Relevant Relations - Example

$\gamma \equiv 2.183 \qquad \psi_s \equiv 0.74$

$$N_{sub} := \frac{\gamma^2 \cdot C_{ox}^2}{2 \cdot \varepsilon_s \cdot q} \qquad \gamma = \frac{\sqrt{N_{sub} \cdot 2 \cdot \varepsilon_s \cdot q}}{C_{ox}}$$

$$N_{sub} = 1.697 \times 10^{22}$$

$$z := \sqrt{\frac{2 \cdot \varepsilon_s}{q \cdot N_{sub}}}$$

$$\phi_F := V_{th} \cdot \ln\left(\frac{N_{sub}}{n_i}\right)$$

$$PHI := 2 \cdot \phi_F$$

$$V_{FBsub} := \frac{-E_g}{2} - \frac{PHI}{2}$$

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$$N_{dose} := 8.5 \cdot 10^{14}$$

$$V_d := N_{dose} \cdot \frac{q}{C_{ox}} \qquad V_d = 0.394$$

$$V_{FB} := V_{FBsub} - V_d$$

$$V_{FB} = -1.31$$

Parameter ψd is the surface-potential equivalent for the doping-density reduction from the compensating implant and is depth, ti, dependent.

$$\psi_d = \frac{q}{\varepsilon_s \cdot 2} \cdot N_o \cdot t_i^2$$

$$\psi_d \equiv 0.135$$

$$t_i := \frac{\psi_d \cdot \varepsilon_s \cdot 2}{q \cdot N_{dose}}$$

Depletion width is extended from the implant.

$$w_d = \sqrt{\psi_s + \psi_d} \cdot z$$

Volume density in implant region,

$$N_o := \frac{N_{dose}}{t_i} \qquad N_o = 4.104 \times 10^{21}$$

Net density in implant region.

$$N_i := N_{sub} - N_o$$

$$N_i = 1.29 \times 10^{22} \qquad N_{sub} = 1.70 \times 10^{22}$$

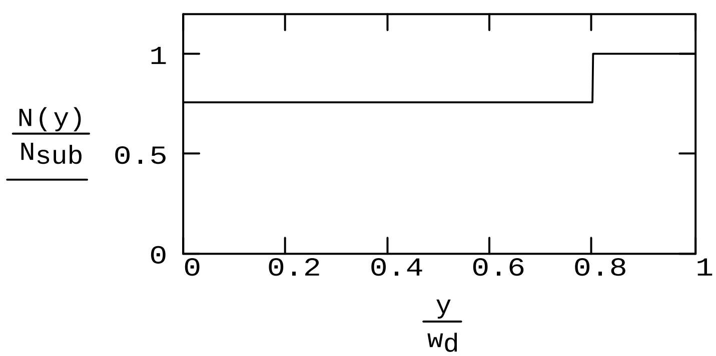
$$t_i := \psi_d \cdot 2 \cdot \frac{\varepsilon_s}{V_d \cdot C_{ox}} \qquad t_i = 2.07 \times 10^{-7}$$

$$t_i := \frac{V_d \cdot C_{ox}}{q \cdot N_o} \qquad t_i := \sqrt{\frac{\psi_d}{q \cdot N_o} \cdot 2 \cdot \varepsilon_s}$$

$$w_d := \sqrt{\psi_s + \psi_d} \cdot z \qquad w_d = 2.6 \times 10^{-7}$$

$$N(y) := \mathrm{if}\left(y < t_i, N_i, N_{sub}\right)$$

$$y := 0, \frac{w_d}{1000} .. w_d$$



Depletion-region charge oxide voltage.

$$V_B := \frac{N_i \cdot t_i \cdot q + N_{sub} \cdot \left(w_d - t_i\right) \cdot q}{C_{ox}}$$

$$V_B = 1.648$$

Depletion-region oxide votage function.

$$V_B := \gamma\cdot\sqrt{\psi_s + \psi_d} - V_d$$

$$V_B = 1.648$$

Threshold voltage with implant.
Pinchoff surface potential.

$$V_T := V_{FBsub} + \psi_s + \left(\gamma\cdot\sqrt{\psi_s + \psi_d} - V_d\right)$$

$$V_{FB} := V_{FBsub} - V_d$$

$$V_T := V_{FB} + \psi_s + \gamma\cdot\sqrt{\psi_s + \psi_d}$$

$$V_g \equiv 1.5$$

$$V_g + \psi_d = V_{FB} + \psi_{sa} + \psi_d + \gamma\cdot\sqrt{\psi_{sa} + \psi_d}$$

$$V_g + \psi_d = V_{FB} + X^2 + \gamma\cdot X$$

$$X := \frac{-\gamma}{2}\cdot\left[1 - \sqrt{1 + 4\cdot\frac{\left(V_g + \psi_d - V_{FB}\right)}{\gamma^2}}\right]$$

$$\psi_{sa} + \psi_d = \left[\frac{-\gamma}{2}\cdot\left[1 - \sqrt{1 + 4\cdot\frac{\left(V_g + \psi_d - V_{FB}\right)}{\gamma^2}}\right]\right]^2$$

$$\psi_d = 0.135$$

$$\psi_{sa} := \left[\frac{-\gamma}{2}\cdot\left[1 - \sqrt{1 + 4\cdot\frac{\left(V_g + \psi_d - V_{FB}\right)}{\gamma^2}}\right]\right]^2 - \psi_d$$

$$\psi_{sa} = 0.754$$

Impant voltage (notch in impurity distribution).

