Haynes - Shockley Experiment

9/9/2014

Continuity Eqn for holes

$$\frac{\partial p(x,t)}{\partial t} = -\frac{1}{q}\frac{\partial J_p}{\partial x} - \frac{\delta p(x,t)}{\tau_p}$$

$$J_p = q p \mu_p \mathcal{E} - q D_p \frac{\partial p}{\partial x}$$

$$p(x,t) = p_0 + \delta p(x,t)$$

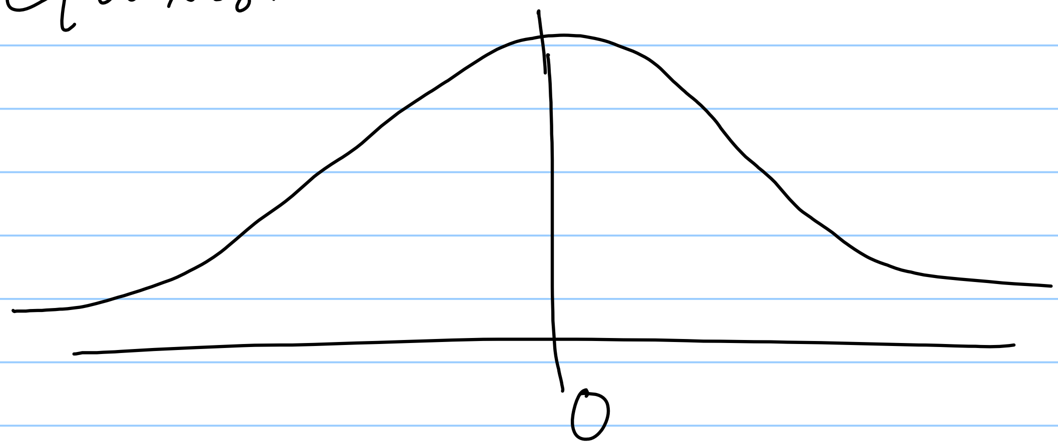
$$\frac{\partial}{\partial t}\delta p(x,t) = -\mu_p \mathcal{E} \frac{\partial}{\partial x}\delta p(x,t) + D_p \frac{\partial^2 \delta p(x,t)}{\partial x^2} - \frac{\delta p(x,t)}{\tau_p}$$

Assume $\mathcal{E} = 0$ and negligible recombination

$$\frac{\partial\, \delta p(x,t)}{\partial t} = D_p \frac{\partial^2 \delta p(x,t)}{\partial x^2}$$

$$\delta p(x,t) = \frac{P_0}{2\sqrt{\pi D_p t}} \exp\left(-\frac{x^2}{4 D_p t}\right)$$

