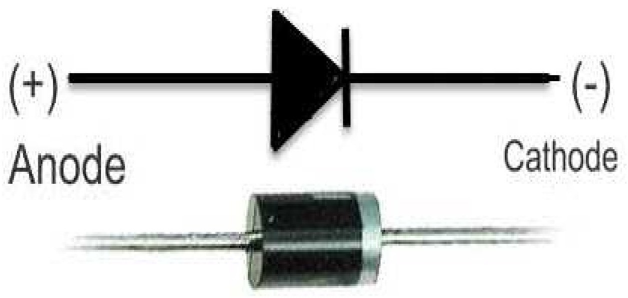

Unit 1
Electronic Circuits:

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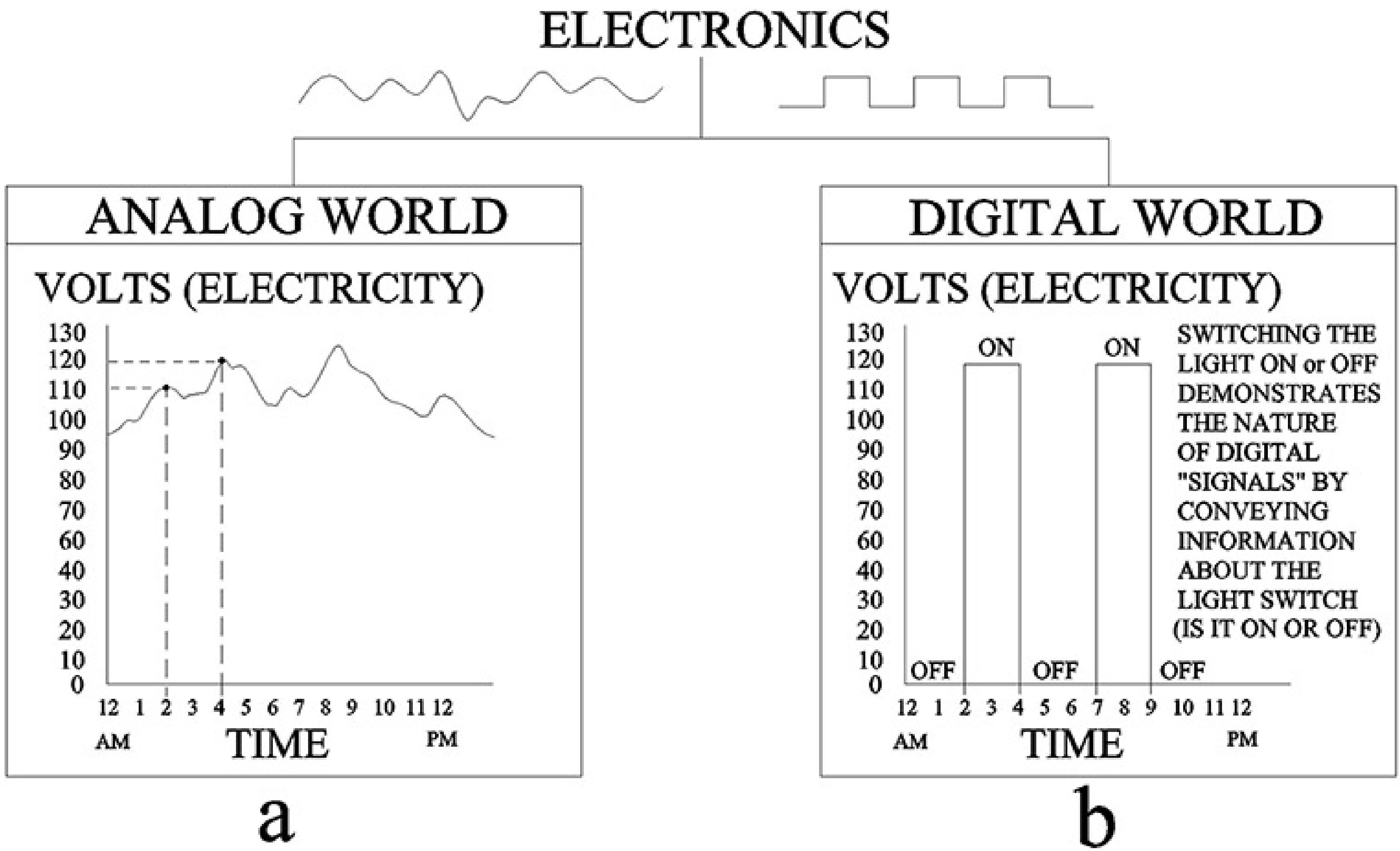
Syllabus

