

Unit 1

Electronic Circuits:



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Syllabus

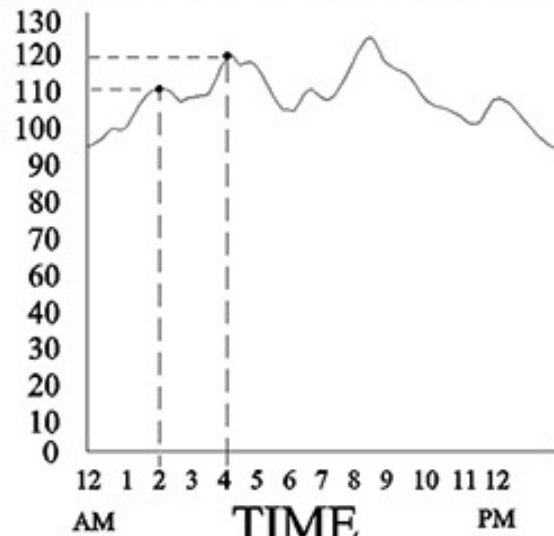
- **Power Supplies** – Block diagram, Rectifiers, Reservoir and smoothing circuits, Full-wave rectifiers, Bi-phase rectifier circuits, Bridge rectifier circuits, Voltage regulators, Output resistance and voltage regulation, Voltage multipliers
- **Amplifiers** – Types of amplifiers, Gain, Input and output 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

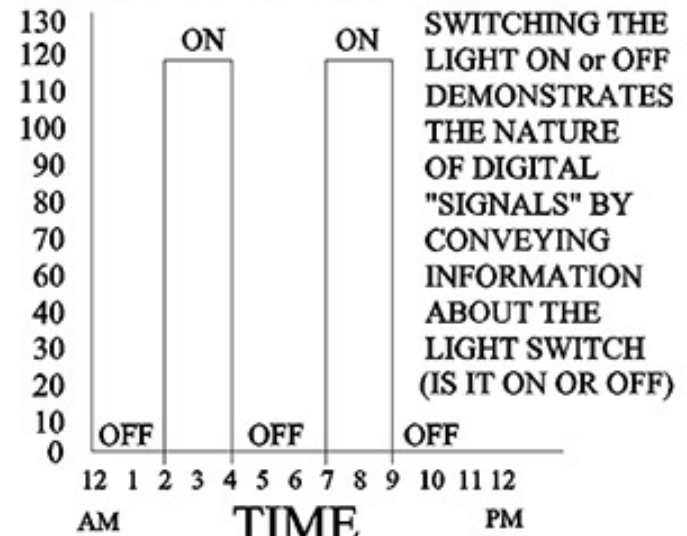
VOLTS (ELECTRICITY)



a

DIGITAL WORLD

VOLTS (ELECTRICITY)

