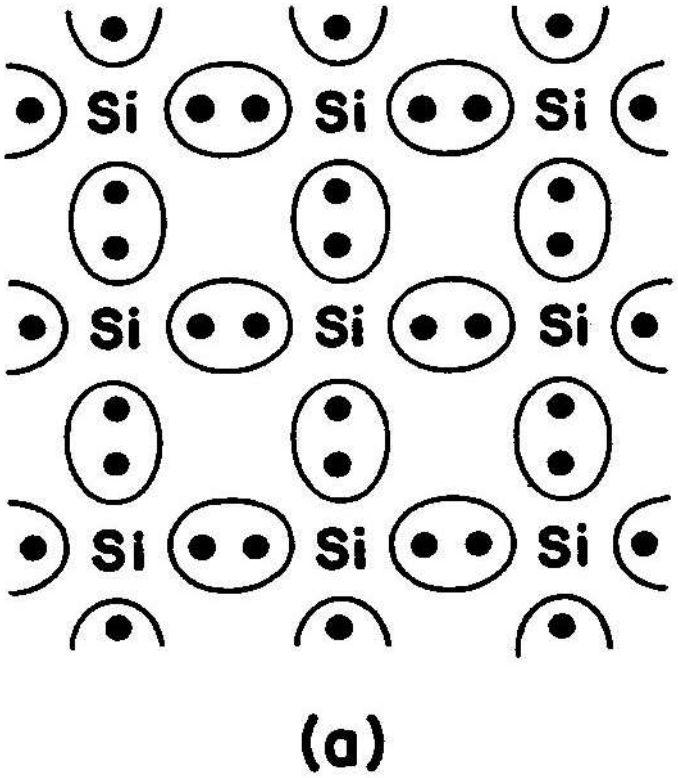
Energy bands of an intrinsic semiconductor



(a) Without thermal excitation

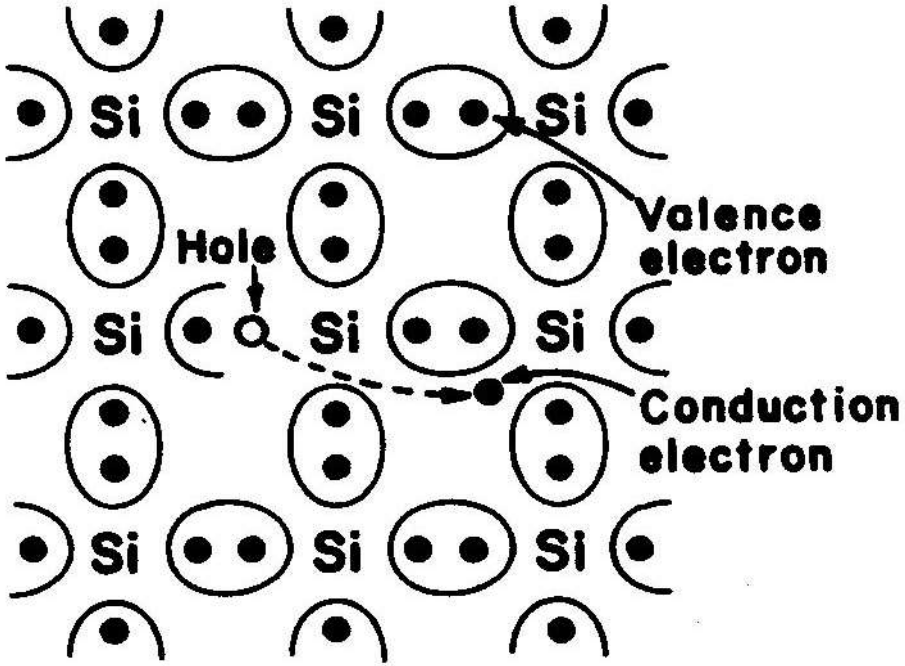
(b) With thermal excitation

Intrinsic silicon



(a)