Gaussian Distribution



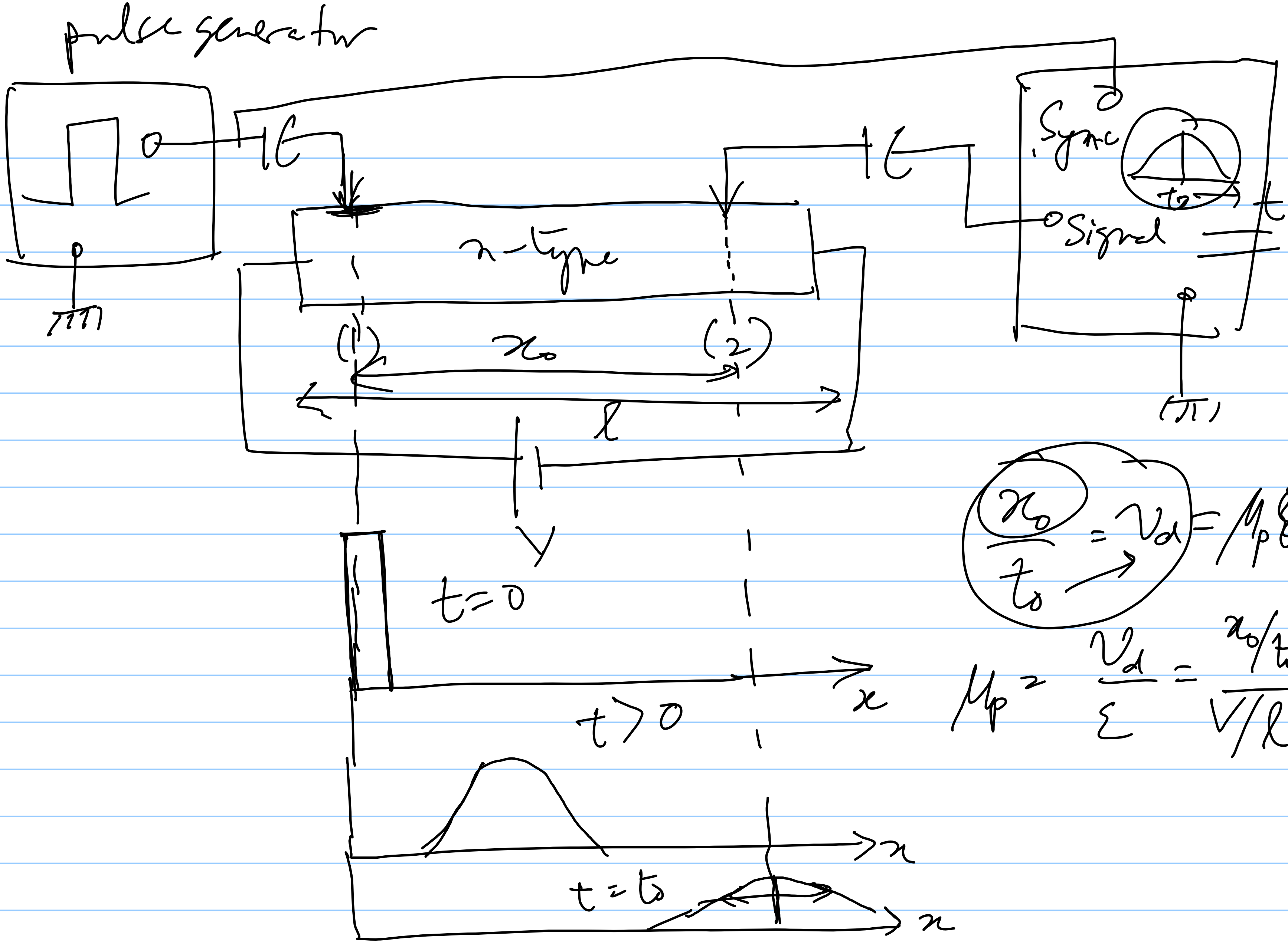
$P_0 \to$ injected excess hole per unit area

$$v_d = \mu_p \mathcal{E} \qquad (x - v_d t) \leftarrow x$$

$$\delta p(x,t) = \frac{P_0}{2\sqrt{\pi D_p t}} \exp\left(-\frac{(x - v_d t)^2}{4 D_p t}\right)$$

$$\delta p(t) = \delta p(t=0) \exp\left(-t/\tau_p\right)$$

$$\delta p(x,t) = \frac{P_0}{2\sqrt{\pi D_p t}} \exp\left(-\frac{(x - v_d t)^2}{4 D_p t} - \frac{t}{\tau_p}\right)$$

