

task_tx86fewvysrcy8fc_with_calculation

Student Group

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Exercise E6 Electron Velocity in Semiconductors (written test, approx. 6 % of a 120-minute written test, SS2022)

A current of $I = 1 \text{ mA}$ flows through a cross-sectional area $A = 10 \text{ } \mu\text{m}^2$ in a semiconductor.

The electron density in the semiconductor is given by the number of dopant atoms per volume.

The doping shall provide 1 donor atom (= one electron) per 10^{10} silicon atoms.

The molar volume of silicon is $V_{\text{mol,Si}} = 12 \text{ } \mu\text{mol}^{-3}$, with $N_{\text{A}} = 6.022 \cdot 10^{23}$ silicon atoms per 1 mol .

The elementary charge is given as: $e_0 = 1.602 \cdot 10^{-19} \text{ As}$

What is the average electron velocity v_e in this semiconductor?

Path

The following formula gives the speed, where n_e is the number of electrons per volume.

$$v_e = \frac{I}{n_e \cdot e_0 \cdot A}$$

n_e can be derived from the overall number of Si-atoms per volume ($\frac{N_{\text{A}}}{V_{\text{mol,Si}}}$) and the fraction k_{Donators} of these atoms, which got substituted by donators.

$$v_e = \frac{I}{\left(\frac{N_{\text{A}}}{V_{\text{mol,Si}}} \cdot k_{\text{Donators}} \cdot e_0 \cdot A \right)}$$

Putting in the numbers:

$$v_e = \frac{1 \cdot 10^{-3} \text{ A}}{\left(\frac{6.022 \cdot 10^{23} \text{ 1/mol}}{12 \cdot 10^{-6} \text{ m}^3/\text{mol}} \cdot 1 \cdot 1.602 \cdot 10^{-19} \text{ As} \cdot 10 \cdot 10^{-6} \text{ m}^2 \right)}$$

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