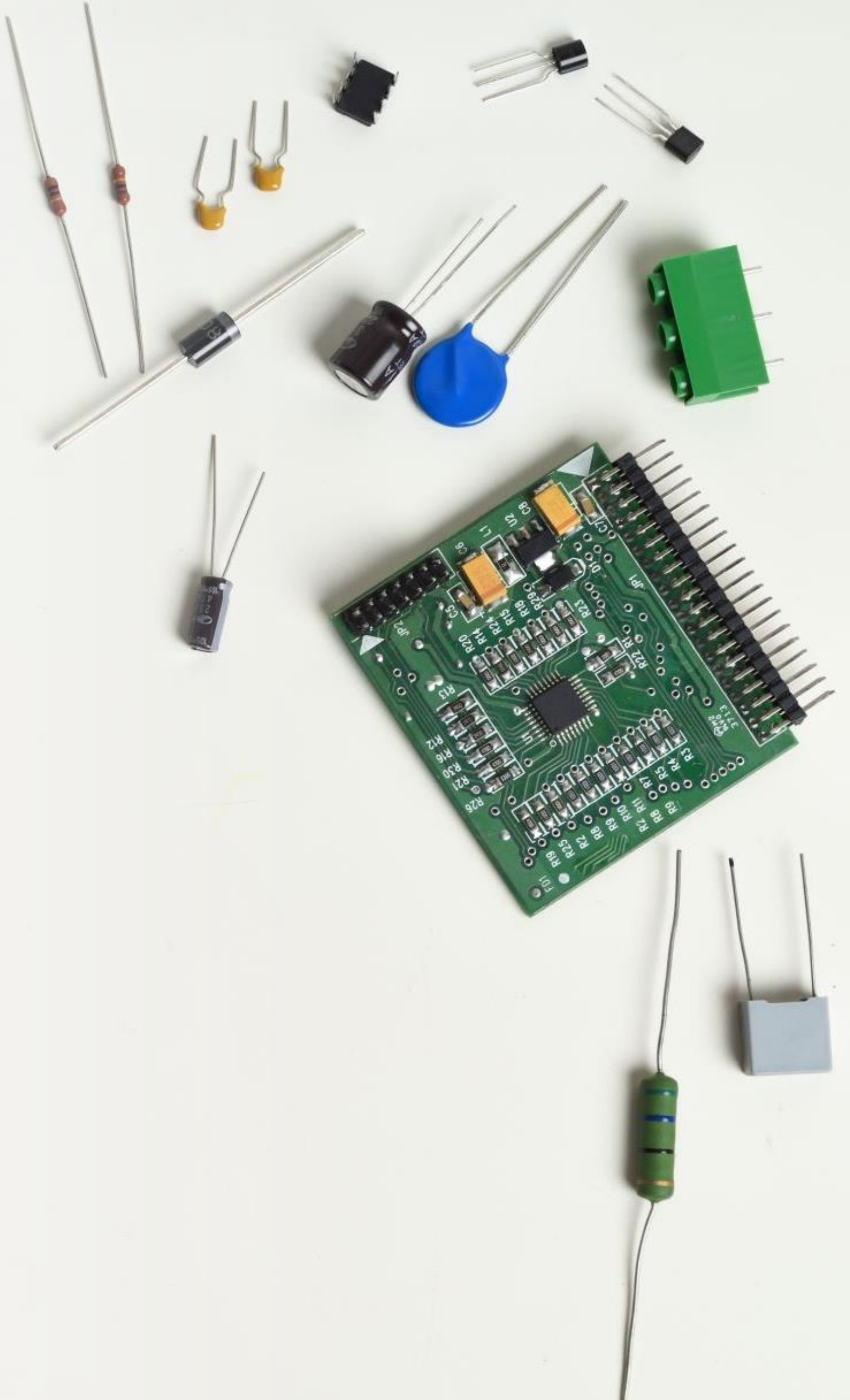
104010 : BASIC ELECTRONICS ENGINEERING

UNIT I

Introduction to Electronics



PN Junction

- *p*-type
  - Silicon atoms and trivalent impurity atoms.
  - Impurity(Boron) adds a hole when it bonds with the silicon atoms.
  - The number of protons and the number of electrons is equal throughout the material.
  - No net charge in the material and so it is neutral.

