Junções PN

Leitura: Sze + Kasap

EEL6760 – Transporte Eletrônico

Prof. Carlo Requião da Cunha, Ph.D.

EEL/CTC/UFSC

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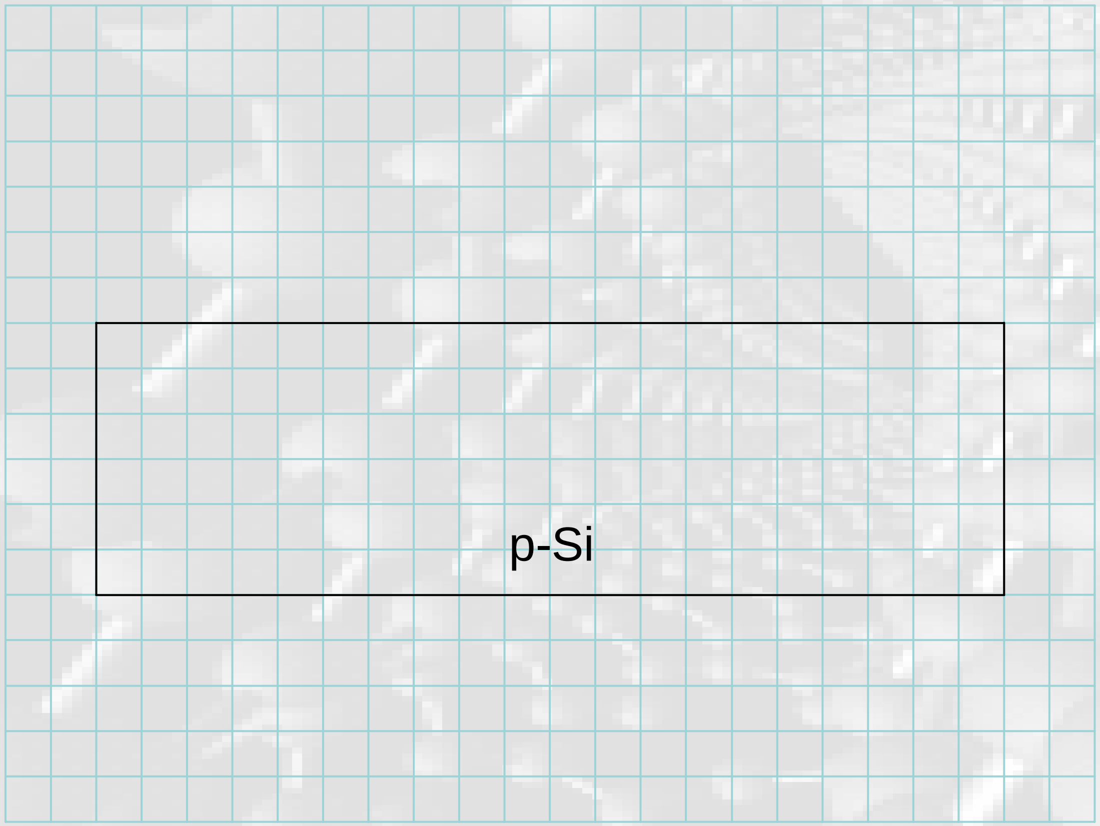
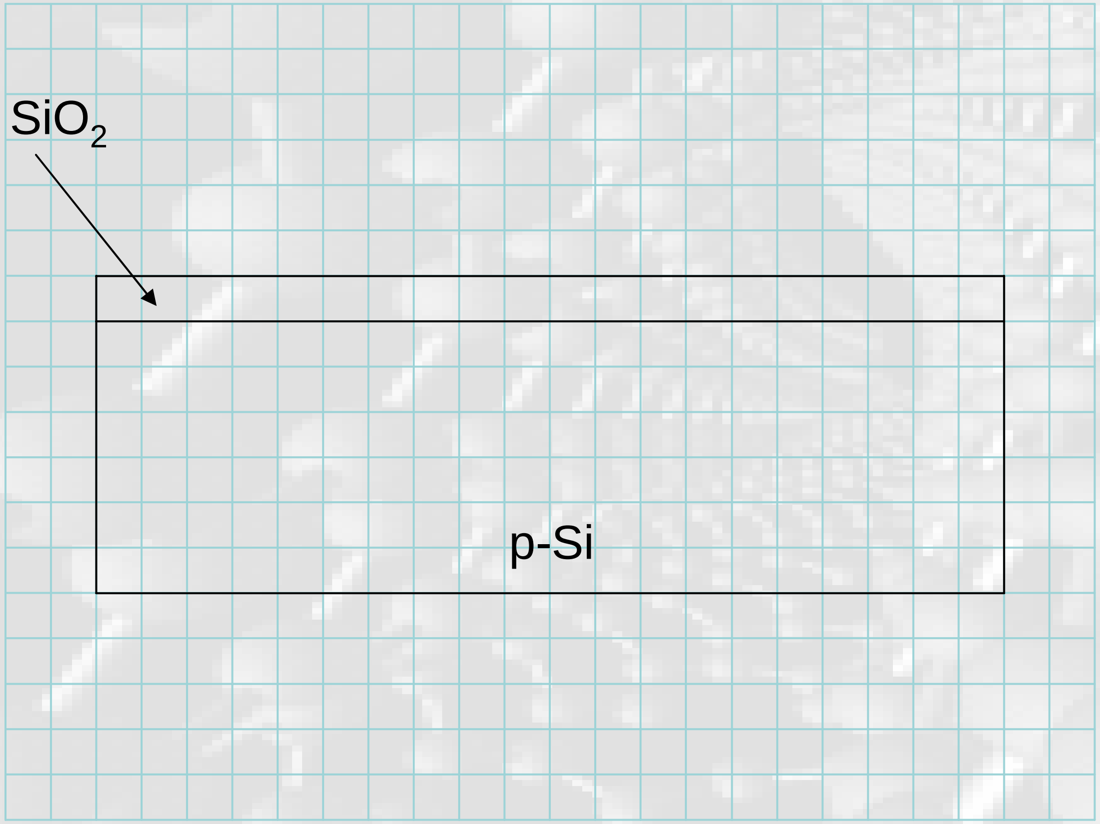
p-Si

