Chapter 12
Electronic Properties

Overview

In a metal, electrical current is proportional to the applied electric field, due to abundant free electrons. This gives rise to two equivalent forms of Ohm's law. The electrical conductivity depends equally on the concentration and mobility of the electrons. In a semiconductor, free electrons are not naturally abundant because the electron energy states lie in two separate energy bands. The lower band normally has all its states doubly occupied by electrons, whereas in the upper band normally all states are empty. Electrons are free to conduct only if excited from the lower to the upper band. Such excitation is possible, but very limited, by thermal energy. It can be greatly enhanced by alloying the material with select impurities. Insulators do not conduct current since their energy bands are such that normally no free charge carriers are present. For the same reason, insulators are optically transparent and exhibit dielectric behavior.

After studying this chapter, you will be able to :

1. Formulate and use Ohm's law in its two equivalent forms;
2. Explain electric current as due to the drift velocity of charge carriers, in response to an electric field applied to a material;
3. Describe electrical conductivity in terms of contributions by the concentration and the mobility of the free charge carriers;
4. Distinguish metals, semiconductors, and insulators on the basis of their electron energy bands;
5. Use the Fermi function and the band structure to describe electrical conduction in semiconductors as arising from electron-hole pairs (intrinsic), electrons (n-type), or holes (p-type);
6. Delineate the effects of temperature and defects on the conductivity of metals and semiconductors;
7. Describe optical absorption and dielectric behavior in insulators.