Semiconductors and Doping

Session 5a for Electronics and Telecommunications
A Fairfield University E-Course
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Module: Semiconductor Electronics (in two parts)

- Text: "Electronics," Harry Kybett, Wiley, 1986, ISBN 0-471-00916-4
- References:
  - Electronics Tutorial (Thanks to Alex Pounds)
  - Electronics Tutorial (Thanks to Mark Sokos)
- Semiconductors, Diodes and Bipolar Transistors
  - 5 on-line sessions plus one lab
- FETs, SCRs, Other Devices and Amplifiers
  - 5 on-line sessions plus one lab
- Mastery Test part 3 follows this Module

Section 5: Semiconductors, Diodes and Bipolar Transistors

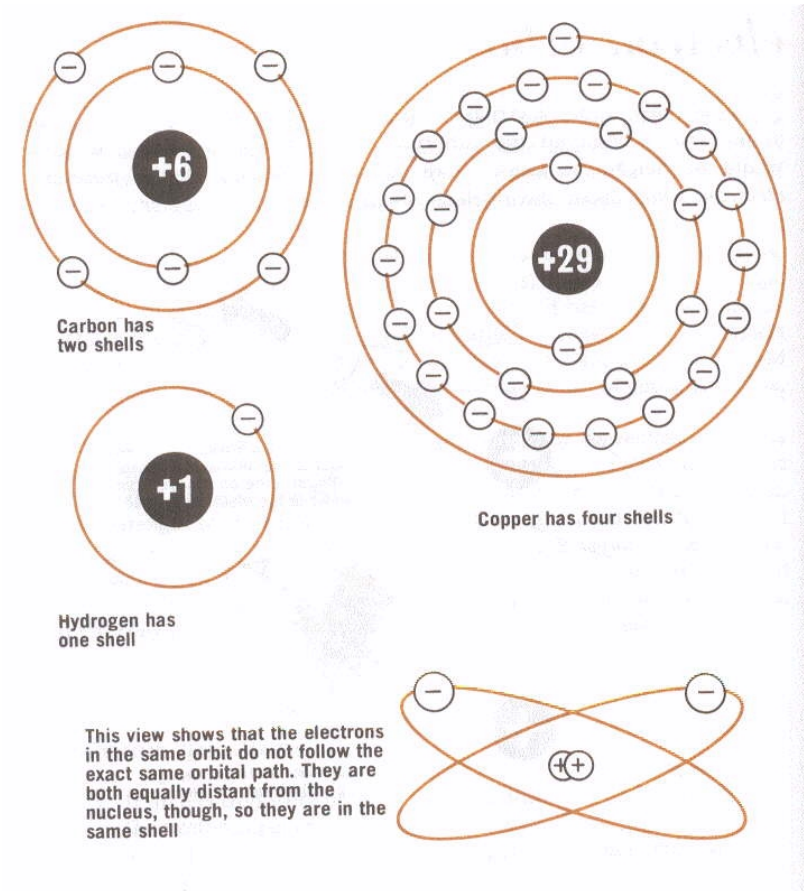
- 0BJECTIVES: This section reviews semiconductors, doping and junctions. The characteristics and application of Diodes and Bipolar Transistors are then studied.

Section 5 Schedule:

Session 5a	**– 09/18**	**Semiconductors and Doping**	**Elect 1-7 1.23 – 1.39**
MT2 Results	– 09/23	We'll discuss MT2	
Session 5b	– 09/25	Diodes	Text Chapter 2
Session 5c	– 09/30	Diode Applications	Text Chapter 11
Session 5d	– 10/02	Bipolar Transistors	Text pp 51 - 70
(lab - 10/05, Sat.)			
Session 5e	– 10/07	Transistor Amplifiers	Text pp 173 - 201
(Quiz 4 due 10/12)			
Session 5f	– 10/14	Review (Discuss Quiz 4)	
Break to introduce Learnlinc version 6.1		About 2 weeks to set up the computers and retrain us	

Electron Shells

- Only the outer electrons (valence shell) form molecular bonds
- Unbound (free) outer electrons can easily move through materials when an electric field is applied.

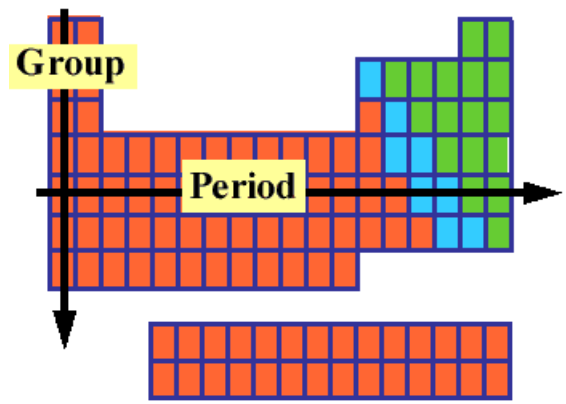


Current

- The flow of electrical charge per unit time (C/sec or Amps - André Marie Ampère 1775 - 1836)
  - Electrons flowing through conductors
    - Conductors have loosely bound outer shell electrons.
    - Insulators have tightly bound electrons in their outer shell.
  - Ions moving through liquids
- Speed of Electricity
  - Electrons flow slowly through a conductive medium
  - Changes in current flow move almost instantaneously
    - Forces between electrons propagate the change as an electromagnetic effect at speeds approaching that of light.
    - Approximately one foot per nanosecond (10^{-9}sec).

