LECTURE 2

Topics to be covered

- Effects of magnetic field
- Applications

Holes and Intrinsic Semiconductors

- When electrons move into the conduction band, they leave behind vacancies in the valence band. These vacancies are called **holes**. Because holes represent the absence of negative charges, it is useful to think of them as **positive charges.**

- Whereas the ***electrons move in a direction opposite*** to the applied electric field, ***the holes move in the direction of the electric field.***

- A semiconductor in which there is a balance between the number of electrons in the conduction band and the number of holes in the valence band is called an **intrinsic semiconductor.**

  Examples of intrinsic semiconductors include pure carbon and germanium.

Impurity Semiconductor

- It is possible to fine-tune a semiconductor's properties by adding a small amount of another material, called a *dopant*, to the semiconductor creating what is a called an **impurity semiconductor.**

- As an example, silicon has four electrons in its outermost shell (this corresponds to the valence band) and arsenic has five.

  Thus while four of arsenic's outer-shell electrons participate in covalent bonding with its nearest neighbors (just as another silicon atom would), the fifth electron is very weakly bound.

  It takes only about 0.05 eV to move this extra electron into the conduction band.

- The effect is that adding only a small amount of arsenic to silicon greatly increases the electrical conductivity.

n-type Semiconductor

- The addition of arsenic to silicon creates what is known as an ***n*-type** semiconductor (*n* for negative), because it is the electrons close to the conduction band that will eventually carry electrical current.

  The new arsenic energy levels just below the conduction band are called **donor levels** because an electron there is easily donated to the conduction band.

Acceptor Levels

- Consider what happens when indium is added to silicon.
  - Indium has one less electron in its outer shell than silicon. The result is one extra hole per indium atom. The existence of these holes creates extra energy levels just above the valence band, because it takes relatively little energy to move another electron into a hole
  - Those new indium levels are called **acceptor levels** because they can easily accept an electron from the valence band. Again, the result is an increased flow of current (or, equivalently, lower electrical resistance) as the electrons move to fill holes under an applied electric field
- It is always easier to think in terms of the flow of positive charges (holes) in the direction of the applied field, so we call this a ***p*-type** semiconductor (*p* for positive).
  - acceptor levels *p*-Type semiconductors
- In addition to intrinsic and impurity semiconductors, there are many **compound semiconductors**, which consist of equal numbers of two kinds of atoms.