3

3.16

For a Si bar of length $5\ \mu m$, doped n-type at $10^{15}\ cm^{-3}$, calculate the current density for an applied voltage of $2.5\ V$ across its length. How about for a voltage of $2500\ V$? The electron and hole mobilities are $1500\ cm^2/Vs$ and $500\ cm^2/Vs$, respectively, in the ohmic region for electric fields below $10^4\ V/cm$. For higher fields, electrons and holes have a saturation velocity of $10^7\ cm/s$.

✓ **Answer**

For $2.5\ V$

$J_x = qn\mu_n\epsilon_x$
$J_x = \frac{(1.6\times10^{-19})(10^{15})(1500)(2.5)}{5\times10^{-4}}$
$J_x = 1200\ A/cm$

For $2500\ V$

$J_x = -qn\langle v_x\rangle$
$J_x = -(1.6\times10^{-19})(10^{15})(10^7)$
$J_x = -1600\ A/cm$

4.6

A Si sample with $10^{15}\ /cm^3$ donors is uniformly optically excited at room temperature such that $10^{19}\ /cm^3$ EHPs are generated per second. Find the separation of the quasi-Fermi levels and the change of conductivity upon shining the light. Electron and hole lifetimes are both $10\ \mu s$ $D_p = 12\ cm^2/s$.

✓ **Answer**

$\delta_n = \delta_p = (10^{19})(10^{-5}) = 10^{14}\ /cm^3$

$n = 1.1\times10^{15}$
$kT\ln(\frac{n}{n_i}) = 0.29\ eV$

$\Delta\sigma = qg_{op}(\tau_n\mu_n + \tau_p\mu_p)$
$\Delta\sigma = (1.6\times10^{-19})(1\times10^{-5})(10^{19})(\mu_n+\mu_p)$
$\Delta\sigma = (1.6\times10^{-19})(1\times10^{-5})(10^{19})\left(1350+\frac{12}{0.0259}\right)$
$\Delta\sigma = 0.029\ S/cm$

4.16

A long Si sample, n-doped at $10^{17}\ cm^{-3}$, with a cross-sectional area of $0.5\ cm^2$ is optically excited by a laser such that $10^{20}\ cm^{-3}$ EHPs are generated per second at $x = 0\ \mu m$. They diffuse to the right. What is the total diffusion current at $x = 50\ \mu m$? Electron and hole lifetimes are both $10\ \mu s$. $\mu_p = 500\ cm^2/Vs$ $D_n = 36\ cm^2/s$.

✓ **Answer**

$g_{op} = 10^{20}\ cm^{-3}$
$n_0 = 10^{17}\ cm^{-3}$
$\tau_n = \tau_p = 10^{-5}\ s$

$\delta p = g_{op}\tau_p e^{-x/\sqrt{D_p\tau_p}}$
$J_p = q\frac{D_p}{L_p} g_{op}\tau_p e^{-x/\sqrt{D_p\tau_p}}$
$J_p = 0.11733$

$\delta n = g_{op}\tau_n e^{-x/\sqrt{D_n\tau_n}}$
$J_n = q\frac{D_n}{L_n} g_{op}\tau_n e^{-x/\sqrt{D_n\tau_n}}$
$J_n = 0.23325$

$I = 0.17529\ A$