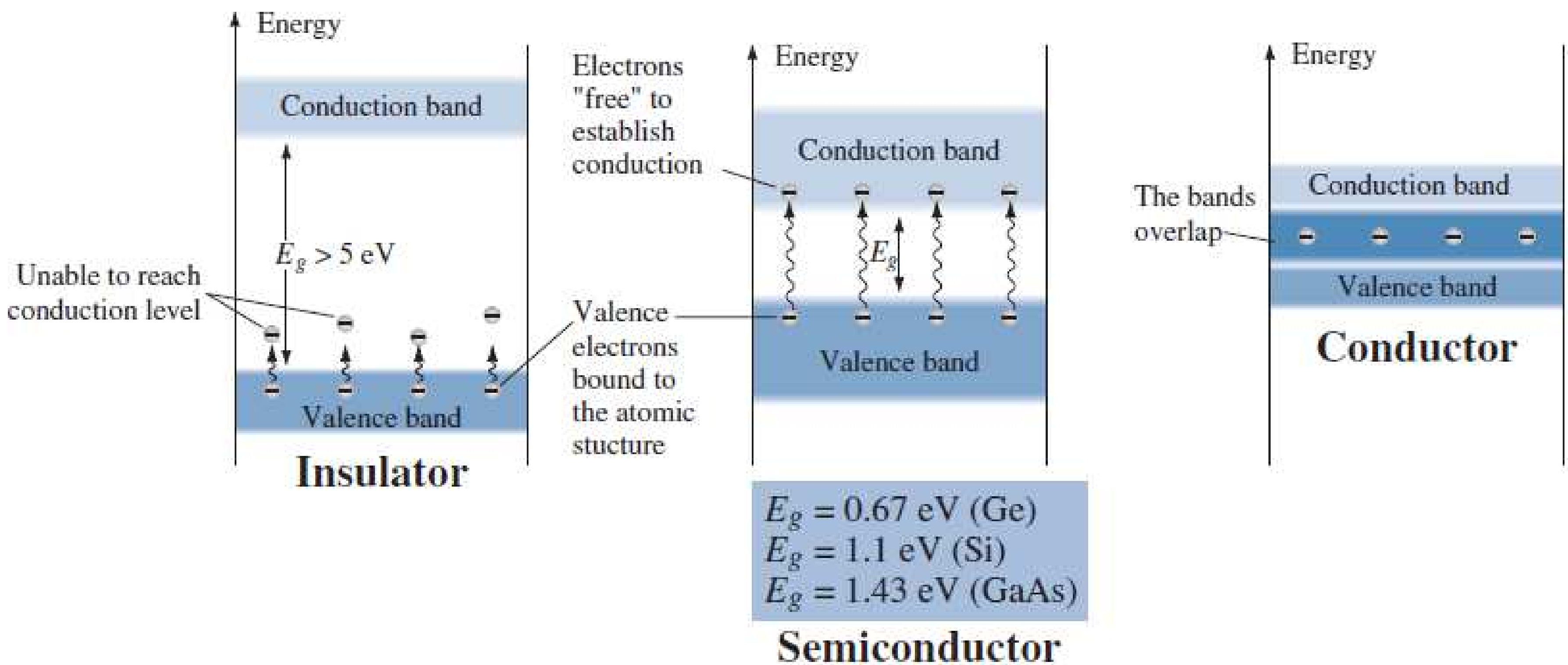
- **Power Supplies** – Block diagram, Rectifiers, Reservoir and smoothing circuits, Full-wave rectifiers, Bi-phase rectifier circuits, Bridge rectifier circuits, Voltage regulators, Output resistance and voltage regulation, Voltage multipliers
- **Amplifiers** – Types of amplifiers, Gain, Input and output resistance, Frequency response, Bandwidth, Phase shift, Negative feedback, Multi-stage amplifiers.
- **Operational amplifiers** - Operational amplifier parameters, Operational amplifier characteristics, Operational amplifier configurations, Operational amplifier circuits.
- **Oscillators** – Positive feedback, Conditions for oscillation, Ladder network oscillator, Wein bridge oscillator, Multivibrators, Single-stage astable oscillator, Crystal controlled oscillators.
- **Self-study topics:** BJT amplifier types, comparison of BJT & FET.