$$V_d := \frac{q\cdot N_o\cdot t_i}{C_{ox}} \qquad V_d = 0.394$$

Implant equivalent surface potential.

$$\psi_d := N_o\cdot\frac{q}{2\cdot\varepsilon_s}\cdot t_i^2$$

Surface potential is that for the substrate minus that of the notch.

$$\psi_d = 0.135$$

$$\psi_s := \frac{1}{2}\cdot\frac{q}{\varepsilon_s}\cdot N_{sub}\cdot w_d^2 - \psi_d$$

$$\psi_s = 0.740$$

Depletion width with implant.

$$w_d := \sqrt{(\psi_s + \psi_d)} \cdot z$$

$$E_s := \frac{q}{\varepsilon_s} \cdot \int_0^{t_i} N_i \, dy + \frac{q}{\varepsilon_s} \cdot \int_{t_i}^{w_d} N_{sub} \, dy$$

$$E_{xo} := \frac{-q}{\varepsilon_s} \cdot N_i \cdot t_i + E_s$$

$$E_s := \frac{q}{\varepsilon_s} \cdot N_i \cdot t_i + \frac{q}{\varepsilon_s} \cdot N_{sub} \cdot (w_d - t_i)$$

$$E_{xo} := \frac{-q}{\varepsilon_s} \cdot (N_{sub} - N_o) \cdot t_i + E_s$$

$$E_s := \frac{-q}{\varepsilon_s} \cdot N_o \cdot t_i + \frac{q}{\varepsilon_s} \cdot N_{sub} \cdot w_d$$

$$E(y) := -\left(\frac{q}{\varepsilon_s} \cdot \int_0^{y} N(y) \, dy\right) + E_s$$

$$E(y) := \frac{-q}{\varepsilon_s} \cdot \int_0^{y} N(y) \, dy + \frac{q}{\varepsilon_s} \cdot \int_0^{w_d} N(y) \, dy$$

$$\psi_s := \frac{E_{xo}}{2} \cdot (w_d - t_i) + E_{xo} \cdot t_i + \frac{E_s - E_{xo}}{2} \cdot t_i$$

$$\psi_s := \frac{E_{xo}}{2} \cdot w_d + \frac{E_{xo} \cdot t_i}{2} + \frac{E_s - E_{xo}}{2} \cdot t_i$$

$$\psi_s := \frac{E_{xo}}{2} \cdot w_d + \frac{E_s}{2} \cdot t_i$$

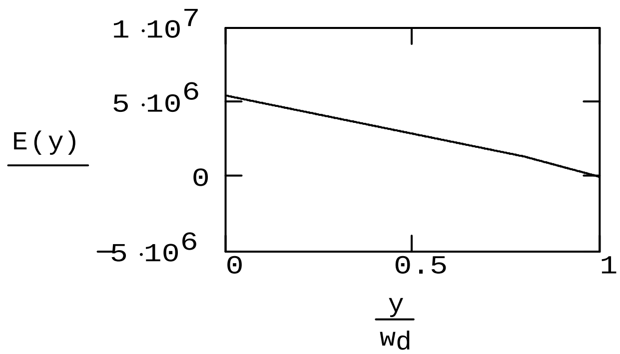
$$\psi_s := \frac{-q}{\varepsilon_s \cdot 2} \cdot N_o \cdot {t_i}^2 + \frac{q}{\varepsilon_s \cdot 2} \cdot N_{sub} \cdot {w_d}^2$$

$$\psi_d := N_o \cdot \frac{q}{2 \cdot \varepsilon_s} \cdot {t_i}^2$$

$$\psi_s := \frac{q}{\varepsilon_s \cdot 2} \cdot N_{sub} \cdot {w_d}^2 - \psi_d$$

