Semiconductor Physics

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Semiconductor Physics

1. What is a semiconductor?
2. Materials and Properties
3. Types
4. Important Terms
5. Introduction to pn junctions

Insulator

High Resistivity

Semiconductor

Somewhere between.
Total resistivity depends of conditions applied on the semiconductor

Conductor

Low Resistivity

Table 1.1 A list of some semiconductor materials

Elemental semiconductors		Compound semiconductors	
Si	Silicon	GaAs	Gallium arsenide
Ge	Germanium	GaP	Gallium phosphide
		AlP	Aluminum phosphide
		AlAs	Aluminum arsenide
		InP	Indium phosphide

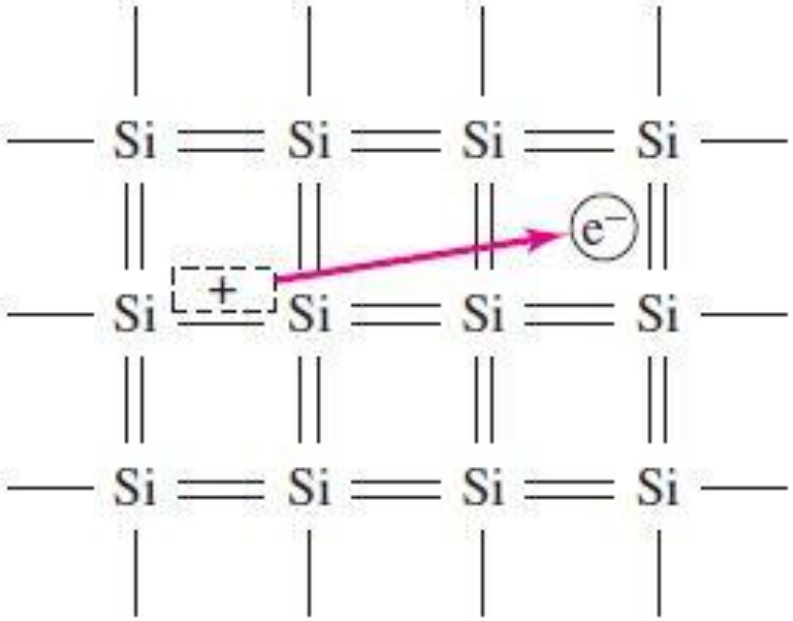
Silicon

-Group IV of periodic table

-4 valence electrons

-Most common

Intrinsic Semiconductor



Bandgap Energy

Minimum energy for any one electron to break the covalent bond

As Temperature ⬆

More covalent bonds broken

More free electrons

More holes

Both “particles” contribute to current and are equal

Intrinsic Carrier Concentration

$$n_i = BT^{3/2} e^{\left(\frac{-E_g}{2kT}\right)}$$

k = 86 × 10−6 eV/K

E_g = 1.1 eV

B(si) = 5.23 x 10^{15}

Calculate the intrinsic carrier concentration in silicon at T = 300 K.

Intrinsic	vs	Extrinsic
Same type of atoms		**Contains controlled amounts of impurities**
Low carrier concentration		**high carrier concentration**
Low current		**high current**
Requires high temp. to break bond		**Bonds bread at room temp.**
Free electrons = Holes		**Free electrons ≠ Holes**

Extrinsic Semiconductors

P-type

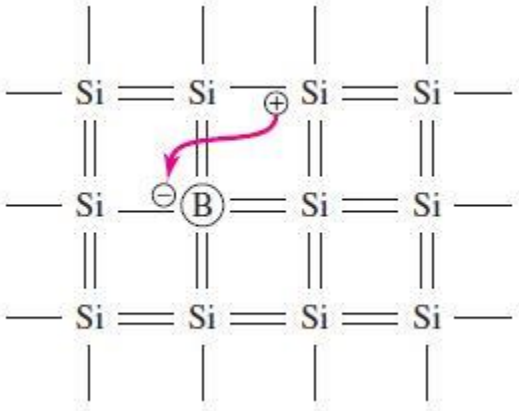
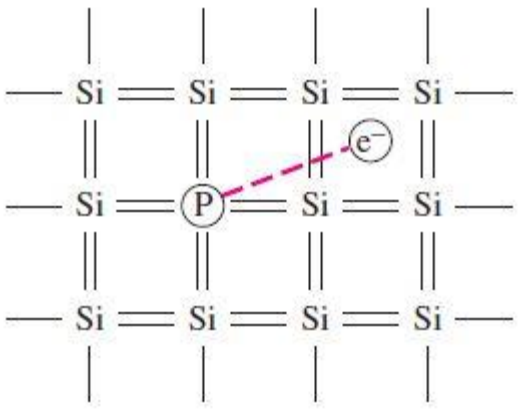


Table 1.2 A portion of the periodic table

III	IV	V
5 **B** Boron	6 **C** Carbon	
13 **Al** Aluminum	14 **Si** Silicon	15 **P** Phosphorus
31 **Ga** Gallium	32 **Ge** Germanium	33 **As** Arsenic
49 **In** Indium		51 **Sb** Antimony

N-type



Doping

Carriers

Free electrons and holes

Drift Current

Movement caused by electric fields

Diffusion Current

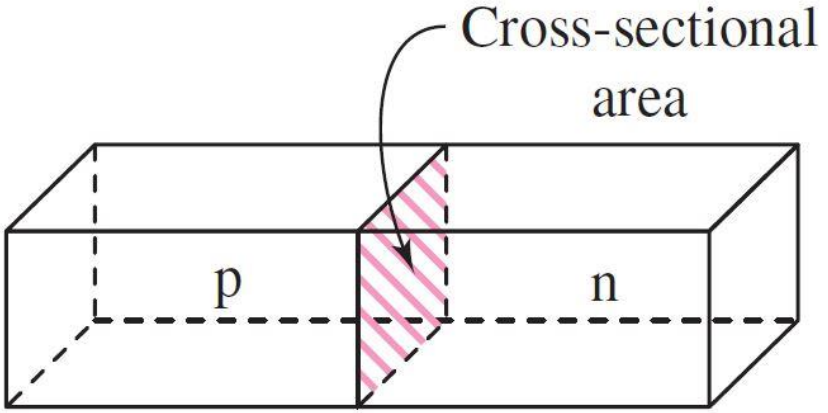
Movement caused by variation in the concentration gradients
High concentration to Low concentration

Total Current Density

Drift Current + Diffusion Current

The pn Junction

"The real power of semiconductor electronics occurs when p- and n-regions are directly adjacent to each other, forming a **pn junction.**"



P-type Doping

N-type Doping

Single Crystal

Resources

Chapter 4.1 in text (Keiser, McGraw Hill, 2011)

Chapter 1.1, 1.2 in text (Neamen, McGraw Hill, 2010)

EECE 315 Notes Dr. Ghang-Ho Lee