

- 10.4** Determine the metal–semiconductor work function difference ϕ_{ms} in a MOS structure with p-type silicon for the case when the gate is (a) aluminum, (b) n^+ polysilicon, and (c) p^+ polysilicon. Let $N_a = 10^{16} \text{ cm}^{-3}$.

From Table B.4, $n_i = 1.5 \times 10^{-10} \text{ cm}^{-3}$ & $E_g = 1.12 \text{ eV}$
for silicon @ 300 K.

$$V_t = \frac{k_B T}{e} = \frac{8.617333 \times 10^{-5} \text{ eV/K} (300 \text{ K})}{e} = 0.025852 \text{ V}$$

$$\begin{aligned} \text{Per (10.4), } \phi_{sp} &= V_t \ln\left(\frac{N_a}{n_i}\right) = 0.025852 \ln\left(\frac{10^{16}}{1.5 \times 10^{-10}}\right) \\ &= 0.3466765 \text{ V} \end{aligned}$$

a) aluminum From Ex. 10.2, $\chi' = 3.25 \text{ V}$ & $\phi_m' = 3.20 \text{ V}$

$$\begin{aligned} \text{Per (10.15), } \phi_{ms} &= \left[\phi_m' - \left(\chi' + \frac{E_g}{2e} + \phi_{sp} \right) \right] \\ &= 3.2 - \left(3.25 + \frac{1.12 \text{ eV}}{2e} + 0.3466765 \right) \\ \phi_{ms} &= -0.95668 \text{ V} \end{aligned}$$

b) n^+ polysilicon

$$\begin{aligned} \text{Per (10.16), } \phi_{ms} &= -\left(\frac{E_g}{2e} + \phi_{sp} \right) = -\left(\frac{1.12}{2} + 0.3466765 \right) \\ \phi_{ms} &= -0.90668 \text{ V} \end{aligned}$$

c) p^+ polysilicon

$$\begin{aligned} \text{Per (10.17), } \phi_{ms} &= \frac{E_g}{2e} - \phi_{sp} = \frac{1.12}{2} - 0.3466765 \\ \phi_{ms} &= 0.21332 \text{ V} \end{aligned}$$