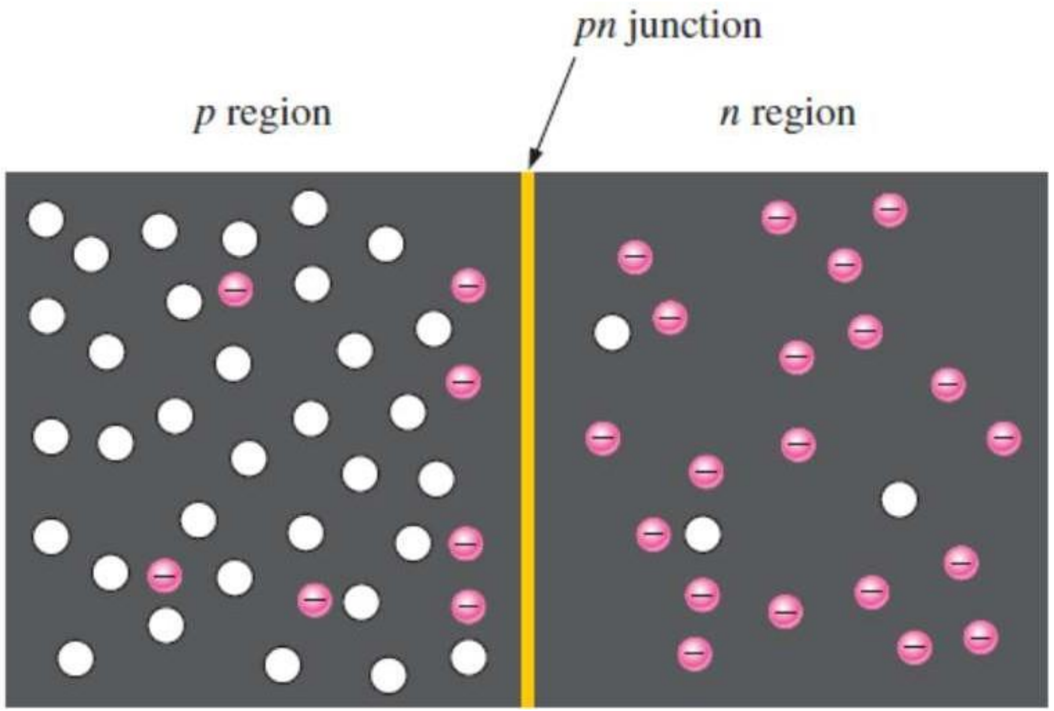
- *n*-type
  - Silicon atoms and pentavalent impurity atoms such as antimony.
  - Impurity atom releases an electron when it bonds with four silicon atoms.
  - Since there is still an equal number of protons and electrons (including the free electrons) throughout the material.
  - No net charge in the material and so it is neutral.

PN Junction

- Piece of intrinsic silicon is doped so that part is *n*-type and the other part is *p*-type.
- A **PN junction** forms at the boundary between the two regions.
- It is called **Diode.**
- *p* Region
  - Many holes (majority carriers)
  - Only a few thermally generated free electrons (minority carriers)
- *n* Region
  - Many free electrons (majority carriers) from
  - Few thermally generated holes (minority carriers)

