Carrier Conduction in n-Type and p-Type Semiconductors

Summary Notes for Semiconductor Physics

1. Overview

Conduction in semiconductors arises from the movement of mobile charge carriers under an applied electric field:

- **n-type:** Majority carriers are electrons in the conduction band.
- **p-type:** Majority carriers are holes in the valence band.

Although both mechanisms produce the same macroscopic effect—electric current—their microscopic details differ.

2. n-Type Conduction Mechanism

- Donor atoms contribute free electrons to the **conduction band**.
- These conduction-band electrons are **delocalized** and respond directly to the electric field.
- When an electric field is applied, electrons drift opposite to the field direction, while current (conventional flow) is in the field direction.
- The electrons remain entirely in the conduction band as they move; they do *not* need to recombine with holes.
- Recombination is negligible in n-type material because holes are extremely scarce.

3. p-Type Conduction Mechanism

- Acceptor atoms create empty states (holes) near the top of the **valence band**.
- The valence band is almost full, but a small number of electrons can move between neighboring atoms by filling nearby holes.
- Each electron hop fills a hole and creates a new one in its previous location—the holes thus appear to drift in the direction of the electric field.
- Electrons in p-type conduction remain **within the valence band** at all times; they never cross into the conduction band.

- At the negative terminal, electrons from the external circuit enter the semiconductor and recombine with holes near that contact.
- At the positive terminal, valence electrons are withdrawn, creating new holes to sustain the current flow.

4. Comparison of n-Type and p-Type Conduction

Type	**Majority Carriers**	**Band of Motion**	**Carrier Drift Direction**	
n-type	Electrons	Conduction band	Opposite to electric field	Electro
p-type	Holes (valence electrons hopping)	Valence band	Same as electric field	Electro

Table 1: Comparison of carrier motion and contact behavior in n-type and p-type semiconductors.

5. Conceptual Summary

- In **n-type materials**, current is carried by electrons freely moving in the conduction band.
- In **p-type materials**, current is carried by holes moving in the valence band—realized physically as valence electrons hopping between holes.
- The external circuit continuously supplies and removes electrons at the contacts to maintain steady-state carrier motion.

In one sentence: Electrons in n-type semiconductors flow freely through the conduction band, while in p-type materials they remain in the valence band, hopping between holes whose drift constitutes the observed current.

n-type semicondcutor : newly supplied electrons from the negative side of the field always stays in conduction band
p-type semiconductor : newly supplied electrons from the negative side of the field hops between holes, which are in the valence band. so all the moving electrons are always in the valence band.