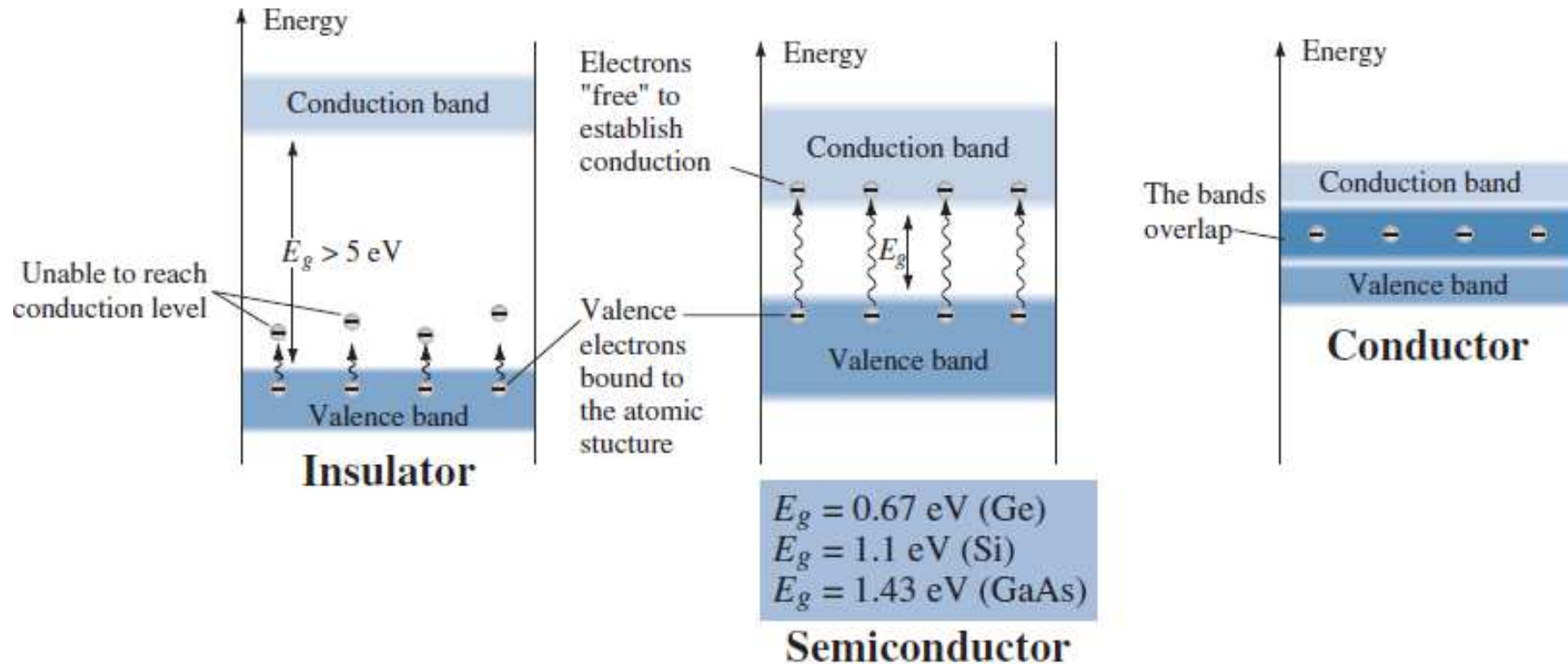


b

Semiconductor

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

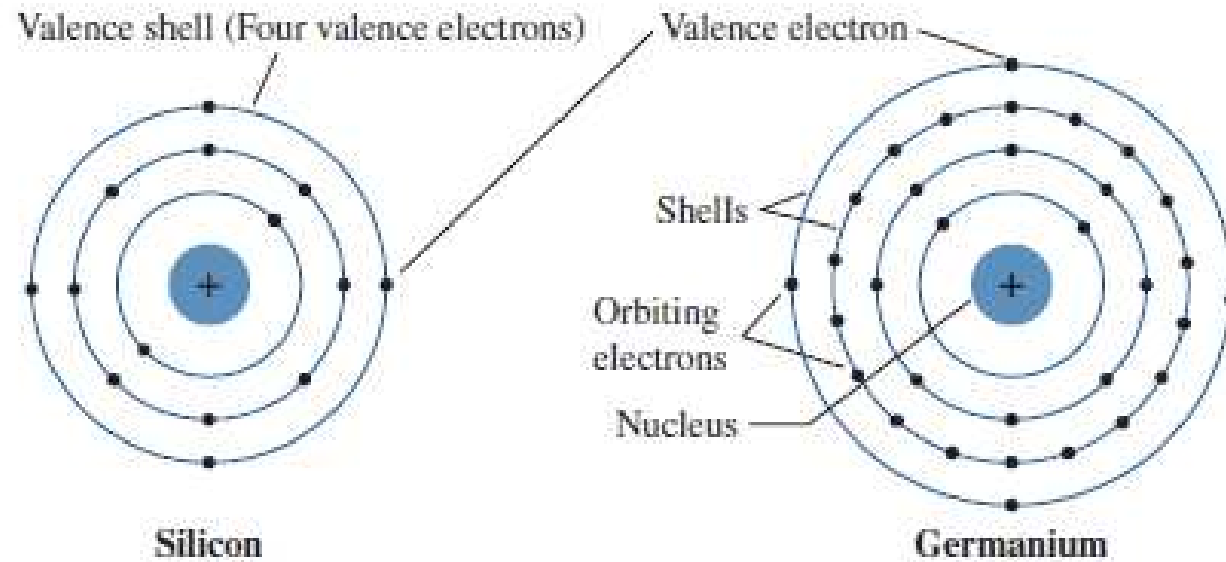
Energy Band Diagram



Two type of charge carriers in Semiconductor :

