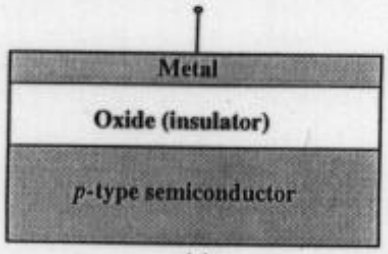
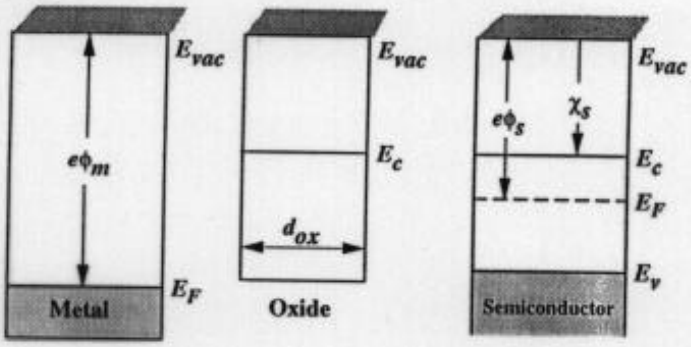
THE MOS SYSTEM

COMPATIBILITY BETWEEN A SEMICONDUCTOR AND AN INSULATOR.

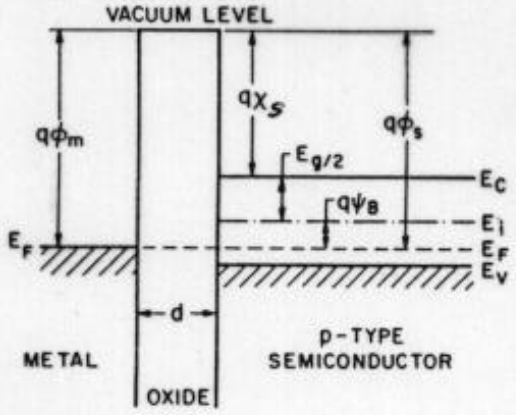


(a)

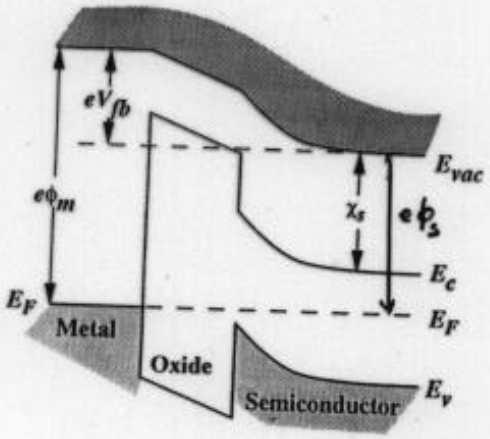
CONSTITUENT BAND DIAGRAM



FLAT BAND CONDITIONS



GENERAL CONDITION



$$\phi_{ms} = \phi_m - \phi_s = 0$$

$$= \phi_m - \left(\chi_s + \frac{E_g}{2q} + \psi_B\right) = 0$$

FLAT BAND VOLTAGE: V_{fb}

$$V_{fb} = \phi_{ms} = \phi_m - \phi_s \neq 0$$

Al - SiO_2 - Si System :- Quantitative Aspect.

- Ideal system (no surface state/charge)