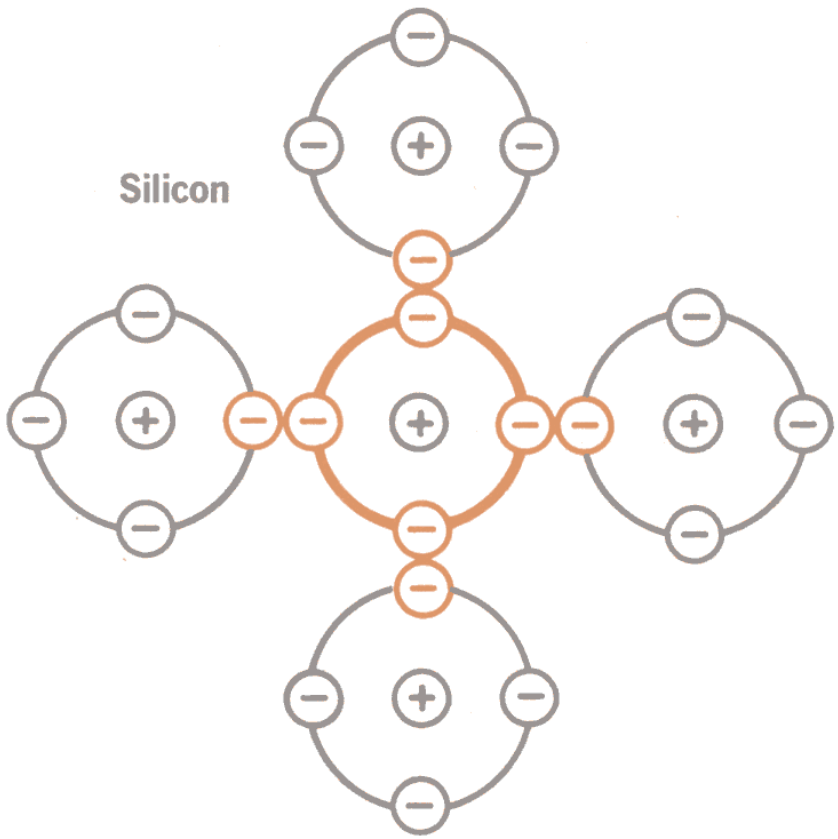
Semiconductors

- Group 4 materials (4 outer shell electrons)
  - Carbon (as diamond)
  - Silicon
  - Germanium
  - Tin and lead (not useful)
- Some compounds
  - Gallium Arsenide (GaAs - LEDs)
  - Indium Antimony (InSb – Photo Diodes)



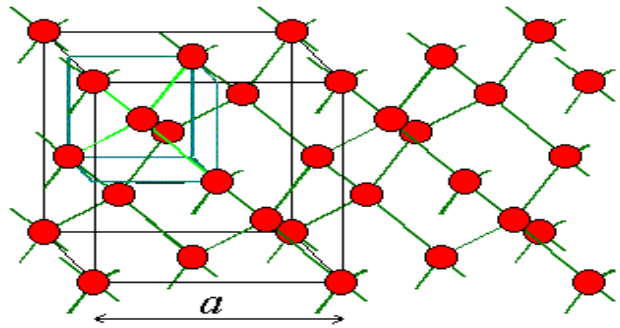
Covalent Bonds

- Crystalline silicon is formed when each of the four valence electrons forms a covalent chemical bond with a neighboring silicon atom. (no free electrons)

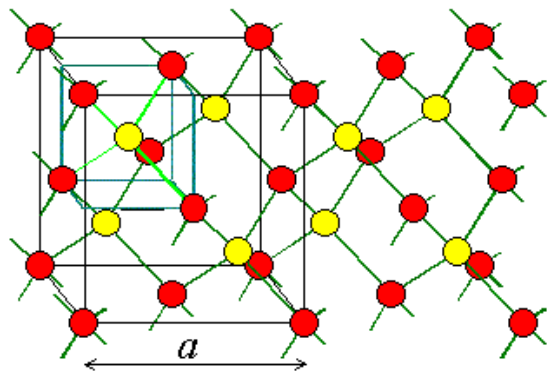


Semiconductor Crystals

The most common crystal structure among frequently used semiconductors (Si, Ge) is the diamond lattice, shown top right. Each atom in the diamond lattice has a covalent bond with four adjacent atoms, which together form a tetrahedron.



Compound semiconductors such as GaAs and InP have a crystal structure that is similar to that of diamond. However, the lattice contains two different types of atoms. Each atom still has four covalent bonds, but they are bonds with atoms of the other type



Current in Semiconductors

- If a pure crystal, there are no free valence electrons and therefore no current can flow
- N – Type
  - If a contaminant is diffused into the structure that has 5 electrons in the outer shell, there is now one free electron per contaminating atom and current can flow
- P – Type
  - If a contaminant is diffused into the structure that has 3 electrons in the outer shell, there is now one missing electron per contaminating atom and current can flow as moving “holes” in the crystal

PN Junctions

- If a semiconductor is doped such that a region of P-type is adjacent to a region of N-Type, The boundary is called a PN Junction
- Since the current is carried by different "Majority" carriers, strange things can happen at a PN Junction. You get a **Diode.**

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