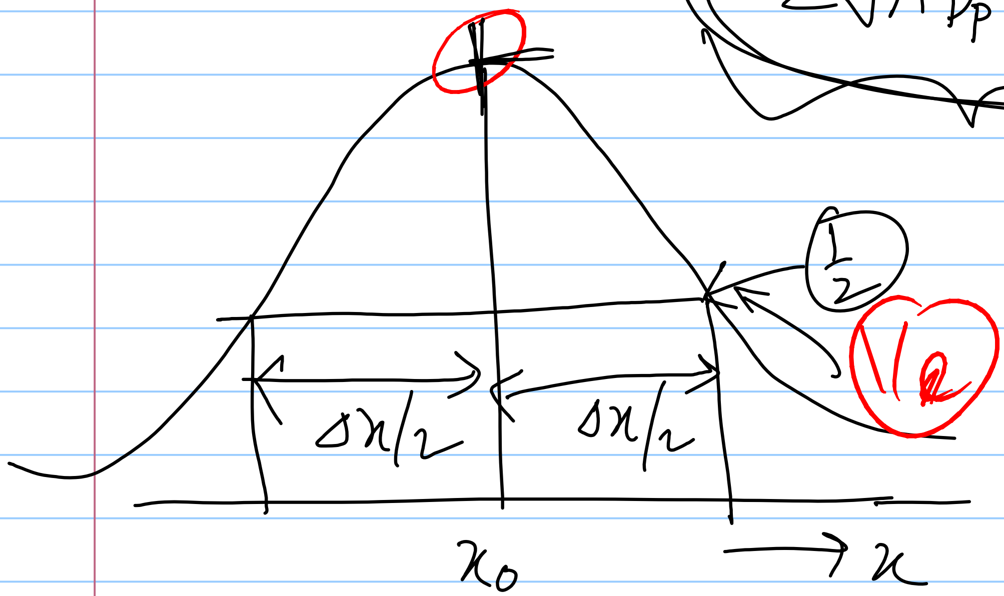


$$\frac{x_0}{t_0} = v_d = \mu_p \mathcal{E}$$

$$\mu_p = \frac{v_d}{\mathcal{E}} = \frac{x_0/t_0}{V/l}$$

$$\delta p(x,t) = \frac{P_0}{2\sqrt{\pi D_p t}} \exp\left[-\frac{(x - v_d t)^2}{4 D_p t} - \frac{t}{\tau_p} \right]$$

$$\delta p(x,t_0) = \frac{P_0}{2\sqrt{\pi D_p t_0}} \exp\left[-\frac{t_0}{\tau_p} \right] \exp\left[-\frac{(x - x_0)^2}{4 D_p t_0} \right]$$

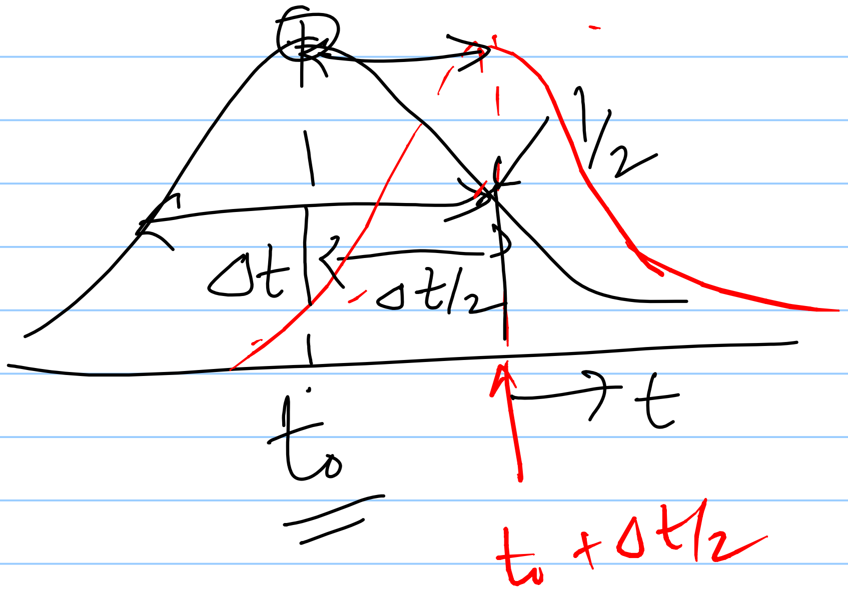


$$\frac{\delta p(x_0 + \Delta x/2,\ t_0)}{\delta p(x_0,\ t_0)} = \frac{1}{2}$$

$$= \exp\left(-\frac{(\Delta x/2)^2}{4 D_p t_0} \right)$$

$$\frac{(\Delta x)^2}{16 D_p t_0} = \ln(2) = 0'69$$

$$\Rightarrow D_p = \frac{(\Delta x)^2}{16 \times 0'69\, t_0} = \frac{(\Delta x)^2}{11\, t_0} = \frac{(v_d \cdot \Delta t)^2}{11\, t_0}$$