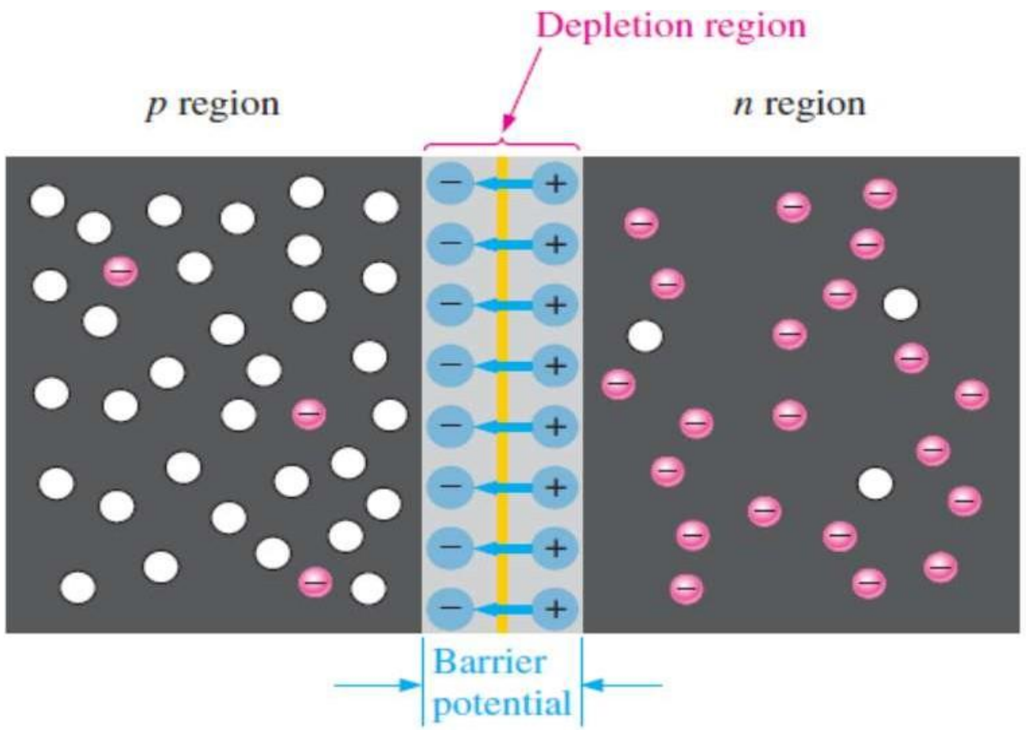
PN Junction

- The basic silicon structure at the instant of junction formation showing only the majority and minority carriers.
- Free electrons in the *n* region near the *pn* junction begin to diffuse across the junction and fall into holes near the junction in the *p* region.



PN Junction

- For every electron that diffuses across the junction and combines with a hole, a positive charge is left in the *n* region.
- A negative charge is created in the *p* region, forming a barrier potential.
- This action continues until the voltage of the barrier repels further diffusion.
- The blue arrows between the positive and negative charges in the depletion region represent the electric field.



Formation of Depletion Region

- The free electrons in the n region are randomly drifting in all directions. At the instant of the pn junction formation, the free electrons near the junction in the n region begin to diffuse across the junction into the p region where they combine with holes near the junction.
- Before the *pn* junction is formed, the material is neutral in terms of net charge.
- As the *pn* junction is formed, the *n* region loses free electrons as they diffuse across the junction.
- This creates a layer of positive charges (pentavalent ions) near the junction.
- As the electrons move across the junction, the *p* region loses holes as the electrons and holes combine.
- This creates a layer of negative charges (trivalent ions) near the junction.
- These two layers of positive and negative charges form the **depletion region.**

Barrier Potential

- Any time there is a positive charge and a negative charge near each other, there is a force acting on the charges as described by Coulomb's law.
- In the depletion region there are many positive charges and many negative charges on opposite sides of the *pn* junction.
- The forces between the opposite charges form an *electric field.*
- This electric field is a barrier to the free electrons in the *n* region, and energy must be expended to move an electron through the electric field.
- External energy must be applied to get the electrons to move across the barrier of the electric field in the depletion region.