- a) Electron
- b) Hole

Silicon vs Germanium



Intrinsic Semiconductor

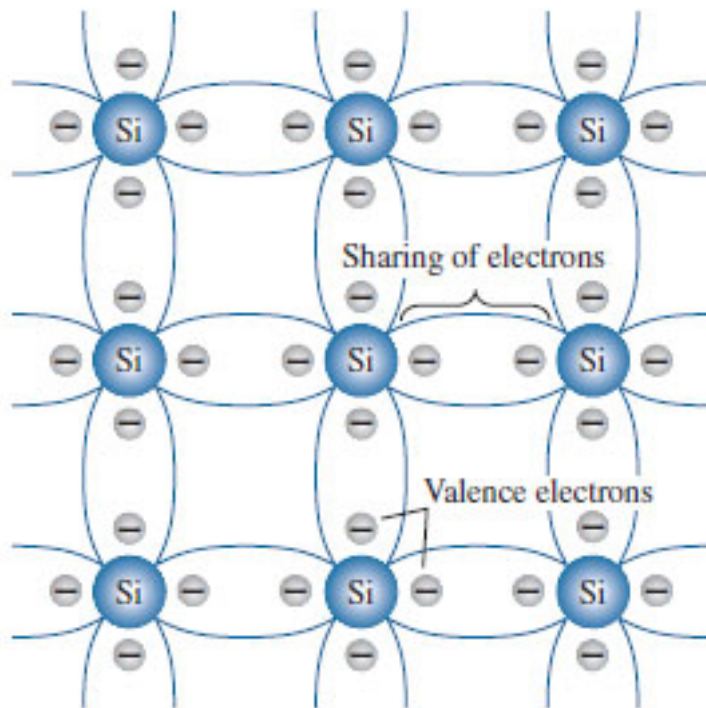


FIG. 4

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

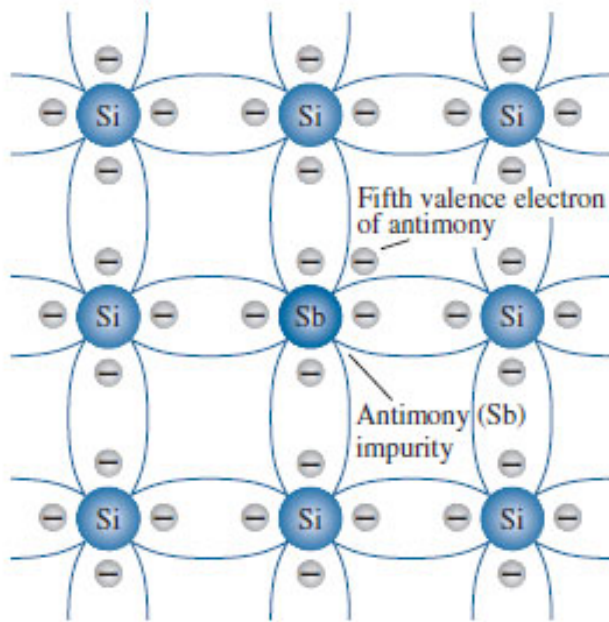
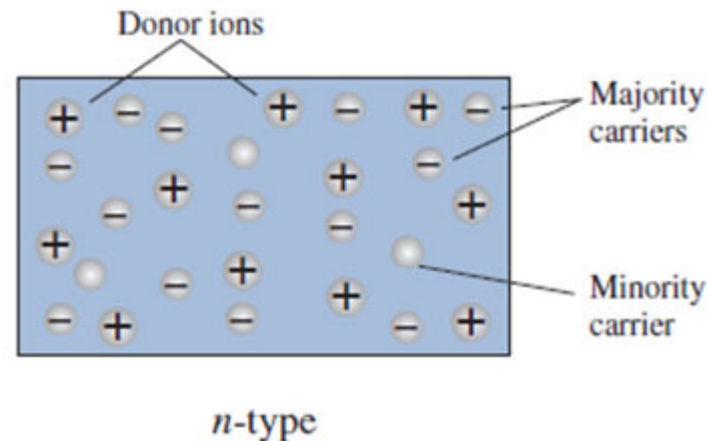


FIG. 7

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.