Máscara



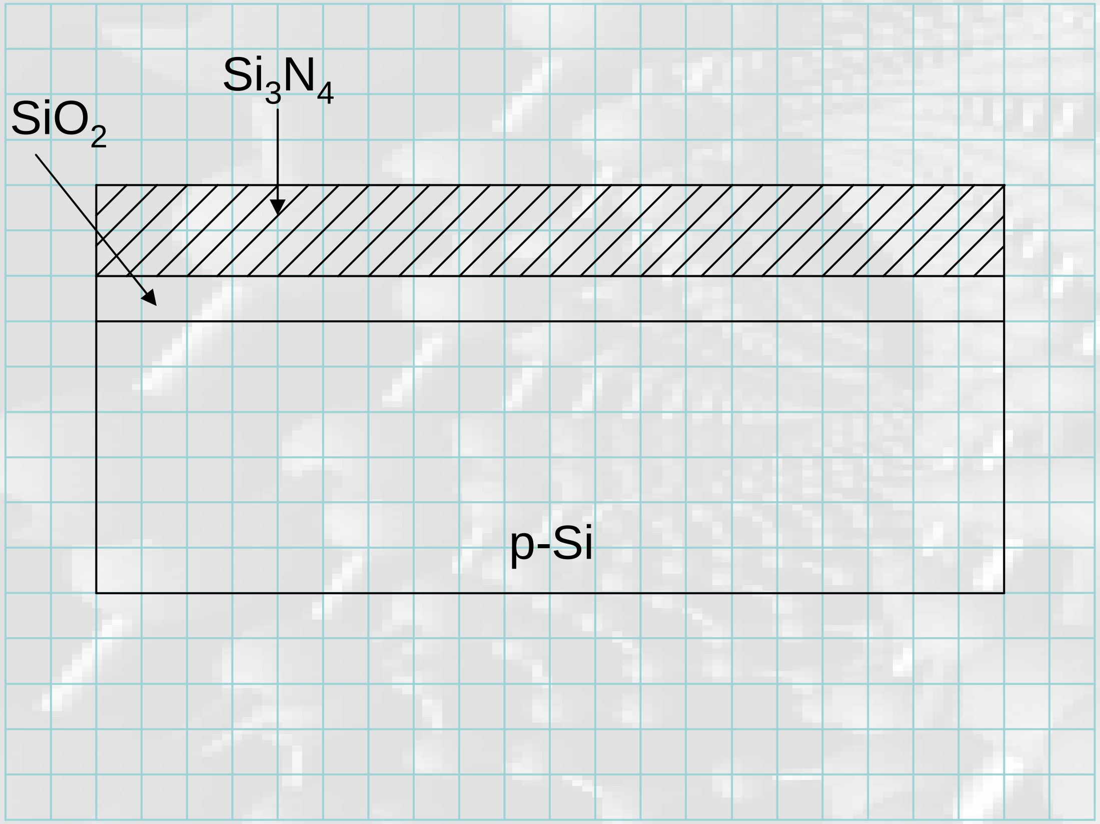
Oxidação

Máscara



Si_3N_4

Máscara



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