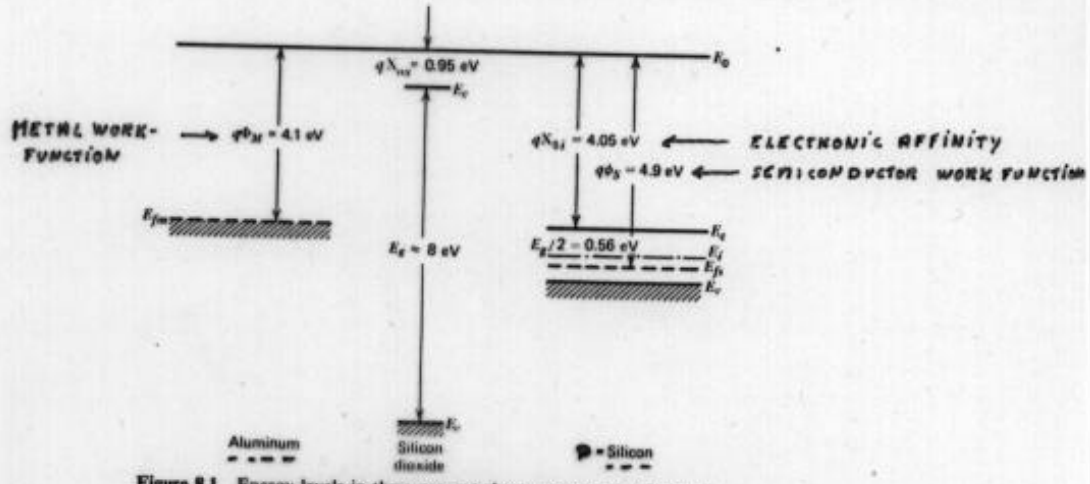
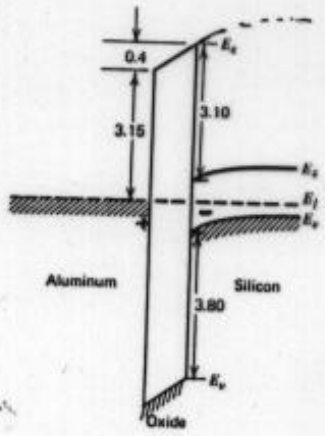


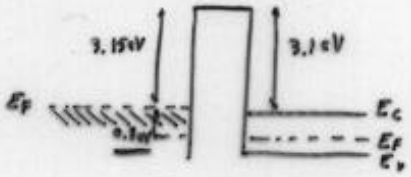
Figure 8.1 Energy levels in three separated components that form an MOS system: aluminum, thermally grown silicon dioxide, and *p*-type silicon containing $N_a \approx 1.1 \times 10^{15}$ cm^{-3}. (Although recent measurements indicate E_g in SiO_2 to be ~9 eV, many experimental data appear to be consistent with the 8 eV value that we will use.)

* There is considerable variation in tabulated values for work functions and electron affinities. The values given here provide accurate correspondence to theory in a number of MOS experiments.

Equilibrium condition



Flat Band condition



$$V_{FB}^{\circ} = \Phi_m - \Phi_s < 0$$

: Flat band voltage

Figure 8.2 Typical energy-band diagram at thermal equilibrium for an MOS system composed of the materials indicated in Figure 8.1. The oxide is assumed to be free of any charge. The energy values are in eV.

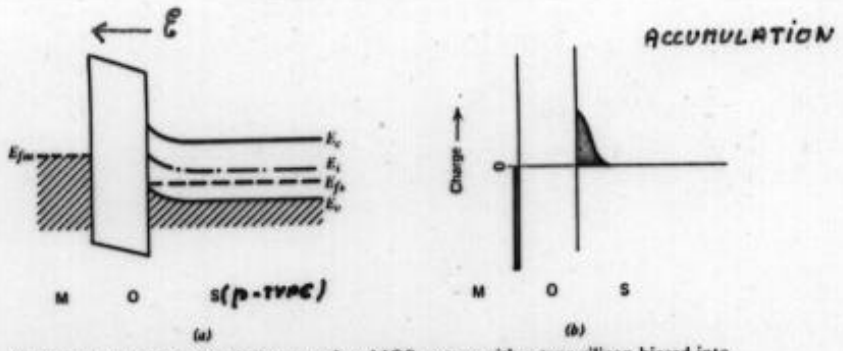


Figure 8.4 (*a*) Energy-band diagram of an MOS system with *p*-type silicon biased into accumulation, (*b*) charge in the same MOS system.