P-type Semiconductor or Acceptor

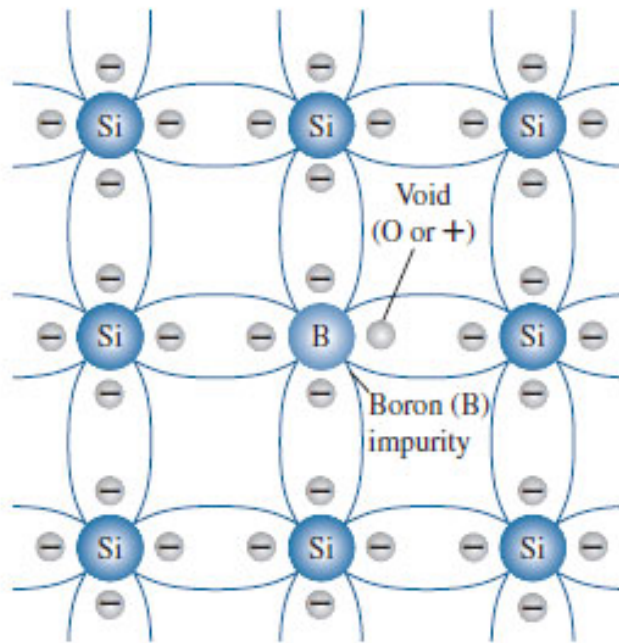
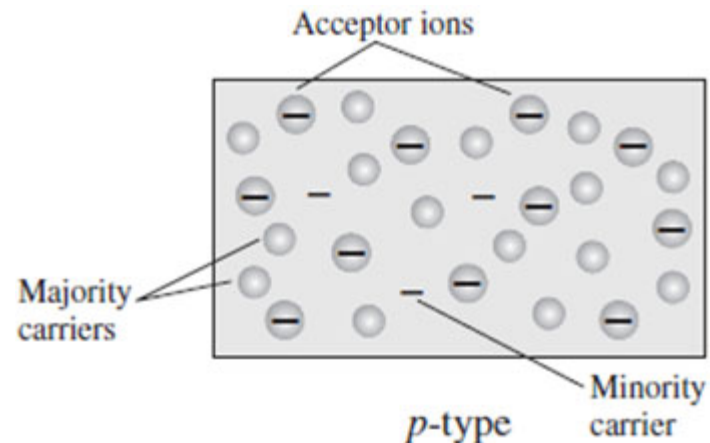


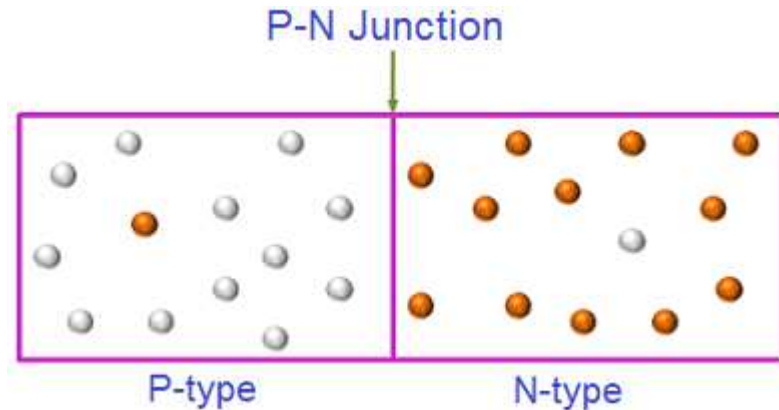
FIG. 9

Boron impurity in p-type material.

- Impurity is trivalent.
- Every impurity atom receives 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.



