

Semiconductors Equation Sheet

Classical Variable		Quantum operator
x	\rightarrow	x
$f(x)$	\rightarrow	$f(x)$
$p(x)$	\rightarrow	$\frac{\hbar}{j} \frac{\partial}{\partial x}$
E	\rightarrow	$-\frac{\hbar}{j} \frac{\partial}{\partial t}$

$$\langle Q_{op} \rangle = \int_{-\infty}^{\infty} \Psi^* Q_{op} \Psi dx$$

$$(\Delta x)(\Delta P_x) \geq \frac{\hbar}{2}, \quad (\Delta E)(\Delta t) \geq \frac{\hbar}{2}$$

$$f(E) = \frac{1}{1 + e^{(E-E_f)/kT}}$$

$$n_o = \int_{E_c}^{\infty} f(E) N(E) dE, \quad p_o = \int_{-\infty}^{E_v} [1 - f(E)] N(E) dE$$

At Equilibrium:

$$n_o p_o = n_i^2, \quad E_g(Si) = 1.15 eV$$

$$n_o = n_i e^{(E_f - E_i)/kT}, \quad p_o = n_i e^{(E_i - E_f)/kT}, \quad n_i = \sqrt{N_c N_v} e^{-E_g/2kT},$$

$$J = I/A \quad \vec{\varepsilon} = \frac{V}{\ell}$$

n-type:

$$\overline{J_n} = q n \mu_n \vec{\varepsilon} = Q_n v_n = q n v_n$$

$$J_{Total_n} = J_{n_o} + J_{p_o}$$

$$\sigma_n = q \mu_n n$$

$$q \phi_{B_n} = q \phi_{F_n} = kT \ln \frac{n_o}{n_i} \approx kT \ln \frac{N_D^+}{n_i}$$

p-type:

$$\overline{J_p} = q p \mu_p \vec{\varepsilon} = Q_p v_p = q p v_p$$

$$J_{Total_p} = J_{p_o} + J_{n_o}$$

$$\sigma_p = q \mu_p p$$

$$q \phi_{B_p} = q \phi_{F_p} = kT \ln \frac{p_o}{n_i} \approx kT \ln \frac{N_A^-}{n_i}$$

$$\text{Velocity} = v = \mu \vec{\varepsilon} \text{ for } \vec{\varepsilon} < \varepsilon_c, \quad v = v_{sat} \approx v_h \text{ for } \vec{\varepsilon} \geq \varepsilon_c$$

$$\rho = R * \frac{A}{\ell}, \quad \rho = \frac{1}{\sigma}$$

$$kT|_{T_0} = kT|_{300K} * \frac{T_0}{300K}$$

Constants:

$$h = 6.626 \times 10^{-34} m^2 kg/s$$

$$\hbar = \frac{h}{2\pi} = 1.055 \times 10^{-31} Js/rad$$

$$m^* = 9.11 \times 10^{-31} kg$$

$$q = 1.6 \times 10^{-19} C$$

$$kT|_{T=300K} \approx 0.026 eV$$

$$n_i(Si)|_{300K} = 1.5 \times 10^{10} cm^{-3}$$

$$v_{th} = \text{Thermal Velocity} \approx 10^7 cm/sec$$

$$\vec{\varepsilon}_c = \text{critical field} = 10^4 V/cm$$

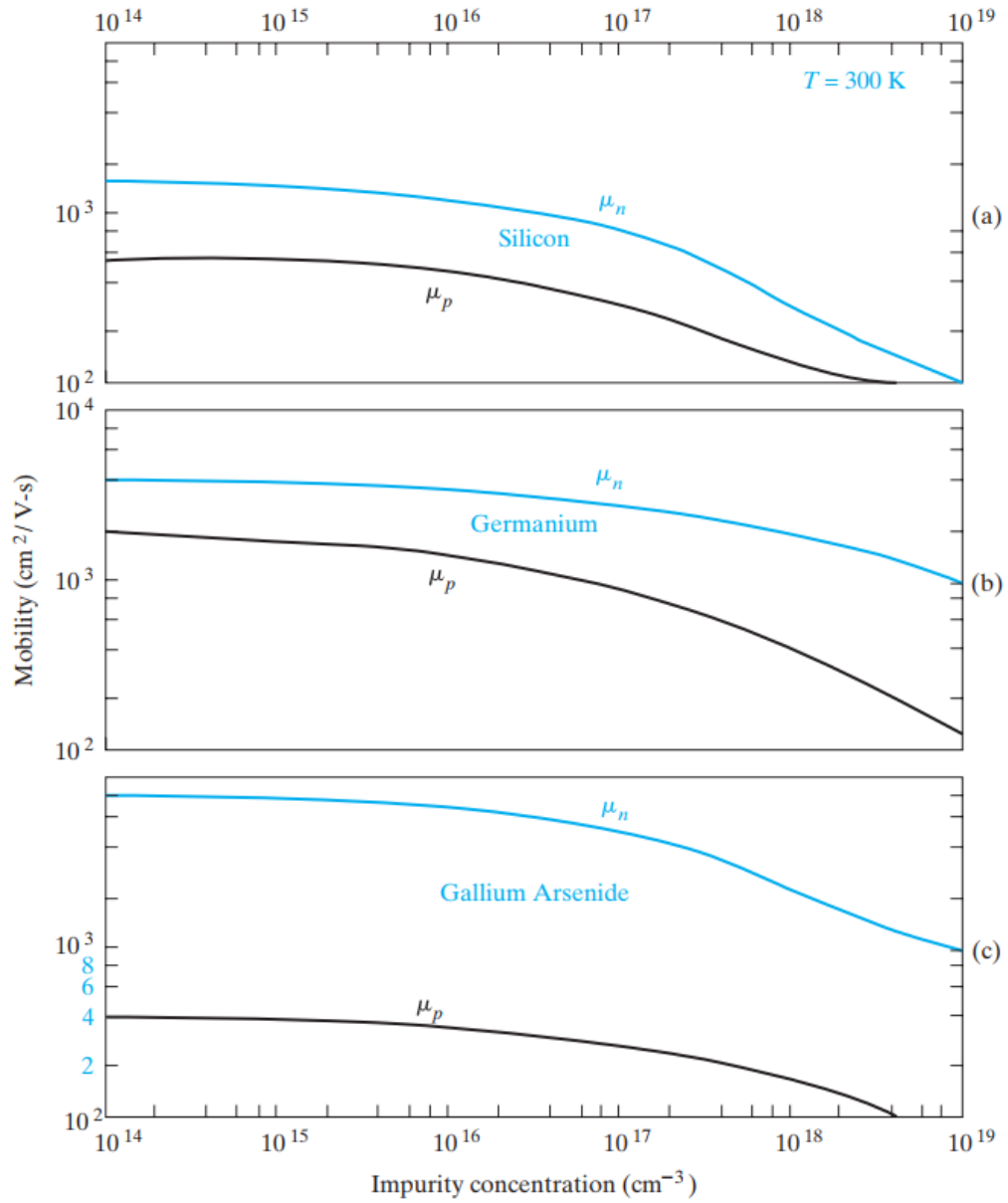


Figure 3–23

Variation of mobility with total doping impurity concentration ($N_a + N_d$) for Ge, Si, and GaAs at 300 K.

Figure 3–17
Intrinsic carrier concentration for Ge, Si, and GaAs as a function of inverse temperature. The room temperature values are marked for reference.