ELECTRONICS
ANALOG WORLD
VOLTS (ELECTRICITY)
130
120
110
100
90
80
70
60
40
30
20
10
0
12 1 2 3 4 5 6 7 8 9 10 11 12
AM
TIME
PM
DIGITAL WORLD
VOLTS (ELECTRICITY)
ON
ON
OFF
OFF
OFF
SWITCHING THE LIGHT ON or OFF DEMONSTRATES THE NATURE OF DIGITAL "SIGNALS" BY CONVEYING INFORMATION ABOUT THE LIGHT SWITCH (IS IT ON OR OFF)
12 1 2 3 4 5 6 7 8 9 10 11 12
AM
TIME
PM
a
b

Semiconductor

- What is semiconductor?
- Why do we need semiconductor?
- Semiconductor material
- Types of semiconductor
- Doping
- Majority and minority charge carriers

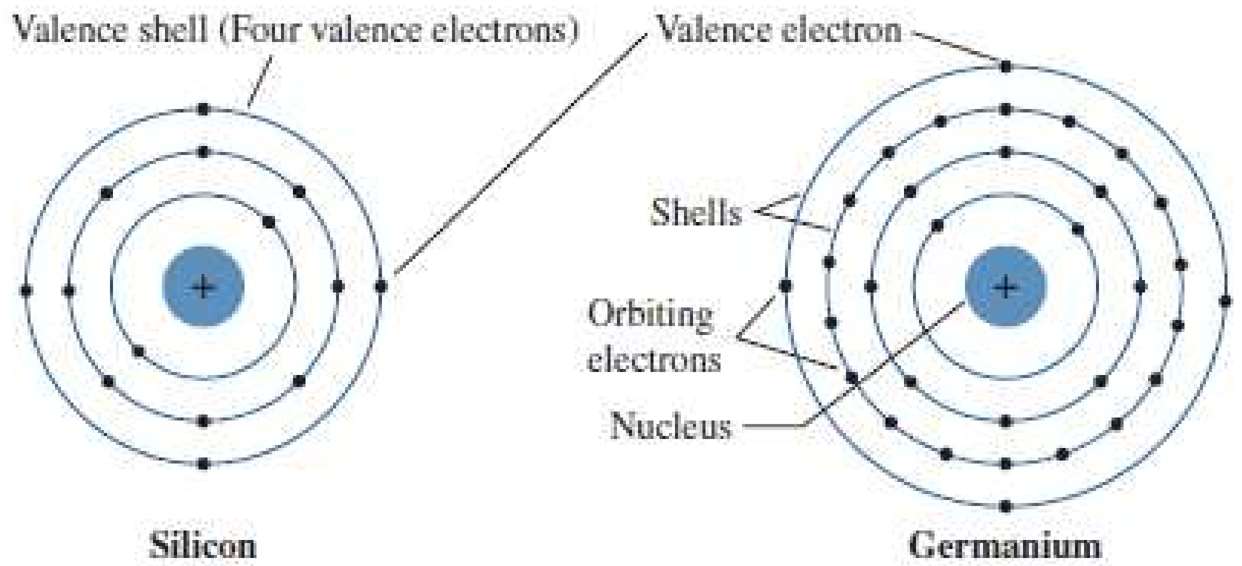
Energy Band Diagram



Two type of charge carriers in Semiconductor :

a) Electron
b) Hole

Silicon vs Germanium



Intrinsic Semiconductor

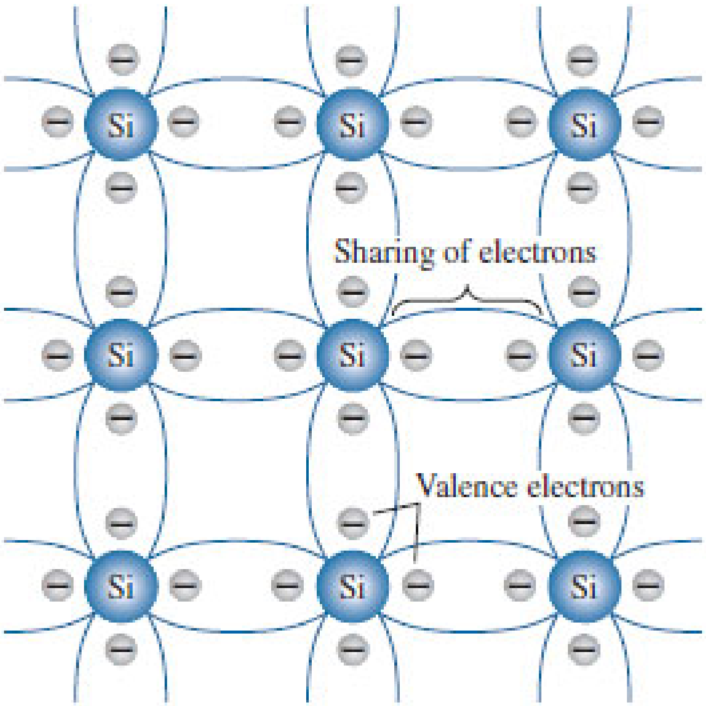


FIG. 4
Covalent bonding of the silicon atom.

$$n = p = n_i$$

- n_i is no. of charge carriers in intrinsic semiconductor
- Poor conductivity

Doping

- The process of adding impurities to pure SC.
- After doping, the SC becomes extrinsic SC.
- Doping increases the no of charge carriers and thereby increases the conductivity.
- Impurities can either be trivalent (or acceptor) impurity or pentavalent (or donor) impurity.
- Example of trivalent and pentavalent impurities are?