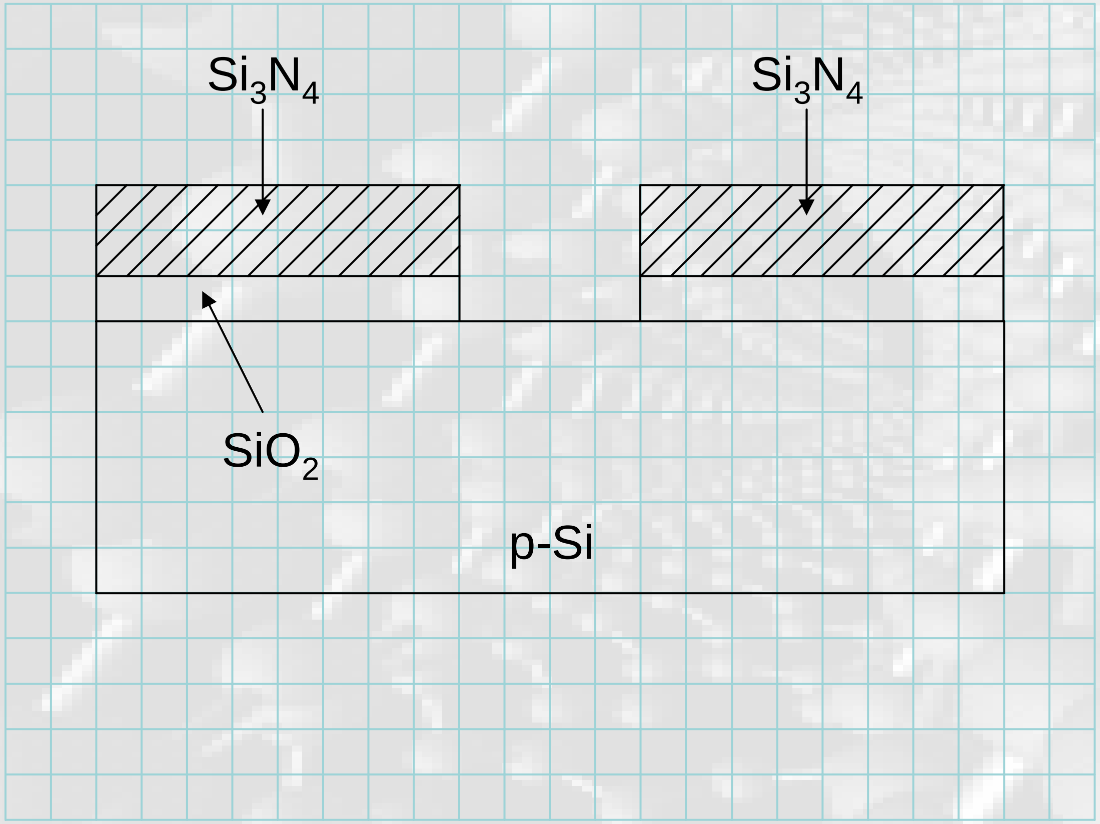
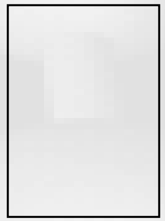
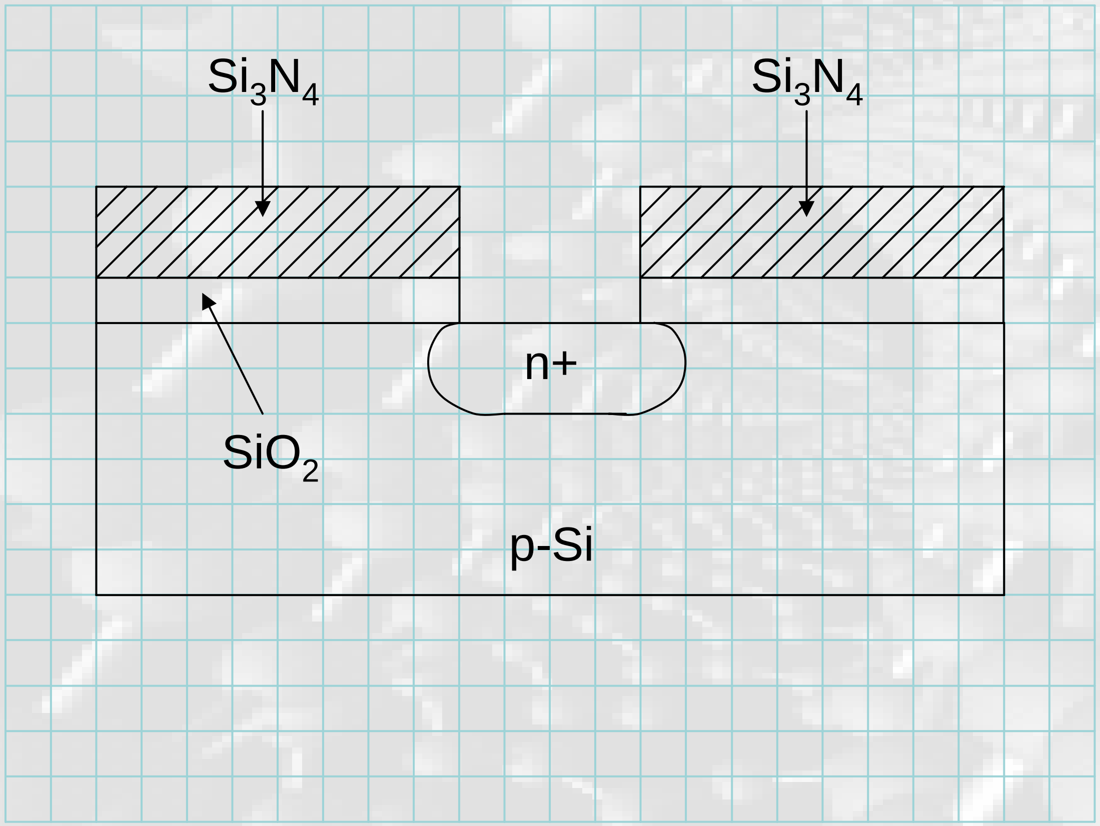
Corrosão