$$\psi_s = 0.740$$

$$E(y) := \frac{-q}{\varepsilon_s} \cdot \int_0^y N(y)\, dy + E_s$$

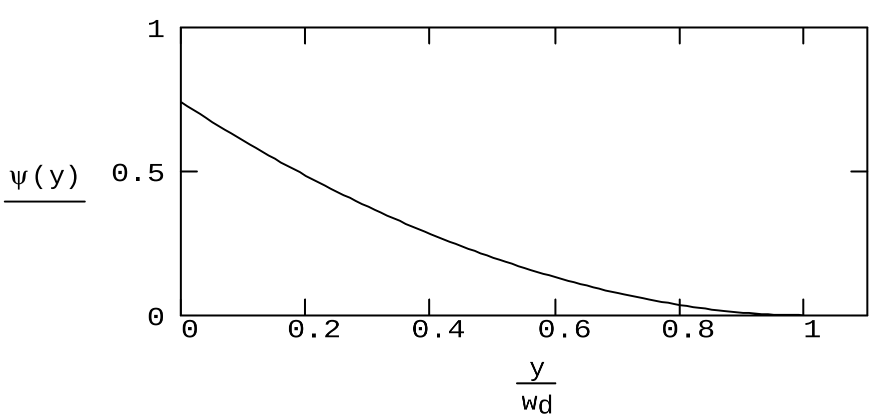


$$\psi_o := \int_0^{t_i} E(y)\, dy$$

$$\psi := \int_0^{w_d} E(y)\, dy \qquad \psi = 0.740$$

$$y := 0, \frac{w_d}{100} .. \; w_d$$

$$\psi(y) := -\left(\int_0^y E(y)\, dy - \psi\right) \qquad \psi(w_d) = 0.000$$



$\psi(0) = 0.740$

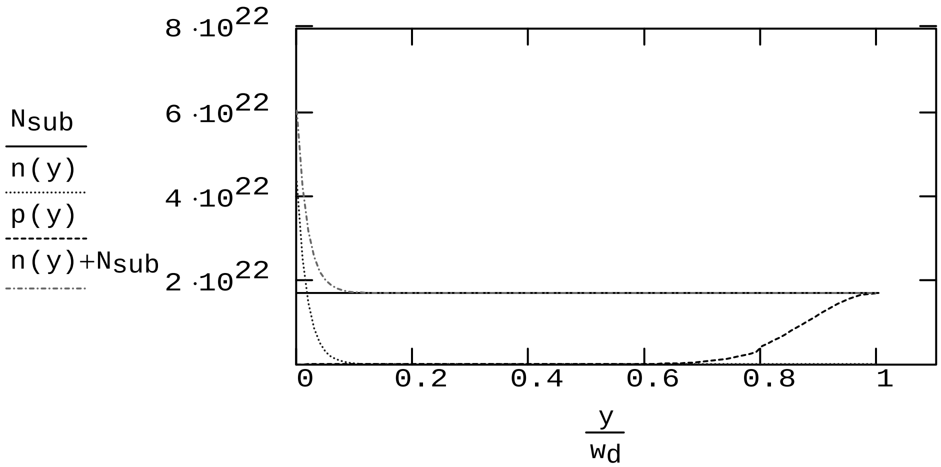
$$E_{xo} := -\frac{q}{\varepsilon_s} \cdot N_i \cdot t_i + E_s \qquad E_s := \frac{q}{\varepsilon_s} \cdot N_i \cdot t_i + \frac{q}{\varepsilon_s} \cdot N_{sub} \cdot (w_d - t_i)$$

$\psi(0) = 0.740$

$$n(y) := \frac{n_i^{\,2}}{N(y)} \cdot \exp\left(\frac{\psi(y)}{V_{th}}\right) \qquad p(y) := \frac{n_i^{\,2}}{n(y)}$$

$N_{sub} = 1.697 \times 10^{22}$

$N(0) = 1.287$



$$N_{sub} := (\gamma \cdot C_{ox})^2 \cdot \frac{1}{(2 \cdot \varepsilon_s \cdot q)}$$

$$\psi_d = N_o \cdot \frac{q}{2 \cdot \varepsilon_s} \cdot t_i^{\,2}$$

$$N_o := \frac{V_d^{\,2}}{\psi_d \cdot \gamma^2} \cdot N_{sub}$$

$$\gamma = \frac{\sqrt{9 \cdot 2 \cdot \varepsilon_s \cdot q}}{C_{ox}}$$

$$t_i := \frac{V_d \cdot C_{ox}}{q \cdot N_o}$$

$n(0) = \blacksquare$

$\psi_s = \blacksquare$

$$w_d := \sqrt{(\psi_s + \psi_d)} \cdot z$$

$\varepsilon_o \equiv 8.854187817 \cdot 10^{-12}$

$\varepsilon_s \equiv 11.8 \cdot \varepsilon_o$ $\quad E_g \equiv 1.1151$

$\varepsilon_{ox} \equiv 3.9 \cdot \varepsilon_o$

$T \equiv 273.16 + 27$ $\quad t_{ox} \equiv 0.10 \cdot 10^{-6}$

$k_B \equiv 1.3807 \cdot 10^{-23}$ $\quad q \equiv 1.60218 \times 10^{-19}$

$n_i \equiv 1.451 \cdot 10^{16}$ $\quad V_{th} \equiv k_B \cdot \frac{T}{q}$

$C_{ox} \equiv \frac{\varepsilon_{ox}}{t_{ox}}$

10^{22}