SNS COLLEGE OF TECHNOLOGY
Coimbatore-35
An Autonomous Institution

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

23ECB101 – CIRCUIT ANALYSIS AND DEVICES

I YEAR/ II SEMESTER

UNIT 4 – SEMICONDUCTOR DIODES AND THEIR APPLICATIONS

TOPIC - Formation of P-N junction

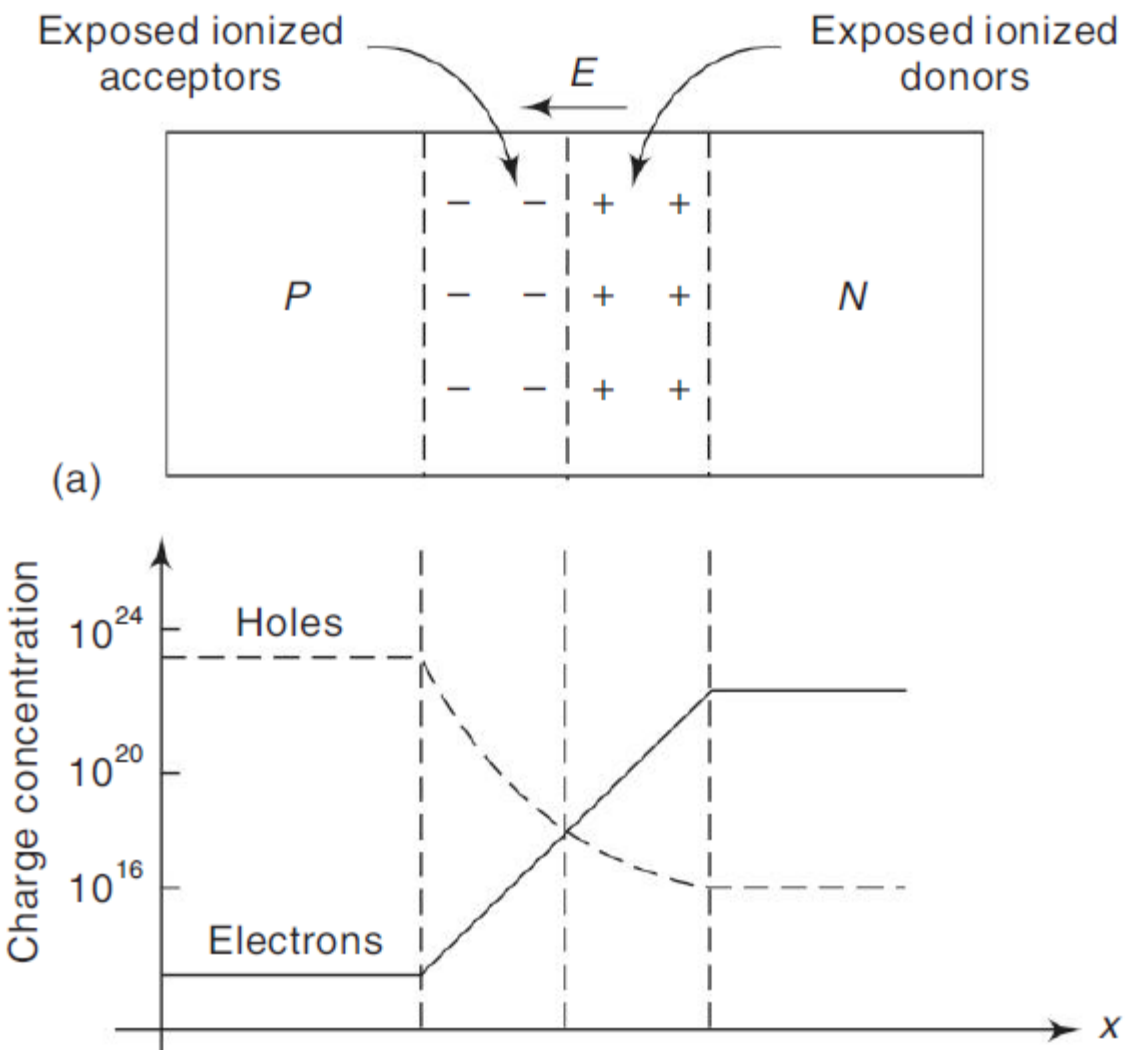
Introduction

- The PN junction diode is one of the semiconductor devices with two semiconductor materials in physical contact, one with excess of **holes (P-type)** and other with excess of **electrons (N-type).**
- A PN junction diode may be formed from a single crystal intrinsic semiconductor by doping part of it with *acceptor impurities and the remaining with donors*.
- Such junctions can form the basis of very efficient rectifiers.
- The most important characteristic of a PN junction is its ability to allow the flow of current in only one direction.
- In the opposite direction, it offers very high resistance. The high vacuum diode has largely been replaced by silicon and selenium rectifiers.

- Semiconductor diodes find wide applications in all phases of electronics, viz.
  - Radio and TV
  - Optoelectronics
  - Power Supplies
  - Industrial Electronics
  - Instrumentation
  - Computers, etc.

Theory of PN Junction Diode

- In a piece of semiconductor material, if *one half is doped by P-type impurity and the other half is doped by N-type impurity*, a PN junction is formed.
- The plane dividing the two halves or zones is called the **PN junction**.
- As shown in Figure, the N-type material has high concentration of *free electrons*, while the P-type material has high concentration of *holes*.
- Therefore, at the junction there is a tendency for the free electrons to diffuse over to the P-side and holes to the N-side.
- This process is called **diffusion**.


Exposed ionized acceptors
E
Exposed ionized donors
P
N
(a)
Charge concentration
10^{24}
10^{20}
10^{16}
Holes
Electrons
x

- As the free electrons move across the junction from N-type to P-type, the donor ions become *positively charged*.
- Hence, a positive charge is built on the N-side of the junction.
- The free electrons that cross the junction uncover the negative acceptor ions by filling in the holes.