Máscara



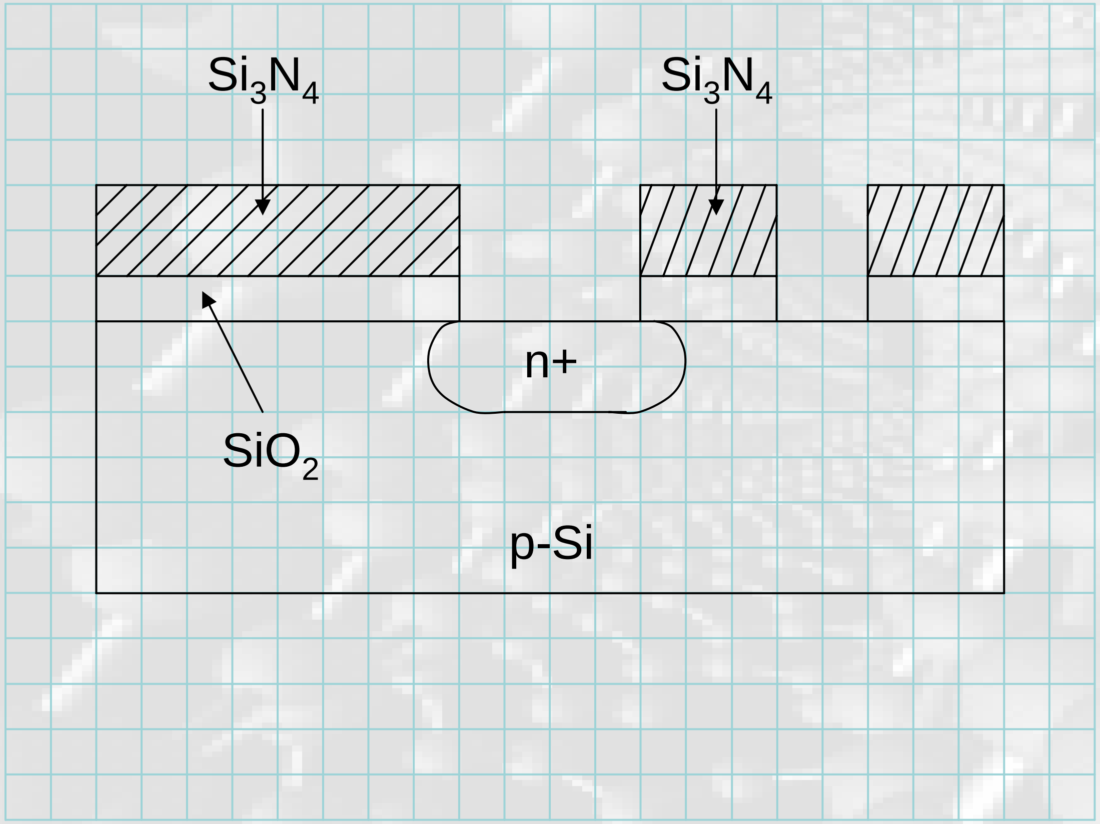


Difusão



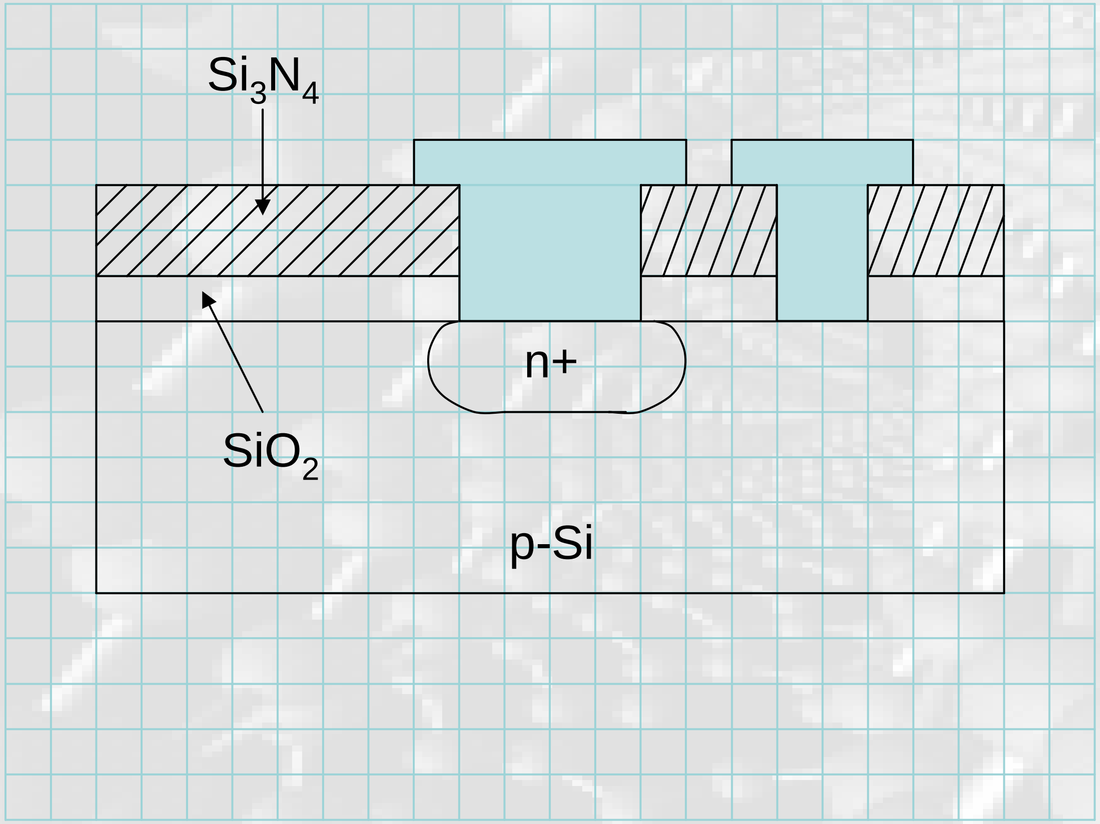
Máscara

Corrosão

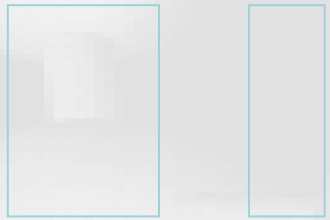