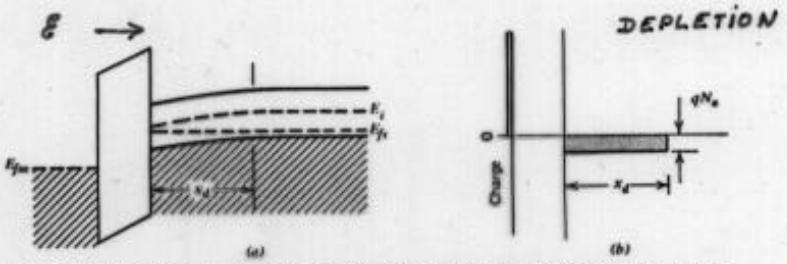


Figure 8.5 (*a*) Energy-band diagram of an MOS system with *p*-type silicon biased into depletion, (*b*) charge in the same MOS system.

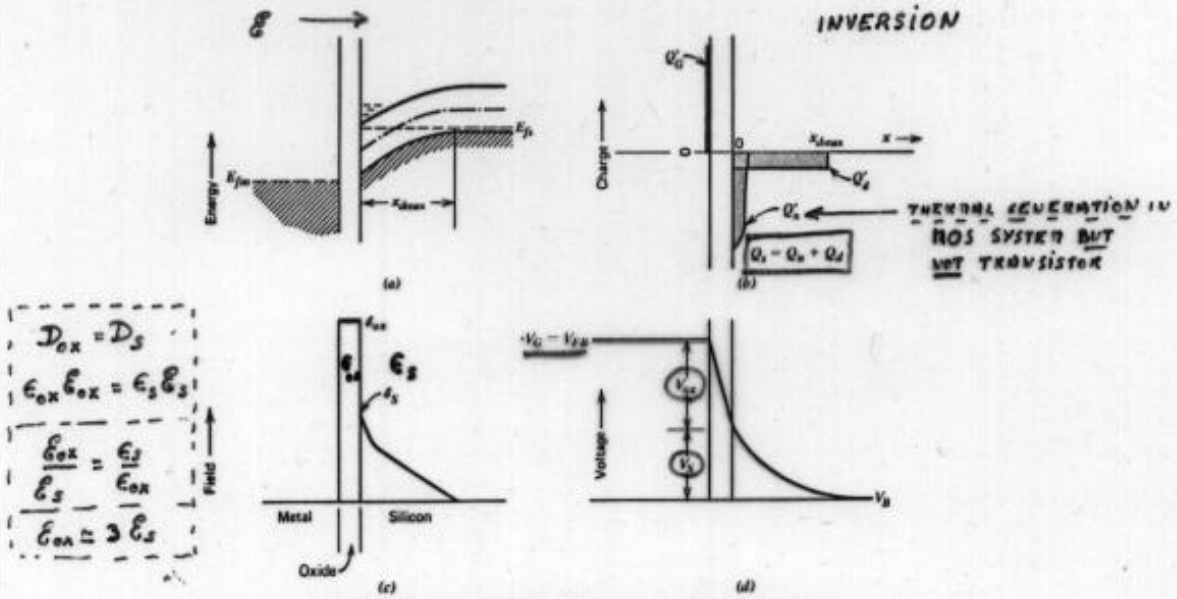
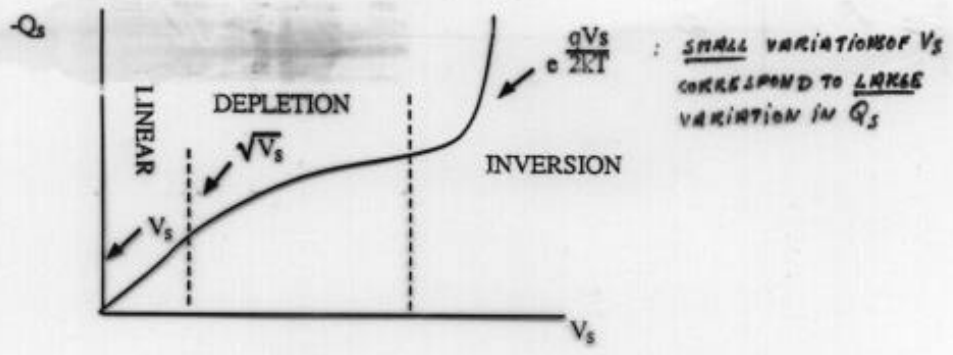


