Relevant Equations Haynes - Shockley

$$\frac{W}{t} = v_d = \mu(T)E \qquad (1)$$

W = distance
t = transit time
v_d = drift velocity

μ = mobility
T = temperature
E = electric field strength.

$$v_d T_p = W_p \qquad (2)$$

$$\frac{D}{\mu} = \frac{kT}{q} = V_T \qquad (3)$$

Einstein's relationship

V_T = thermal voltage
q = charge of charge carrier ($\pm 1.6 \times 10^{-19}$)
k = Boltzman const.
T = temperature

D = diffusion coefficient
μ = drift mobility

Diffusion theory shows that if a bunch starts at $t=0$ as a δ function, it will spread out in a Gaussian distribution with density proportional to

$$\frac{1}{2\sqrt{\pi D t}} \exp\left(-\frac{x^2}{4Dt}\right) \qquad (4)$$

* more in-depth info.

number of holes decays exponentially:

$$\exp\left(\frac{-t}{\tau}\right) \qquad (5)$$

where τ = lifetime

$$E = \frac{V}{L} \qquad (6)$$

E = electric field strength
V = applied voltage

L = length

$$t = \frac{d_3 L}{\mu V} \qquad (7)$$

t = time of transit
d_3 = distance between E and C_3 → change for d_1 and d_2 for C_1 and C_2

Carrier transport:

$$\frac{1}{2} m v_{Th}^2 = \frac{3kT}{2} \qquad (8)$$

v_{Th} = thermal velocity

$$dp = F dt = -qE\tau_F = mv_d \qquad (9)$$

$$v_d = -\left(\frac{q\tau_F}{m}\right)E \equiv -\mu E \qquad (10)$$

$$\mu = \frac{q\tau_F}{m} \qquad (11)$$

τ_F = mean free scattering time

Carrier diffusion:

If all excess holes were generated as a pulse of initially 0 width (δ)

$$W = \sqrt{(16\ln(2) D_h t)} \qquad (12)$$

W = spatial width at half peak amplitude
D_h = diffusion constant

$$t_p = \frac{W}{\mu E} = \frac{WL}{\mu V} \qquad (13)$$

t_p = pulse duration at half peak amplitude.

- linear relationship between t_p^2 and t^3

Recombination:

condition for zero recombination loss:

$$V_p t_p V = \text{constant} \tag{14}$$

V_p = height of observed pulse

assuming lifetime τ_h before hole-electron recombination:

$$V_p t_p V \propto \exp\left(-\frac{t}{\tau_h}\right)$$