Exam 1 Proposed Problems

ECE2204 CRN:82929

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Problem 1:

Derived from p1.17 by changing values and swapping D_p and J_p.

Design

The hole concentration in silicon is given by

$$p(x) = 10^3 + 10^{12} e^{\frac{-x}{L_p}} \quad x \geq 0 \tag{1}$$

The value of L_p is $13\mu m$. The hole diffusion current density is $J_p = 1.44 \times 10^{-3} A/cm^2$. Assume the value of the elementary charge is $\mathbb{e} = 1.6 \cdot 10^{-19} C$. Determine the hole diffusion current density at $x = 23\mu m$.

$$\frac{dp}{dx} p(x) = \frac{-10^{12}}{L_p} e^{\frac{-x}{L_p}} \tag{2}$$

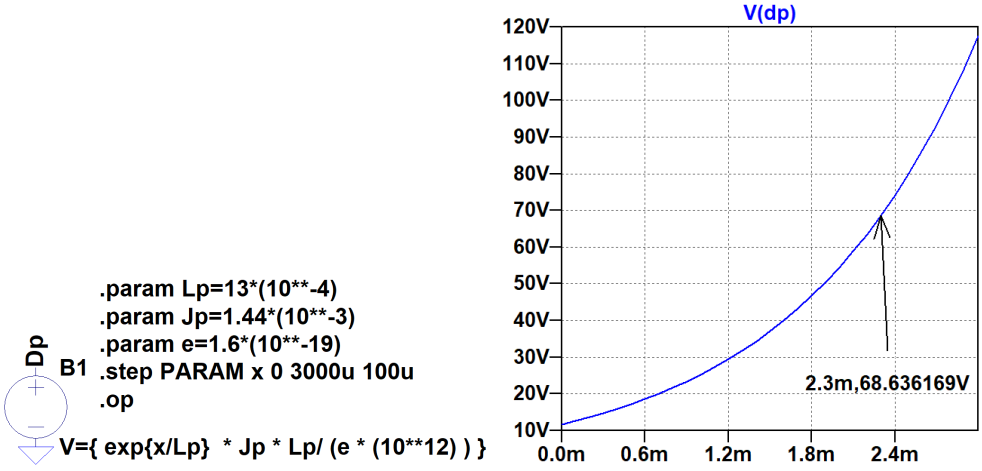
$$J_p = -\mathbb{e} D_p \frac{dp}{dx} \implies D_p = \frac{L_p \times J_p \times e^{\frac{x}{L_p}} \times cm^3}{\mathbb{e} \times 10^{12}} \tag{3}$$

$$J_p = \frac{13\mu m \times 1.44 \times 10^{-3} A/cm^2 \times e^{\frac{23\mu m}{13\mu m}} \times cm^3}{1.6 \times 10^{-19} C \times 10^{12}} = 68.64 cm^2/s \tag{4}$$

The hole diffusion coefficient is $D_p = 68.64 cm^2/s$.

Validation

LTSpice Implementation (accurate with $< 1\%$ deviation from design result)



$$Err = \frac{|68.64 - 68.636|}{68.64} = 0.00005 = 0.01\%$$

Problem 2:

What is the variable I_S, what is its unit, what happens when I_S increases or decreases?

I_S is the reverse bias saturation current. As it is a current, it has a unit of Amperes. This variable is one of the major drivers of the ideal pn junction current-voltage equation. Therefore increasing i_d is directly dependent on I_S.