N-type Semiconductor or Donor

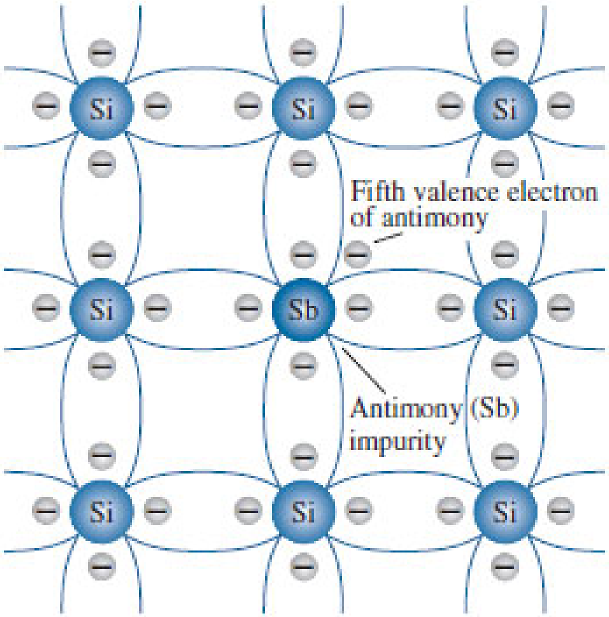
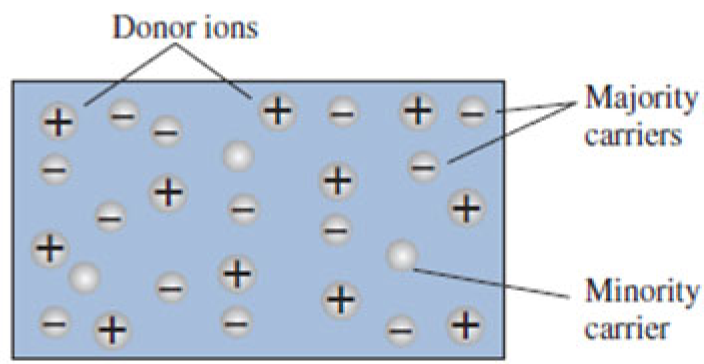


FIG. 7
Antimony impurity in n-type material.

- Impurity is pentavalent.
- Every impurity atom will be donating 1 electron, so called donor.
- Majority carriers are electrons.
- Minority carriers are holes.
- Conductivity due to minority carriers is negligible and current is mainly dominated by flow of electrons.



n-type

P-type Semiconductor or Acceptor

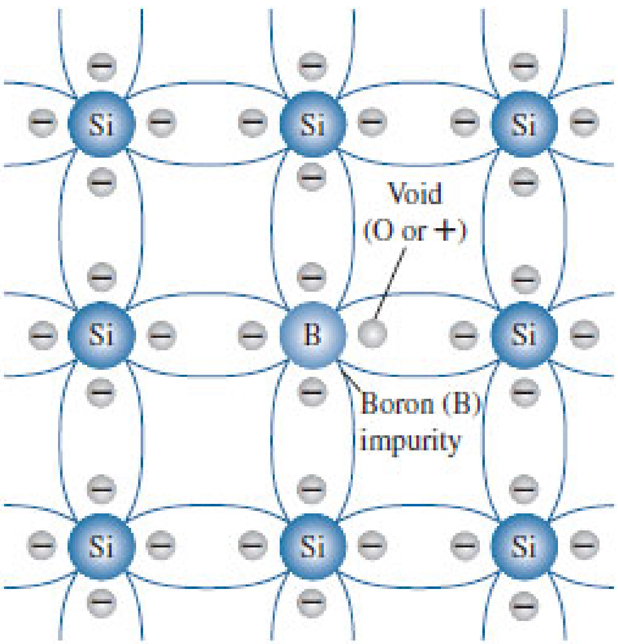
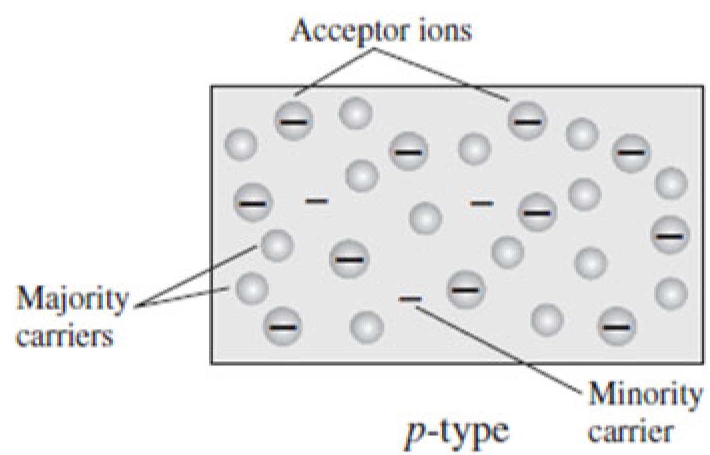
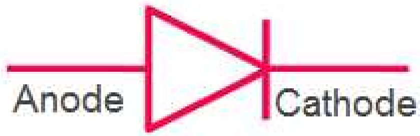