Máscara

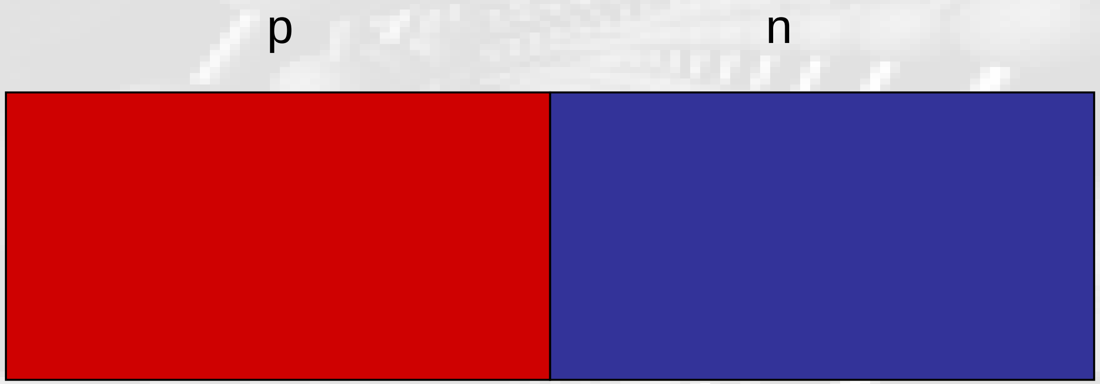
Sputtering



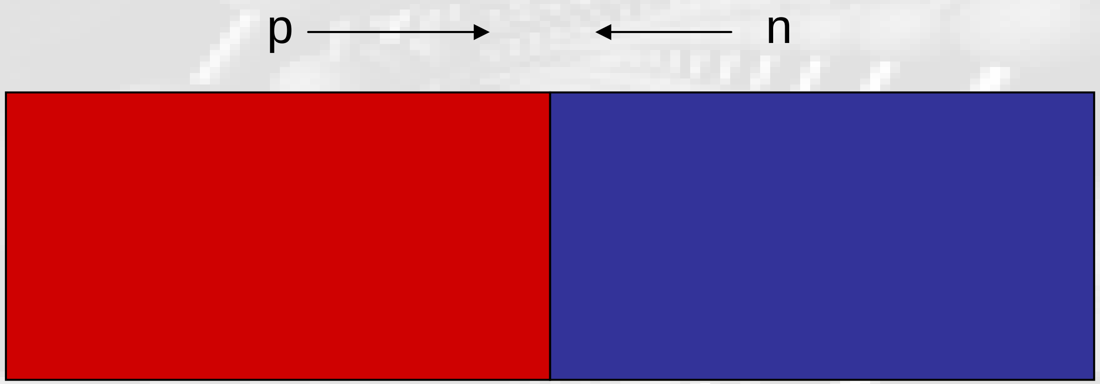
Máscara



Junção Metalúrgica

