Fundamentals of Electronics Devices

Unit-4

Lecture-5

MOSFET Operation

- When excess carriers are created non-uniformly in a semiconductor, the electron and hole concentrations vary with position in the sample.
- Any such special variation (*gradient*) in *n* and *p* calls for a net motion of the carriers from regions of high carrier concentration to regions of low concentration.

Introduction

- This type of motion is called *diffusion* and represents an important charge transport process in semiconductors.
- The two basic processes of current conduction are diffusion due to a carrier gradient and drift in an electric field.

Diffusion Processes

- When a bottle of perfume is opened in one corner of a closed room, the scent is soon detected throughout the room. If there is no convection or other net motion of air, the scent spreads by diffusion.
- The diffusion is the natural result of the *random motion* of the molecules.

- Consider, for example, a volume of arbitrary shape with scented air molecules inside and unscented molecules outside the volume.
- All the molecules undergo random thermal motion and collisions with other molecules.
- Thus each molecule moves in an arbitrary direction until it collides with another air molecule, after which it moves in a new direction.

Diffusion and Drift of Carriers

- If an electric field is present in addition to the carrier gradient, the current densities will each have a drift component and a diffusion component.

$$J(x) = q\mu n(x)\xi(x) + qDdn(x)/dx$$

and the total current density is the sum of the contributions due to electrons and holes:

$$J(x) = J_e(x) + J_p(x)$$

- We can best visualize the relation between the particle flow and the current of the equation by considering a diagram.
- Holes drift in the direction of the electric field, whereas electrons drift in the opposite direction because of their negative charge.
- The resulting drift current is in the +x direction in each case.

- In discussing the motion of carriers in an electric field, we should indicate the influence of the field on the energies of electrons in the band diagrams.
- Assuming an electric field $\xi(x)$ in the x-direction, we can draw the energy bands to include the change in potential energy of electrons in the field.