- Therefore, a net negative charge is established on the P-side of the junction.
- This net negative charge on the P-side prevents further diffusion of electrons into the P-side.
- Similarly, the net positive charge on the N-side repels the hole crossing from P-side to N-side.
- Thus, a barrier is set up near the junction which prevents further movement of charge carriers, i.e., electrons and holes.

- As a consequence of the induced electric field across the depletion layer, an electrostatic potential difference is established between P- and N-regions, which is called the *potential barrier, junction barrier, diffusion potential, or contact potential*, Vo.
- The magnitude of the contact potential Vo varies with doping levels and temperature.
- The electrostatic field across the junction caused by the positively charged N-type region tends to drive the *holes away* from the junction
- And negatively charged P-type region tends to drive the *electrons away* from the junction.

- The majority holes diffusing out of the P-region leave behind negatively charged acceptor atoms bound to the lattice, thus exposing negative space charge in a previously neutral region.
- Similarly, electrons diffusing from the N-region expose *positively ionized donor atoms*, and a double-space-charge layer builds up at the junction
- It is noticed that the space-charge layers are of opposite sign to the majority carriers diffusing into them, which tends to reduce the diffusion rate.
- Thus, the double space of the layer causes an electric field to be set up across the junction directed from N- to P-regions, which is in such a direction to inhibit *diffusion of majority electrons and holes*,

Assessment Questions

1. Diodes can be used in the making of
a) Rectifiers
b) LED lamps
c) Logic gates
d) **All of the mentioned**

2. A diode
a) Is the simplest of the semiconductor devices
b) Has a characteristic that closely follows that of a switch
c) Is two terminal device
d) All of the mentioned

3. In a PN junction with no external voltage, the electric field between acceptor and donor ion is called a
a) Peak
b) Barrier
c) Threshold
d) Path


THANK YOU