Calculating all params for Substrate

P-~~Type~~ MOS capacitor

Q-density = $-q N_A$ — * Assuming uniform density

K_{-s} → relative permittivity of ~~wrt~~ silicon

~~E~~ Electric Field

$$-\left(E(x) - E(w)\right) = \int_x^w \frac{-q N_a}{K_{-si}\,\varepsilon_0}\,dx$$

$$= E(w) - E(x) = \frac{-q N_a}{K_{-s}\,\varepsilon_0}(w - x) = -E(x) \quad [\text{as } E(w) = 0]$$

$$\Rightarrow E(x) = q N_a (w - x)$$

$$E(0) = \frac{q N_a W}{K_{-s} \times \varepsilon_0}$$

Potential $(\phi(x))$

$$E = -\frac{d\phi}{dx} \Rightarrow d\phi = -E\,dx$$

$$\phi(w) - \phi(x) = -\int_x^w E(x)\,dx$$

$$= \phi(w) - \phi(x) = -\frac{q N_a}{K_{-s}\,\varepsilon_0}\int_x^w (w-x)\,dx$$

*

Substituting $t = w - x$ $\quad \frac{dt}{dx} = -1 \quad dt = -dx$

$$\Rightarrow \frac{q N_a}{K_{-s}\,\varepsilon_0}\int_x^0 t\,dt = \frac{q N_a}{K_{-s}\,\varepsilon_0}\left.\frac{t^2}{2}\right|_x^0$$

$$= \frac{-q N_a}{K_{-s}\,\varepsilon_0}\frac{t^2}{2} = \frac{-q N_a (w-x)^2}{2 K_{-s}\,\varepsilon_0} = \cancel{\phi(w)}_{0} - \phi(x)$$

$$\phi(x) = \frac{q N_a (w-x)^2}{2 K_{-s}\,\varepsilon_0}$$

depletion width

$$\phi_s = \phi(x=0) = \frac{q N_a W^2}{2 K_{-s}\,\varepsilon_0} \Rightarrow w = \sqrt{\frac{2 K_{-s}\,\varepsilon_0\,\phi_s}{q N_a}}$$

To compute ϕ_s (surface potential) without depletion width

$$V_G = \underbrace{E_{ox}(T_{ox})}_{V_{ox}} + \phi_s + V_{FB} \qquad [V_{FB} = \phi_M - \phi_P]$$

$$= \frac{q N_a}{K_{ox} \varepsilon_0} \sqrt{\frac{2 K_s \varepsilon_0}{q N_a}} (T_{ox}) \sqrt{\phi_s} + \phi_s + V_{FB}$$

$$\underbrace{\sqrt{\frac{2 q N_a K_s (T_{ox})^2}{K_{ox}^2 \varepsilon_0}}}_{b} \sqrt{\phi_s} + \phi_s + V_{FB} = V_G$$

$$b\sqrt{\phi_s} + \phi_s + V_{FB} = V_G$$

$$(V_G - V_{FB} - \phi_s)^2 = b^2 \phi_s$$

$$\Rightarrow (V_G - V_{FB})^2 - 2(V_G - V_{FB})\phi_s + \phi_s^2 = b^2 \phi_s$$

$$\underbrace{(V_G - V_{FB})^2}_{C} - \underbrace{\left[2(V_G - V_{FB}) + b^2\right]}_{B} \phi_s + \phi_s^2 = 0$$

$$\phi_s = \frac{-B \pm \sqrt{B^2 - 4ac}}{2a}$$

$$b^2 = \frac{2 q N_a K_s (T_{ox})^2}{K_{ox}^2 \varepsilon_0}$$

Here T_{ox} is oxide thickness

$\phi_s \rightarrow$ surface potential

$V_{FB} \rightarrow$ Flat band voltage

$E_{ox} \rightarrow$ electric field in oxide layer

$$K_{ox} \varepsilon_0 E_{ox} = K_s \varepsilon_0 E(0) = K_s \varepsilon_0 \frac{q N_a w}{K_s \varepsilon_0}$$

[EM theory normal displacement vector at boundary is equal]

$$E_{ox} = \frac{q N_a W}{K_{ox} \varepsilon_0}$$

Scanned with CamScanner