

Level 3 Condensed Matter Physics- Part II

Weekly problem 3

(1) n - and p -type silicon with doping concentrations of $5 \times 10^{21} \text{ m}^{-3}$ and $2 \times 10^{22} \text{ m}^{-3}$ are brought together to form a pn-junction at room temperature (300 K). Calculate:

- i) the built-in potential [2 marks]
- ii) the space charge width on the n - and p -side [2 marks]
- iii) the magnitude of the maximum electric field [1 mark]

For silicon, band gap $E_g = 1.1 \text{ eV}$, permittivity $\epsilon = 11.7\epsilon_0$, effective density of states of conduction band $N_c = 2.8 \times 10^{25} \text{ m}^{-3}$ and valence band $N_v = 1.0 \times 10^{25} \text{ m}^{-3}$ (ϵ_0 = permittivity of free space).

(2) Using the values for parts (i) and (ii) from the previous question estimate the capacitance per unit area of the pn-junction. [2 marks]

(3) When a forward bias of 0.2 V is applied to a pn-junction at 300 K a current of 25 mA flows. Calculate the reverse saturation current. [3 marks]