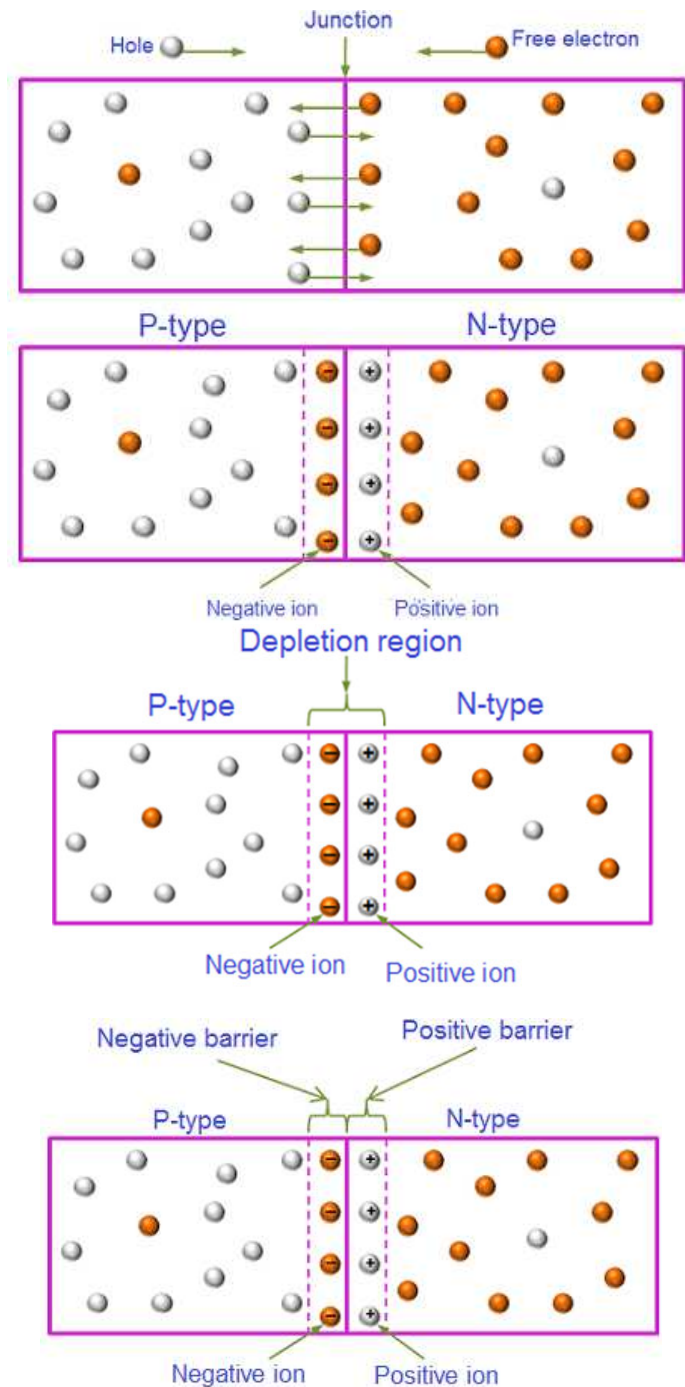
Forward biased



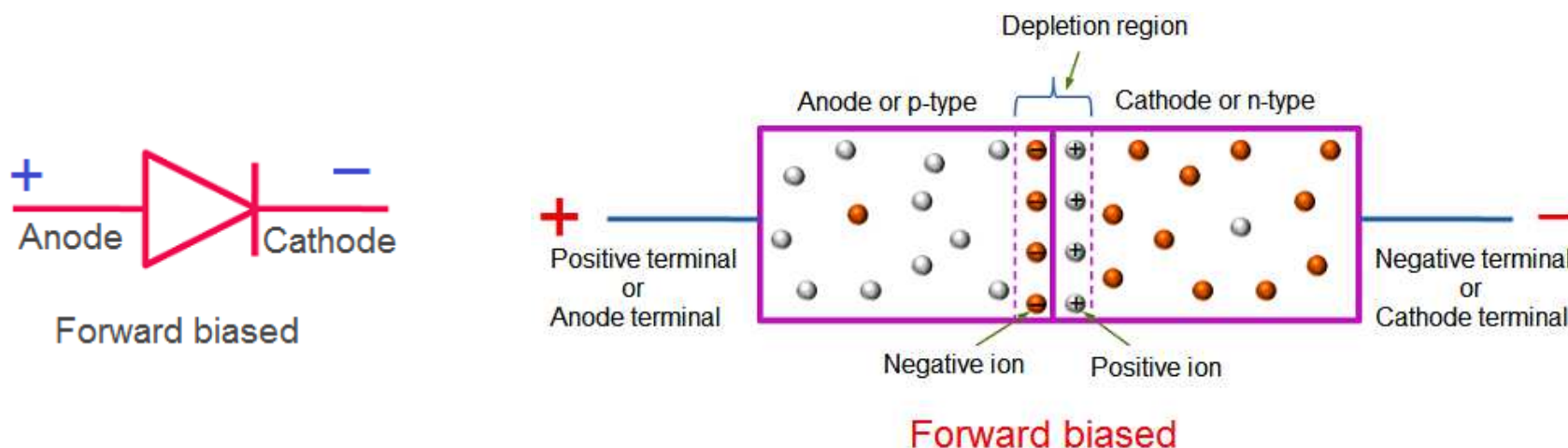
Reverse biased

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

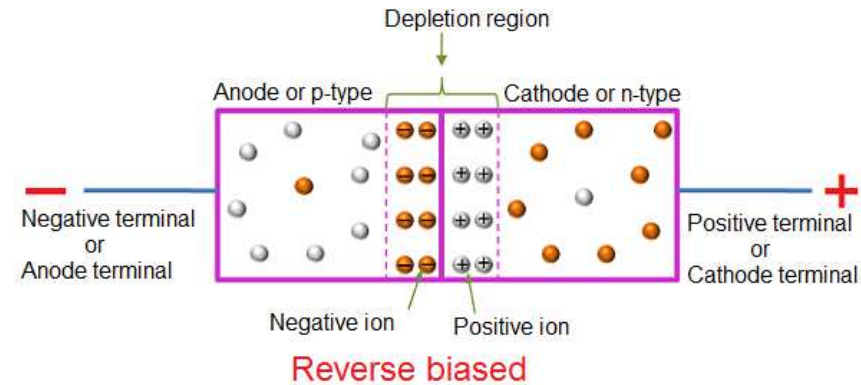


- P region is connected to positive and n region is connected to negative of dc supply.
- Negative of the battery pushes free electrons across the depletion region, provided the applied voltage exceeds barrier voltage. Similarly, negative of the battery pushes holes against barrier from p to n region
- 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

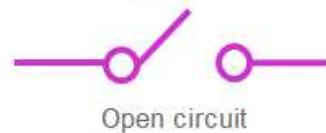
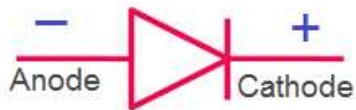


- P region is connected to negative and n region to positive of the dc voltage.
- Negative of the battery attracts holes in p region and positive of the battery attracts electrons in n region.
- Majority charge carriers move away from the junction.
- Depletion region widens and barrier potential increases.
- 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