Barrier Potential

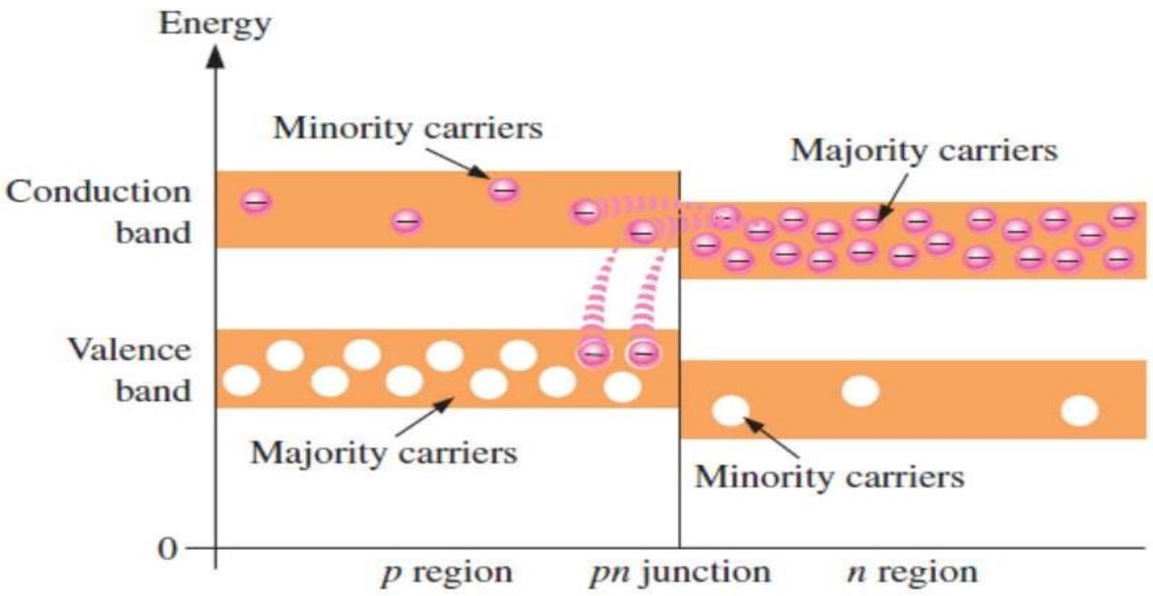
- The potential difference of the electric field across the depletion region is the amount of voltage required to move electrons through the electric field.
- This potential difference is called the **barrier potential** and is expressed in volts.
- The barrier potential of a *pn* junction depends on several factors, including the type of semiconductive material, the amount of doping, and the temperature.
- The typical barrier potential is approximately 0.7 V for Silicon and 0.3 V for Germanium at 25° C.

Energy Bands

- The valence and conduction bands in an *n*-type material are at slightly lower energy levels than the valence and conduction bands in a *p*-type material.
- *p*-type material has trivalent impurities and *n*-type material has pentavalent impurities.
- The trivalent impurities exert lower forces on the outer-shell electrons than the pentavalent impurities.
- The lower forces in *p*-type materials mean that the electron orbits are slightly larger and hence have greater energy than the electron orbits in the *n*-type materials.