Without thermal excitation

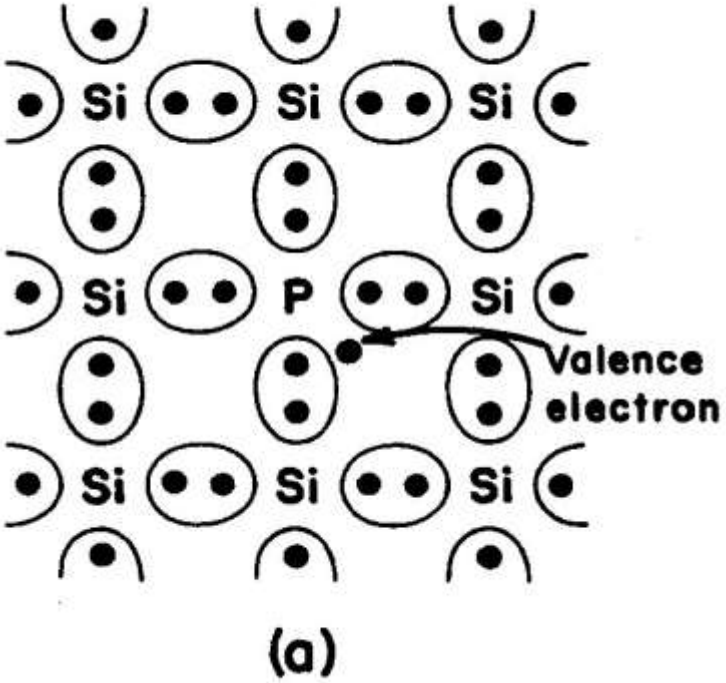


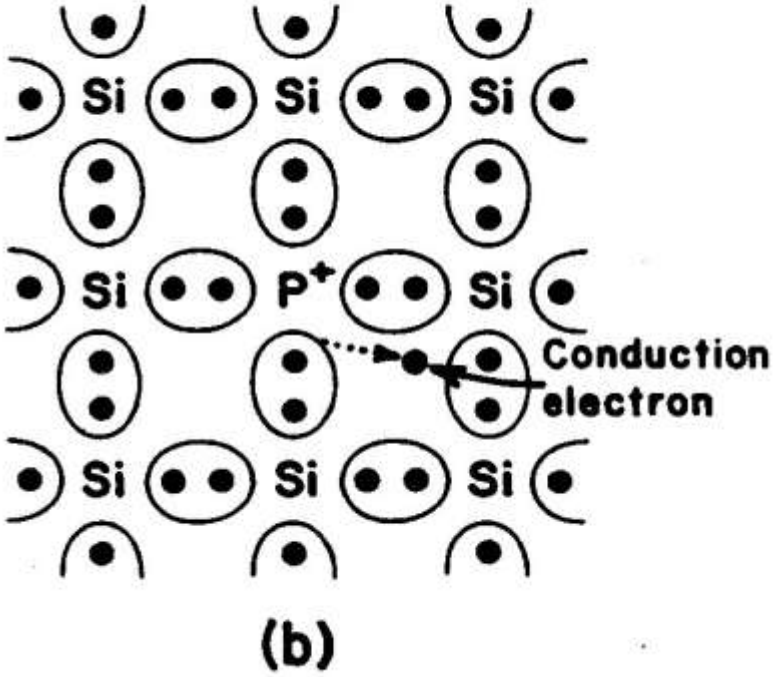
(b)

With thermal excitation

- Intrinsic semiconductor - A semiconductor in which properties are controlled by the element or compound that makes the semiconductor and not by dopants or impurities.
- Extrinsic semiconductor - A semiconductor prepared by adding dopants, which determine the number and type of charge carriers.
- Doping - Deliberate addition of controlled amounts of other elements to increase the number of charge carriers in a semiconductor.

Extrinsic semiconductor (doped with an electron donor)

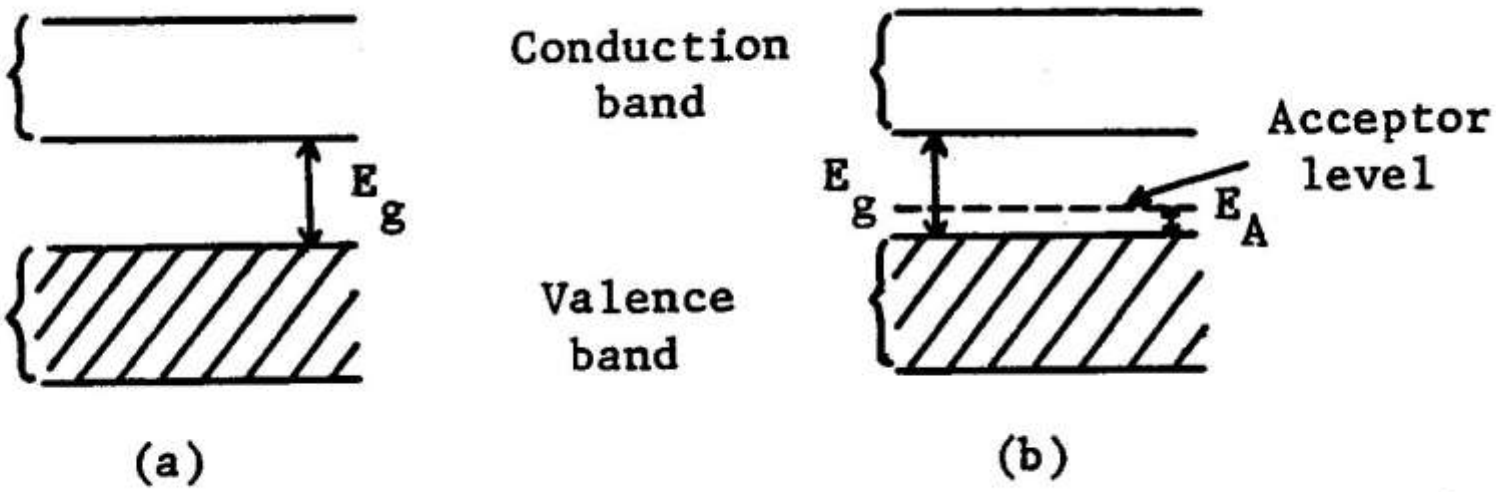




Without thermal excitation

With thermal excitation

Energy bands



Intrinsic semiconductor

Extrinsic semiconductor (doped with an electron acceptor)