$$\boxed{\Delta x = v_d\, \Delta t}$$

$$D_p = \frac{x_0^2\, \Delta t^2}{11\, t_0^3}$$

$l = 1\,cm$

Sample - Ge

$x_0 = 0.95\,cm$

$\mu_p = ?$

$V = 2V$

$t_0 = 0.25\,ms$

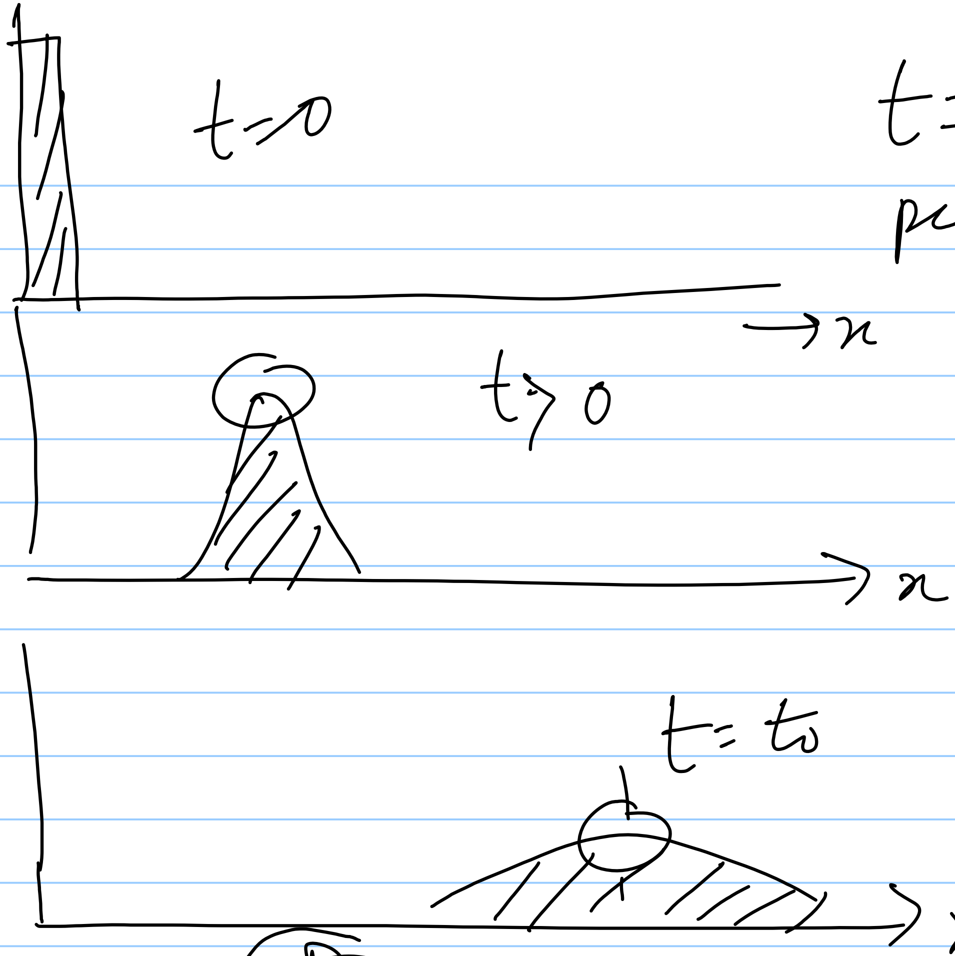
$$v_d = \frac{x_0}{t_0} = \mu_p \mathcal{E} = \mu_p \left(\frac{V}{l}\right)$$

$$\mu_p = 1900\,cm^2/V\text{-}sec$$

$$\Delta t \Big|_{\frac{1}{e} A_{peak}} = 117\,\mu sec$$

$$D_p = \frac{x_0^2\, \Delta t^2}{16\, t_0^3} \simeq 49.4\,cm^2/sec$$

$$\frac{D_p}{\mu_p} = ? = 0.026V = \frac{kT}{q}$$



$t = 50\,ns$

peak = 100 mV

$t = 250\,ns$

peak = 25 mV

$$4 = \frac{1/\sqrt{50\,ns}\; e^{-50/\tau_p}}{1/\sqrt{250\,ns}\; e^{-250/\tau_p}}$$

$$\tau_p = \frac{400}{\ln(3.2)}\,ns$$

$$\text{peak} = \frac{P_0}{2\sqrt{\pi D_p t}} \exp\left(-t/\tau_p\right)$$