Energy Bands

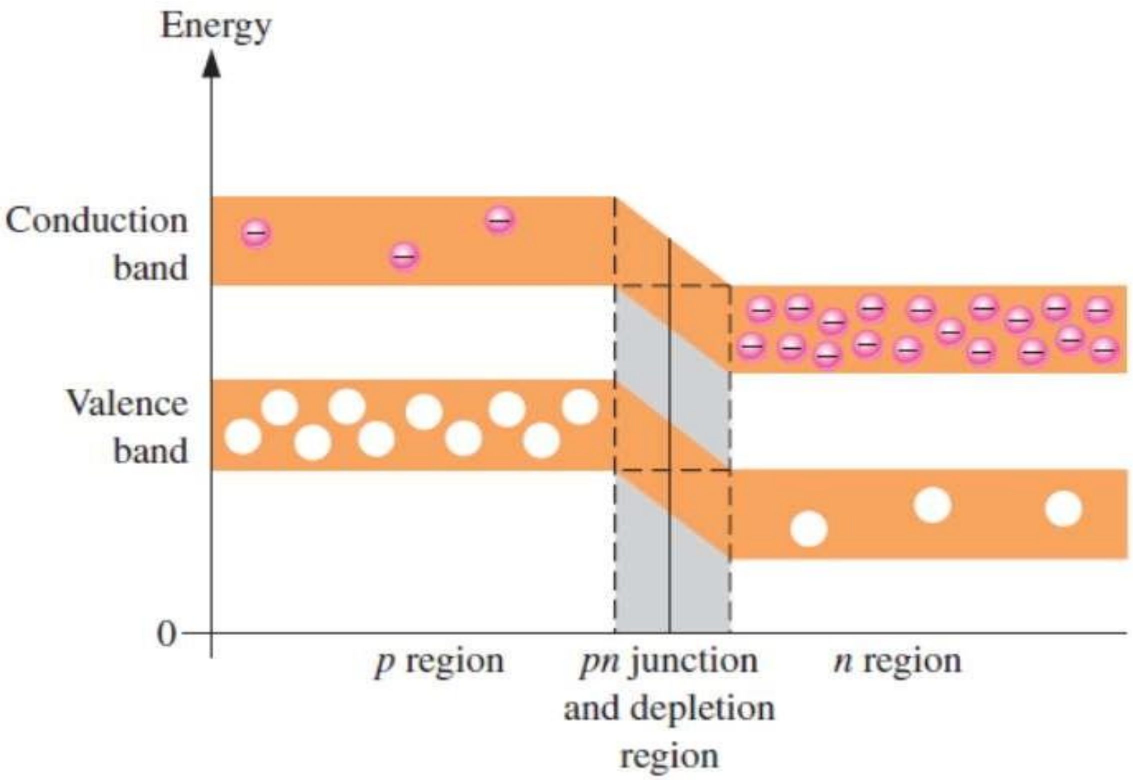
- An energy diagram for a *pn* junction at the instant of formation is shown in Figure. The valence and conduction bands in the *n* region are at lower energy levels than those in the *p* region, but there is a significant amount of overlapping.
- The free electrons in the *n* region that occupy the upper part of the conduction band in terms of their energy can easily diffuse across the junction (they do not have to gain additional energy) and temporarily become free electrons in the lower part of the *p*-region conduction band.
- After crossing the junction, the electrons quickly lose energy and fall into the holes in the *p*-region valence band as indicated in Figure.



(a) At the instant of junction formation

Energy Bands

- As the diffusion continues, the depletion region begins to form and the energy level of the n-region conduction band decreases.
- The decrease in the energy level of the conduction band in the *n* region is due to the loss of the higher-energy electrons that have diffused across the junction to the *p* region.



(b) At equilibrium

Energy Bands

- There are no electrons left in the *n*-region conduction band with enough energy to get across the junction to the *p*-region conduction band, indicated by the alignment of the top of the *n*-region conduction band and the bottom of the *p*-region conduction band. At this point, the junction is at equilibrium; and the depletion region is complete because diffusion has ceased.
- As the energy level of the *n*-region conduction band has shifted downward, the energy level of the valence band has also shifted downward.
- There is an energy gradiant across the depletion region which acts as an "energy hill" that an n-region electron must climb to get to the p region.
- It still takes the same amount of energy for a valence electron to become a free electron.
- In other words, the energy gap between the valence band and the conduction band remains the same.

Acknowledgements

1. Electronic Devices, Thomas L. Floyd
2. Web Resources

Thank You..