Forward biased



Reverse biased

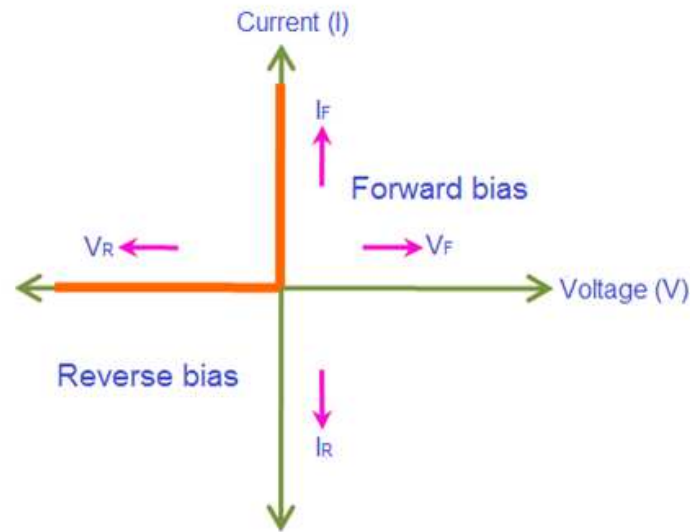
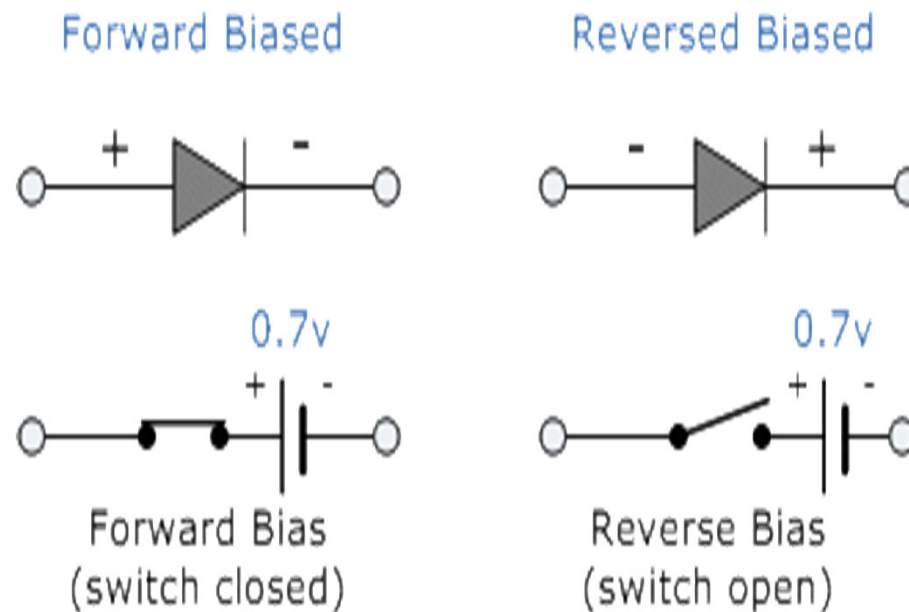


Fig: V-I characteristics of ideal diode

- Ideal diode FB \rightarrow Short circuit (SC).
- Ideal diode RB \rightarrow Open circuit (OC).
- Under FB, ideal diode acts as a perfect conductor with zero resistance ($R_f=0$).
- Under RB, it acts as a perfect insulator with infinite resistance ($R_r=\infty$).
- Ideal diode does not have depletion region, which resist the flow of electric current. Hence, ideal diode has no voltage drop or voltage loss ($V_\gamma=0$).

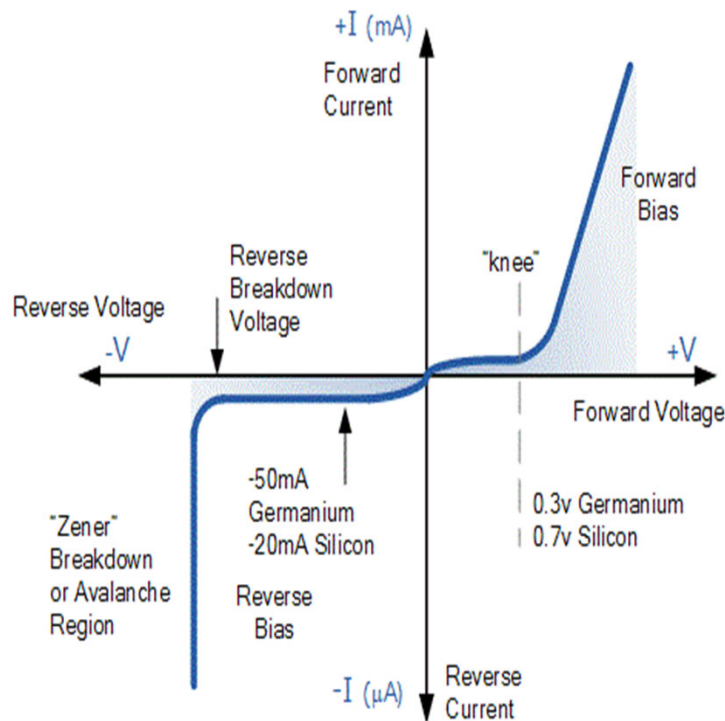
Diode Approximations : Non-ideal (Practical) Diode

- 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.