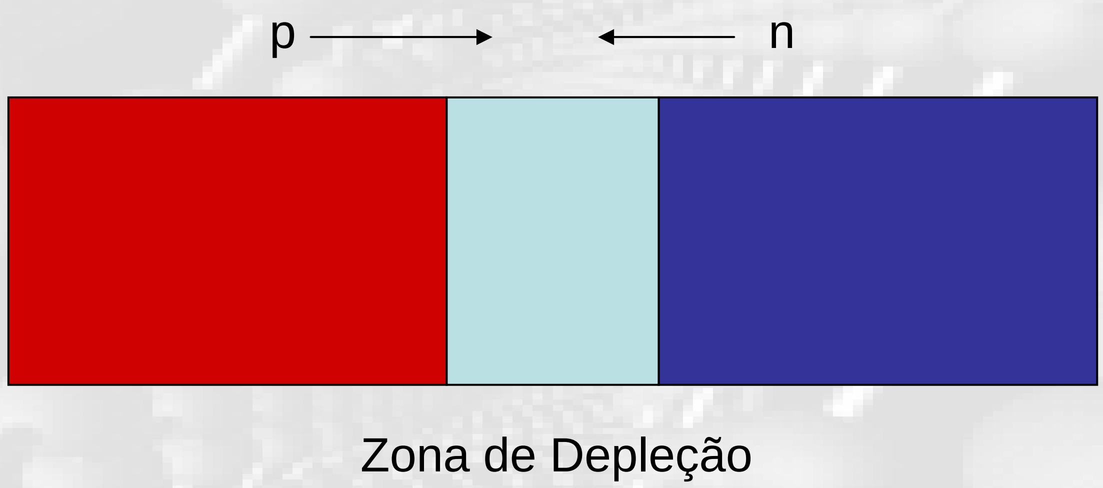


Difusão de Cargas

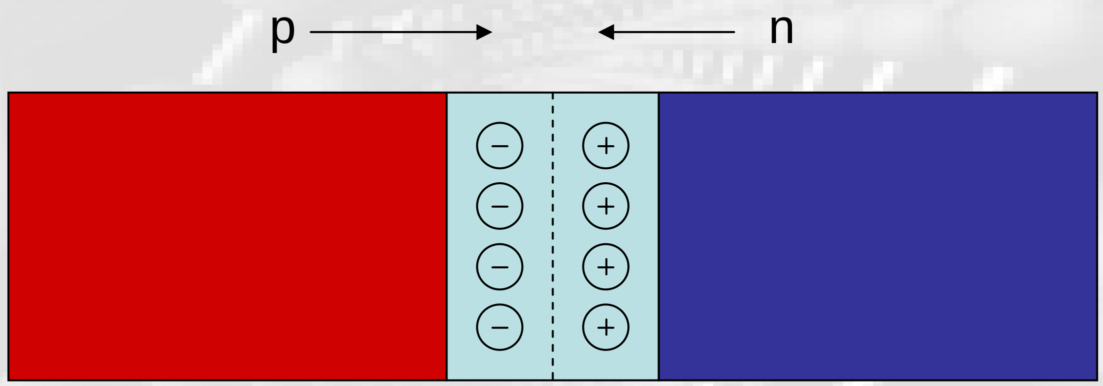


$$\vec{J} = -D.\nabla\vec{C}$$