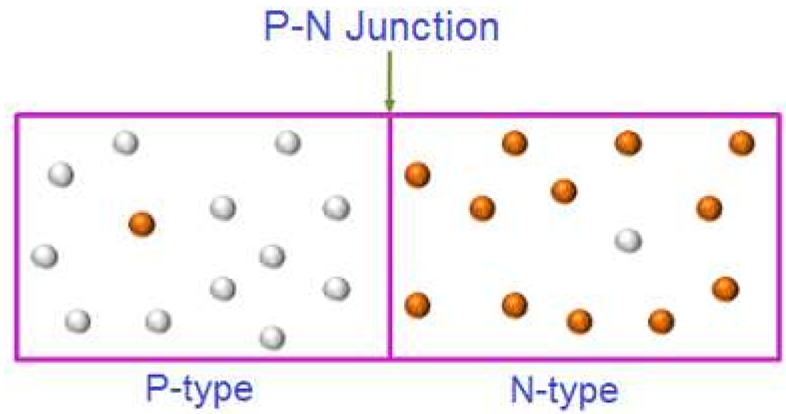
FIG. 9
Boron impurity in p-type material.

- Impurity is trivalent.
- Every impurity atom receive 1 electron to complete its covalent bonding so called acceptor.
- Majority carriers are holes.
- Minority carriers are electrons.
- Conductivity due to minority carriers is negligible and current is mainly dominated by flow of holes.

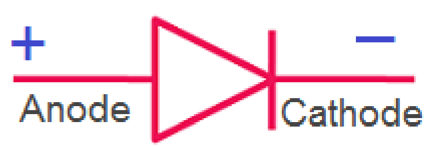


PN Junction Diode

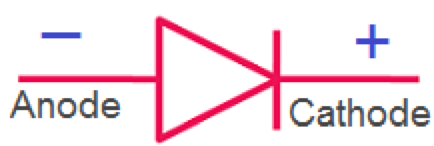




- Two-terminal unilateral device which allows the flow of current in only one direction.
- Anode and cathode are the two terminals.
- Diode offers low resistance hence permits current flow from Anode to Cathode.
- It offers high resistance or restricts the flow of current from Cathode to Anode.
- It can be biased (applying voltage across terminals of diode) in two ways: **Forward bias** and **Reverse bias.**
- Diode is a pn junction which permits current flow when forward biased and blocks current when reverse biased.