Figure 8.6 (*a*) Energy-band diagram, (*b*) space-charge configuration, (*c*) field, and (*d*) potential distribution for an MOS system with *p*-type silicon biased into inversion.

SURFACE CHARGE VS SURFACE POTENTIAL (SYLLABUS)



: SMALL VARIATION OF V_s CORRESPOND TO LARGE VARIATION IN Q_s

Figure 1

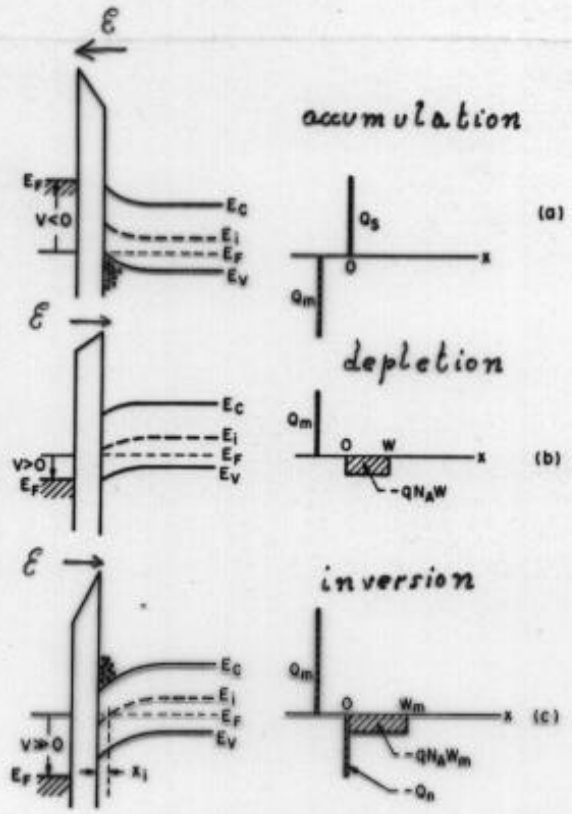
See K. Hess: *Advanced Theory of Semiconductor Devices*, pp. 149-152,

LINEAR REGIME : $-Q_s = \epsilon_0 \epsilon_s \frac{V_s}{L_D}$ (30) HERE $V_s = \phi_s - \phi_p$

DEPLETION REGIME : $-Q_s = \frac{\epsilon_0 \epsilon_s}{L_D}\sqrt{\frac{2kT}{q}}\sqrt{V_s} = \sqrt{2\, q N_a \epsilon_0 \epsilon_s V_s}$ (31)

INVERSION : $-Q_s = \frac{\epsilon_0 \epsilon_s \sqrt{2}\, kT}{q L_D}\frac{n_i}{N_a} e^{\frac{qV_s}{2kT}}$ (32)

$$L_D = \sqrt{\frac{\epsilon_0 \epsilon_s kT}{q^2 N_a}}$$



$$Q_S = Q_n + Q_{SC}$$

Fig. 23 Energy band diagrams and charge distributions of an ideal MOS diode. (a) Accumulation. (b) Depletion. (c) Inversion.

$$p_p = n_i e^{(E_i - E_F)/kT}$$

$$n_p = n_i e^{(E_F - E_i)/kT}$$