Properties of Si and GaAs at T=300K	Si	GaAs	Unit
Intrinsic carrier density (n_i)	$1.5\ 10^{10}$	$1.8\ 10^{6}$	cm^{-3}
Mobility of electrons (μ_n)	1350	8500	$cm^2/(V.s)$
Mobility of holes (μ_p)	480	450	$cm^2/(V.s)$
Effective density of the state function in Conduction Band (N_{C0})	$2.8\ 10^{19}$	$4.7\ 10^{17}$	cm^{-3}
Effective density of the state function in Valence Band (N_{V0})	$1.04\ 10^{19}$	$7\ 10^{18}$	cm^{-3}
Effective mass of electrons (m_n^*)	$1.08\ m_0$	$0.067\ m_0$	kg
Effective mass of holes (m_p^*)	$0.56\ m_0$	$0.48\ m_0$	kg
Bandgap Energy (E_g)	1.12	1.43	eV

Physical constants

q	elementary charge	$1.602\ 10^{-19}$ C
k	Boltzmann's constant	$8.617\ 10^{-5}$ eV/K
k_e	Coulomb's constant	$8.99\ 10^{9}$ $N.m^2/C^2$
kT	(for T=300K)	0.026 eV
h	Planck's constant	$6.625\ 10^{-34}$ J.s
ħ	Modified Planck's constant	$1.054\ 10^{-34}$ J.s
c	velocity of light	$3\ 10^{8}$ m/s
m_0	Mass of electrons	$9.11\ 10^{-31}$ kg
ε_0	Dielectric constant of vacuum	$8.85\ 10^{-12}$ F/m
ε_{rSi}	Relative dielectric coefficient of Si	11.7

Energy levels of a one-electron atom: $E_n = -\frac{m_0 q^4}{(4\pi\varepsilon_0)^2\, 2\hbar^2 n^2} = -\frac{13.58}{n^2}[eV]$

Fermi – Dirac probability distribution: $f(E) = \frac{1}{1+e^{\frac{E-E_F}{kT}}}$

$$D_C(E) = \frac{4\pi\left(2m_n^*\right)^{3/2}}{h^3}\sqrt{E-E_C} \quad ; \quad D_V(E) = \frac{4\pi\left(2m_p^*\right)^{3/2}}{h^3}\sqrt{E_V-E}$$

$$n_0 = N_C(T)e^{-\frac{E_C-E_F}{kT}} = n_i(T)\cdot e^{\frac{E_F-E_{Fi}}{kT}} \quad ; \quad p_0 = N_V(T)e^{-\frac{E_F-E_V}{kT}} = n_i(T)\cdot e^{-\frac{E_F-E_{Fi}}{kT}}$$

$$n_i^2(T) = N_C(T)N_V(T)e^{-\frac{E_g}{kT}}$$

$$N_C(T) = N_{C0}\left(\frac{T}{T_0}\right)^{\frac{3}{2}}; \quad N_V(T) = N_{V0}\left(\frac{T}{T_0}\right)^{\frac{3}{2}} \qquad \mu_n(T) = \mu_{n0}\left(\frac{T_0}{T}\right)^{\frac{3}{2}}; \quad \mu_p(T) = \mu_{p0}\left(\frac{T_0}{T}\right)^{\frac{3}{2}}$$

Carrier concentrations for low and medium temperatures:

$$n_0(T) = \frac{1}{2}N_C e^{-\frac{\Delta E_D}{kT}}\left[\sqrt{4\frac{N_D}{N_C}e^{\frac{\Delta E_D}{kT}}+1}-1\right]; \; p_0(T) = \frac{1}{2}N_V e^{-\frac{\Delta E_A}{kT}}\left[\sqrt{4\frac{N_A}{N_V}e^{\frac{\Delta E_A}{kT}}+1}-1\right]$$

Carrier concentrations for high temperatures:

$$n_0(T) = \frac{N_D}{2}+\sqrt{\left(\frac{N_D}{2}\right)^2+n_i^2(T)}\,; \qquad p_0(T) = \frac{N_A}{2}+\sqrt{\left(\frac{N_A}{2}\right)^2+n_i^2(T)}$$

Continuity equations for nonequilibrium excess carriers:

$$\frac{dp(t)}{dt} = -\frac{p - p_0}{\tau_p} + g(t) \text{ (n-type)} \qquad \frac{dn(t)}{dt} = -\frac{n - n_0}{\tau_n} + g(t) \text{ (p-type)}$$

Neutrality Condition: $p_0 + N_D^+ = n_0 + N_A^-$

Current equations:

$$\vec{J}_n = q\mu_n n\vec{E} + qD_n \frac{dn}{dx} \qquad D_n = \mu_n V_{th} \quad ; \quad V_{th} = kT/q$$

$$\vec{J}_p = q\mu_p p\vec{E} - qD_p \frac{dp}{dx} \qquad D_p = \mu_p V_{th}$$

Poisson's equation:

$$\frac{\partial^2 \Psi}{\partial x^2} = -\frac{\rho}{\varepsilon} = -\frac{q}{\varepsilon}\left[p_0 - n_0 + N_D^+ - N_A^- \right]$$

p-n Junction:

$$\mathrm{W} = \sqrt{\frac{2\varepsilon_S}{q}\left(\frac{N_A + N_D}{N_A N_D}\right)(V_{total})} \quad ; \quad x_n = \frac{N_A}{N_A + N_D} W \quad ; \quad x_p = \frac{N_D}{N_A + N_D} W$$

$$E_{max} = -\frac{2(V_{total})}{W}$$

$$V_{total} = \begin{cases} V_{bi} & \text{for zero-bias} \\ V_{bi} + V_R & \text{for reverse-bias} \\ V_{bi} - V_a & \text{for forward-bias} \end{cases}$$

$$C_j = \frac{\varepsilon_S}{W} A$$

$$V_{bi} = \frac{kT}{q} \ln\left(\frac{N_D N_A}{n_i^2}\right) = V_{th} \ln\left(\frac{N_D N_A}{n_i^2}\right)$$

$$\delta p_n(x) = p_n(x) - p_{n0} = p_{n0}\left(e^{\frac{V_a}{V_{th}}} - 1\right).e^{-\frac{x - x_n}{L_p}} \quad for\ x \geq x_n \qquad L_p = \sqrt{D_p \tau_p}$$

$$\delta n_p(x) = n_p(x) - n_{p0} = n_{p0}\left(e^{\frac{V_a}{V_{th}}} - 1\right).e^{\frac{x + x_p}{L_n}} \quad for\ x \leq -x_p \qquad L_n = \sqrt{D_n \tau_n}$$

$$J = J_{p,diff}(x)\Big|_{x = x_n} + J_{n,diff}(x)\Big|_{x = -x_p} = -qD_p \frac{dp_n}{dx}\Big|_{x = x_n} + qD_n \frac{dn_p}{dx}\Big|_{x = -x_p}$$