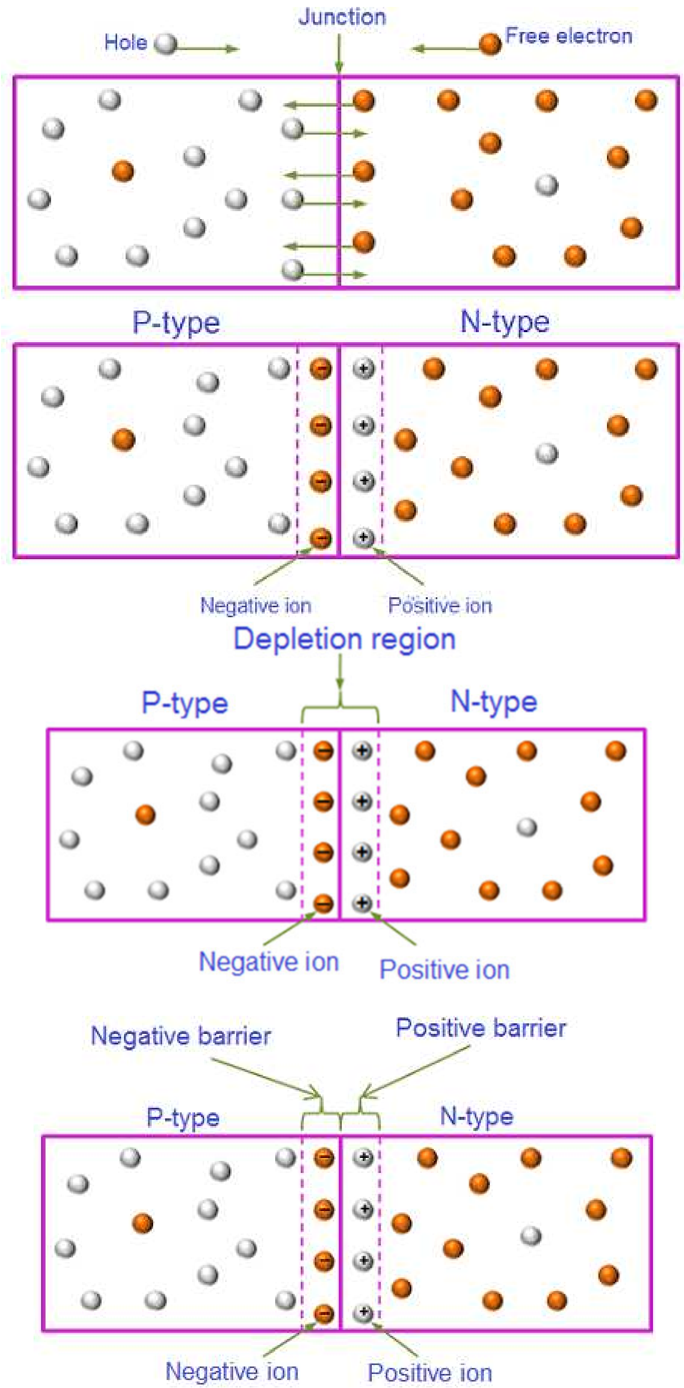
Forward biased



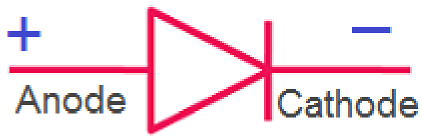
Reverse biased

Unbiased Diode

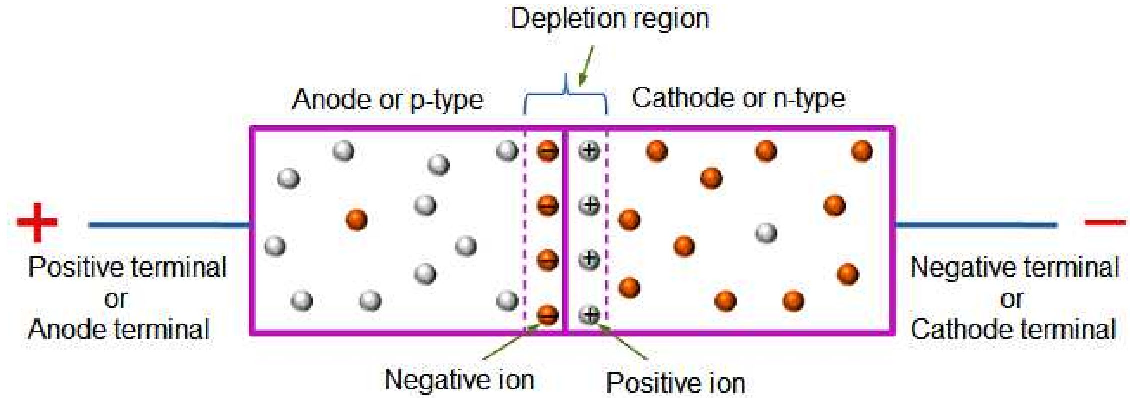
- No voltage applied across the junction.
- Majority holes on p side start diffusing into n side.
- Majority free electrons on n side start diffusing into p side.
- Positive immobile ions are formed on n side and negative ions on p side near the junction, this is called depletion region.
- In equilibrium condition, depletion region widens up to a point where no further electrons or holes can cross the junction. This acts as a barrier.
- Potential difference across depletion region is called barrier potential/junction potential/built-in voltage/cut-in potential.
- Net current in unbiased diode is zero.



