12.1 ENERGY BAND DIAGRAMS

The basic device we consider first is the MOS capacitor or diode consisting of a thin layer of silicon dioxide sandwiched between a metal, such as aluminum or heavily doped polycrystalline silicon, and a silicon substrate, as shown in Fig. 12.1. In this chapter, aluminum will be the metal used in the illustrations and most of the examples. The advantages of using polysilicon will be discussed in the chapter on MOSFETs (Chapter 13).

The energy band diagram of solids in contact provides the necessary background information for the study of the properties of the system. We draw the separate energy level diagrams, shown in Fig. 12.2, for the metal, the oxide, and the silicon using the vacuum energy level as the common reference for all three solids. In this illustration, we have selected a P-type silicon substrate and aluminum as the metal.

We will make the following assumptions concerning the solids:

1. The insulator is ideal, its resistance is infinite, and hence no charges pass through it. For the ideal insulator, no charges exist on the surface of the oxide nor inside the solid.
2. The only charges that can exist in the system are in the semiconductor at the surface or near the surface of the oxide and in the metal surface adjacent to the oxide.

As the solids are brought into contact with $V_G = 0$ in Fig. 12.1, the Fermi levels of the metal and the silicon are immediately aligned.

The work function of the aluminum, $q\Phi_m$, is 4.1eV. Assuming that the work function of the substrate P silicon, $q\Phi_s$, is 5.05eV (for $N_A = 5 \times 10^{15}\text{cm}^{-3}$), so that the work function difference, defined as $(q\Phi_s - q\Phi_m)$, as calculated from Fig. 12.2, is 0.95eV.

With $V_G = 0$, thermal equilibrium, and because the work function of the metal is smaller than that of the silicon, electrons are transferred through the terminals of the device from the metal to the semiconductor. On the metal interface with the oxide, a thin sheet of surface positive charges is formed. On the semiconductor side,

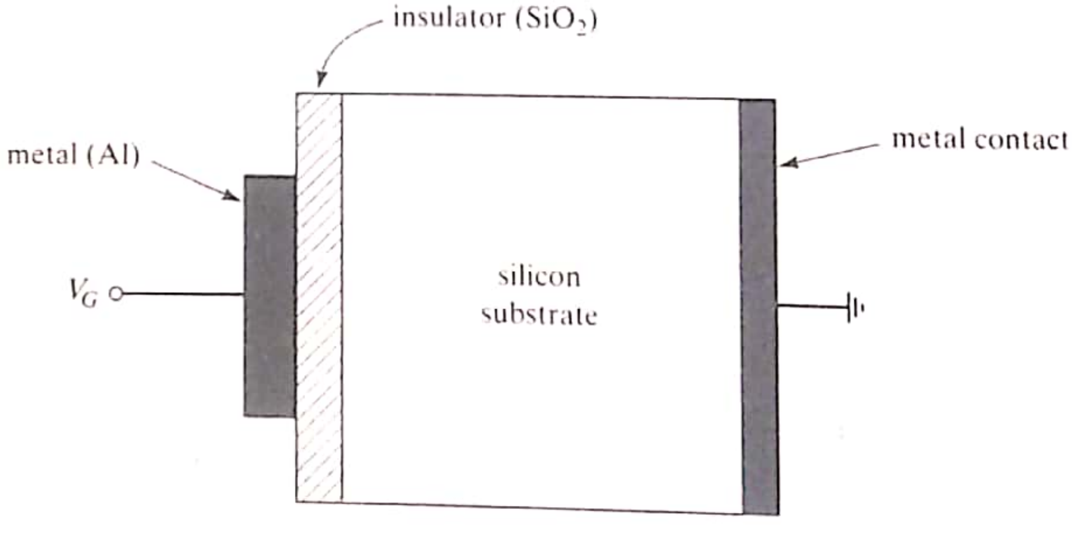

Figure 12.1 Basic composition of an MOS diode.