Forward Biased Diode



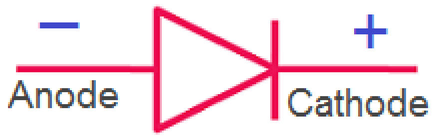
Forward biased



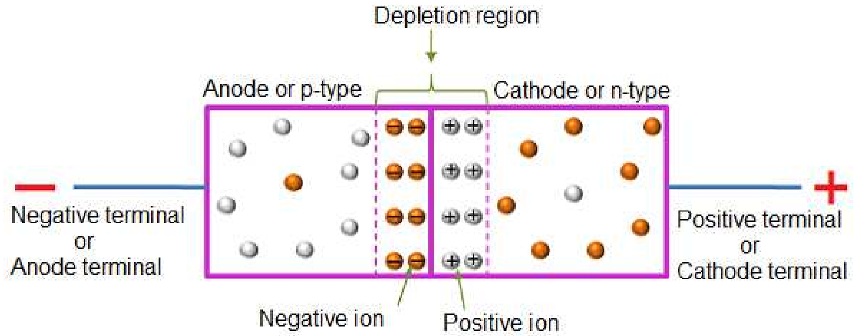
Forward biased

- P region is connected to positive and n region is connected to negative of dc supply.
- Negative of the battery pushes free electrons across the depletion region, provided the applied voltage exceeds barrier voltage. Similarly, negative of the battery pushes holes against barrier from p to n region
- Barrier voltage for Si diode is 0.7 V and Ge diode is 0.3 V.
- Due to this width of the depletion region reduces and barrier potential also reduces.
- Majority carriers cross the junction.
- Hence current starts flowing from p to n side (Anode to cathode terminal)-Forward current.

Reverse Biased Diode



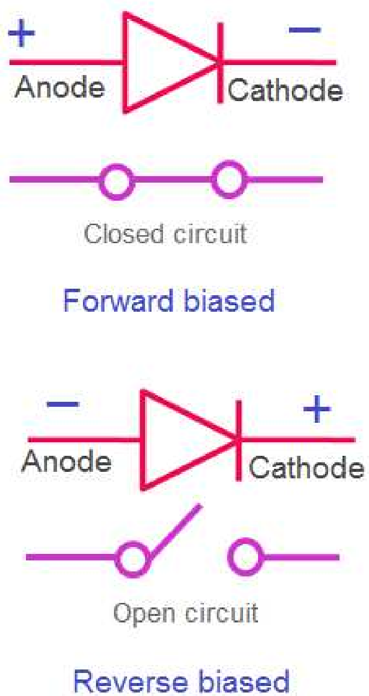
Reverse biased



Reverse biased

- P region is connected to negative and n region to positive of the dc voltage.
- Negative of the battery attracts holes in p region and positive of the battery attracts electrons in n region.
- Majority charge carriers move away from the junction.
- Depletion region widens and barrier potential increases.
- Resistance of diode is high.
- Due to increased barrier potential, free electrons on p side are attracted towards positive while holes towards negative of the battery.
- There is a very small reverse current due to the flow of minority carriers.
- Reverse current is constant though reverse voltage is increased upto a limit. It is called reverse saturation current.
- Minority charge carriers are thermally generated hence is temperature dependant.
- Reverse current is in order of micro amperes for Ge and few nano amperes for Si diodes.

Diode Approximations : Ideal Diode



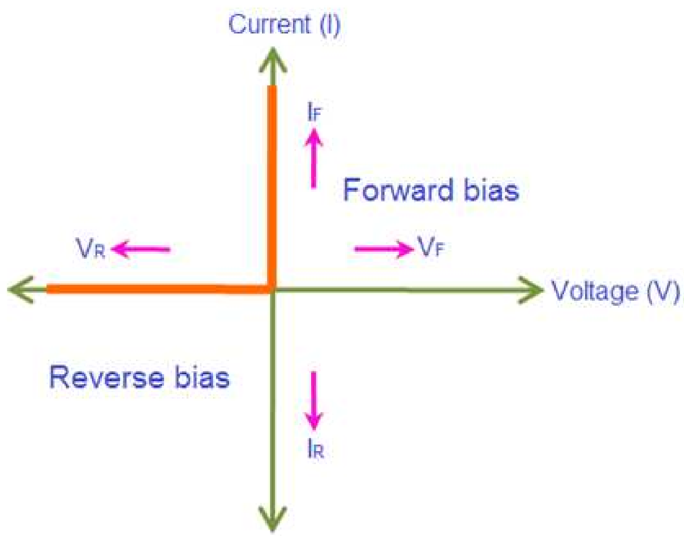


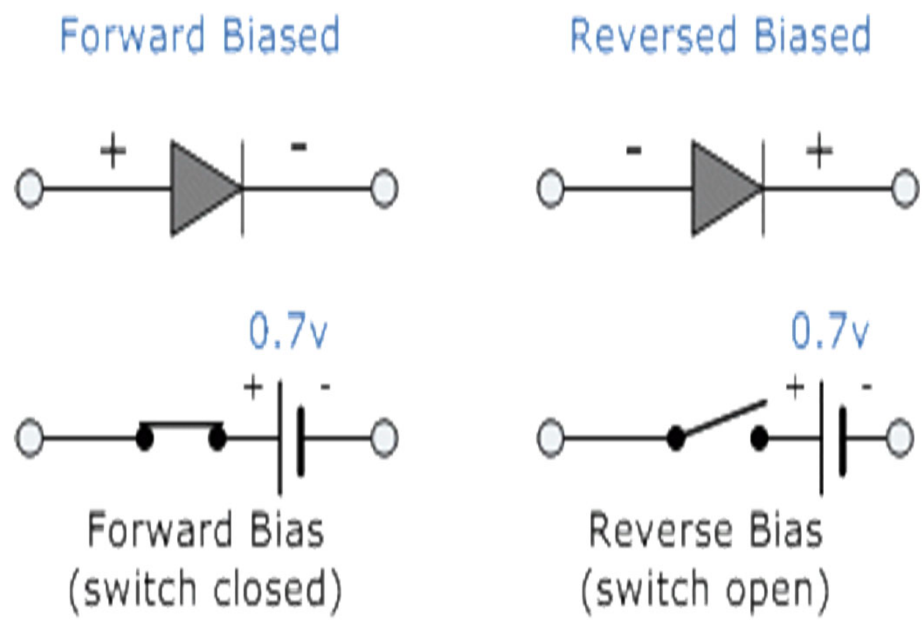
Fig: V-I characteristics of ideal diode

- Ideal diode FB → Short circuit (SC).
- Ideal diode RB → Open circuit (OC).

- Under FB, ideal diode acts as a perfect conductor with zero resistance (Rf=0).
- Under RB, it acts as a perfect insulator with infinite resistance (Rr=∞).
- Ideal diode does not have depletion region, which resist the flow of electric current. Hence, ideal diode has no voltage drop or voltage loss ($V\gamma=0$).

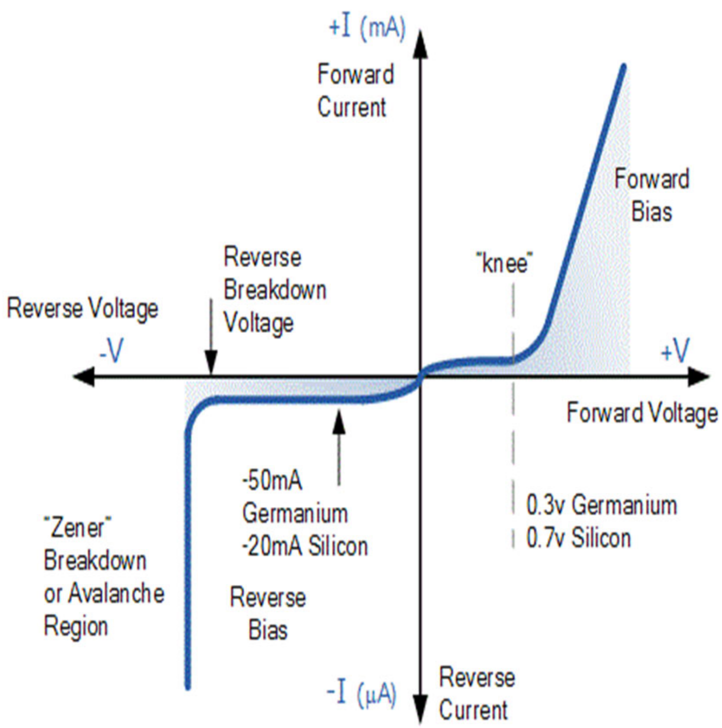
Diode Approximations : Non-ideal (Practical) Diode

- When a practical diode is FB, it acts as a practical voltage source.
- When a practical diode is RB, it is replaced with a high resistance.



Constant voltage drop model

Current Voltage or I-V Characteristics of Diode



- First quadrant indicates the behaviour of diode when forward biased
- Current is nearly zero when forward voltage is less than knee or barrier voltage
- As forward voltage exceeds barrier voltage, current increases exponentially
- Third quadrant indicates the characteristics of reverse biased diode
- As the reverse voltage is increased, reverse current increases initially but after a small voltage becomes constant equal to reverse saturation current. Though reverse voltage is increased the reverse current remains constant.
- At reverse breakdown voltage, breakdown of diode occurs and current increases sharply damaging the diode.