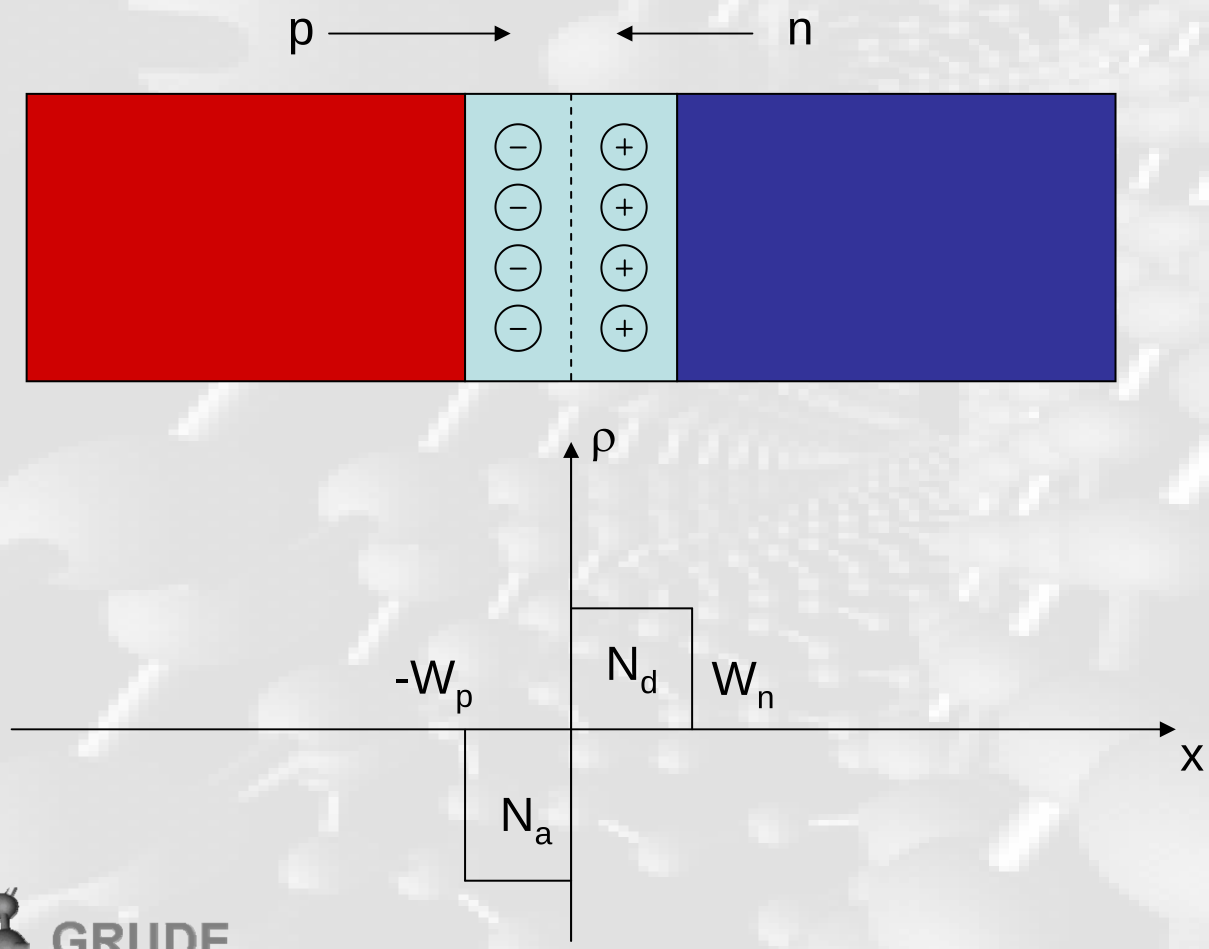
Neutralização de Cargas



Exposição de Íons



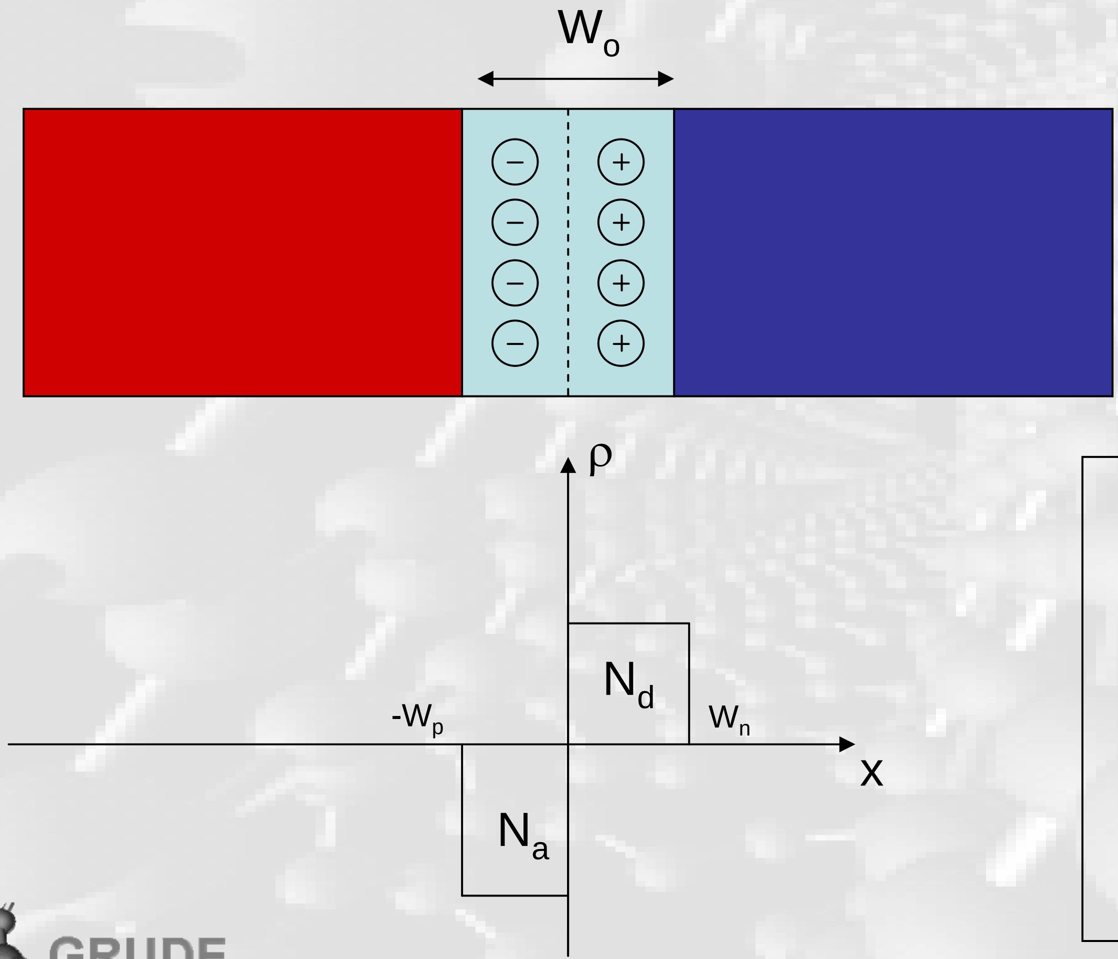
Densidade de Cargas



Neutralidade:

$$W_p N_a = W_n N_d$$

Neutralidade de Cargas

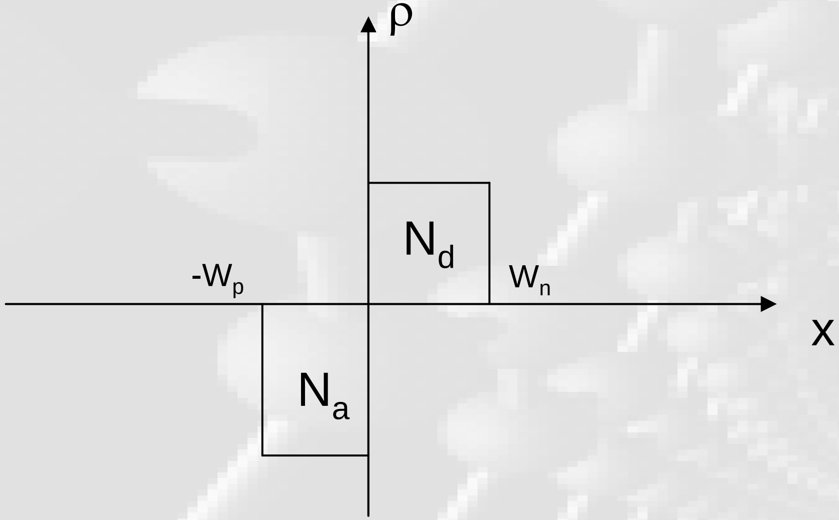


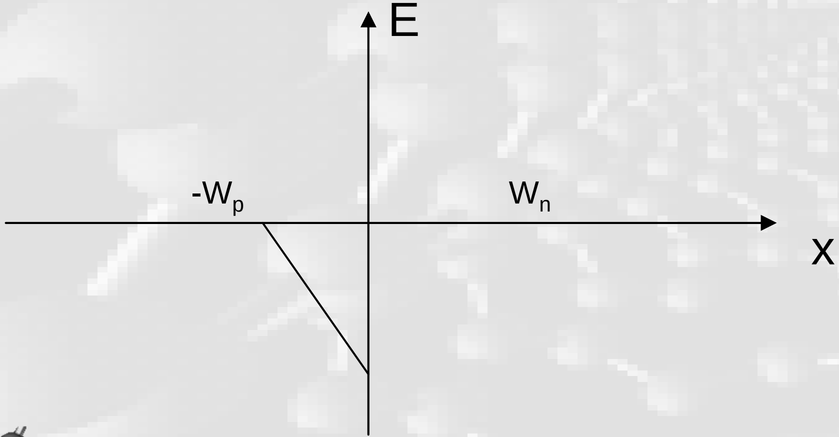
$$\begin{cases} W_p N_a = W_n N_d \\ W_p + W_n = W_0 \end{cases}$$

$$W_p = W_0 \frac{N_d}{N_a + N_d}$$

$$W_n = W_0 \frac{N_a}{N_a + N_d}$$

Campo Elétrico 1



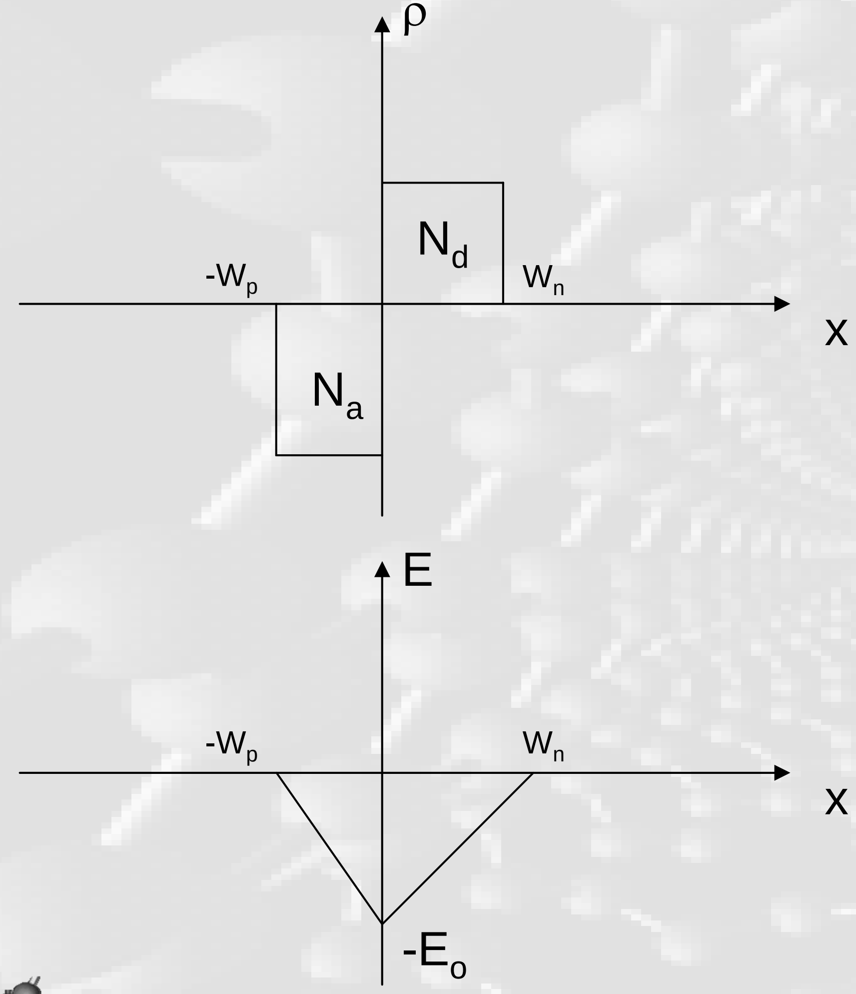


$$\nabla \cdot \vec{E} = \frac{\rho(\vec{r})}{\varepsilon}$$

$$E(\vec{r}) = \frac{1}{\varepsilon} \int_{-W_p}^{r} \rho(\vec{r}) d\vec{r}$$

= ACUMULAÇÃO

Campo Elétrico 2

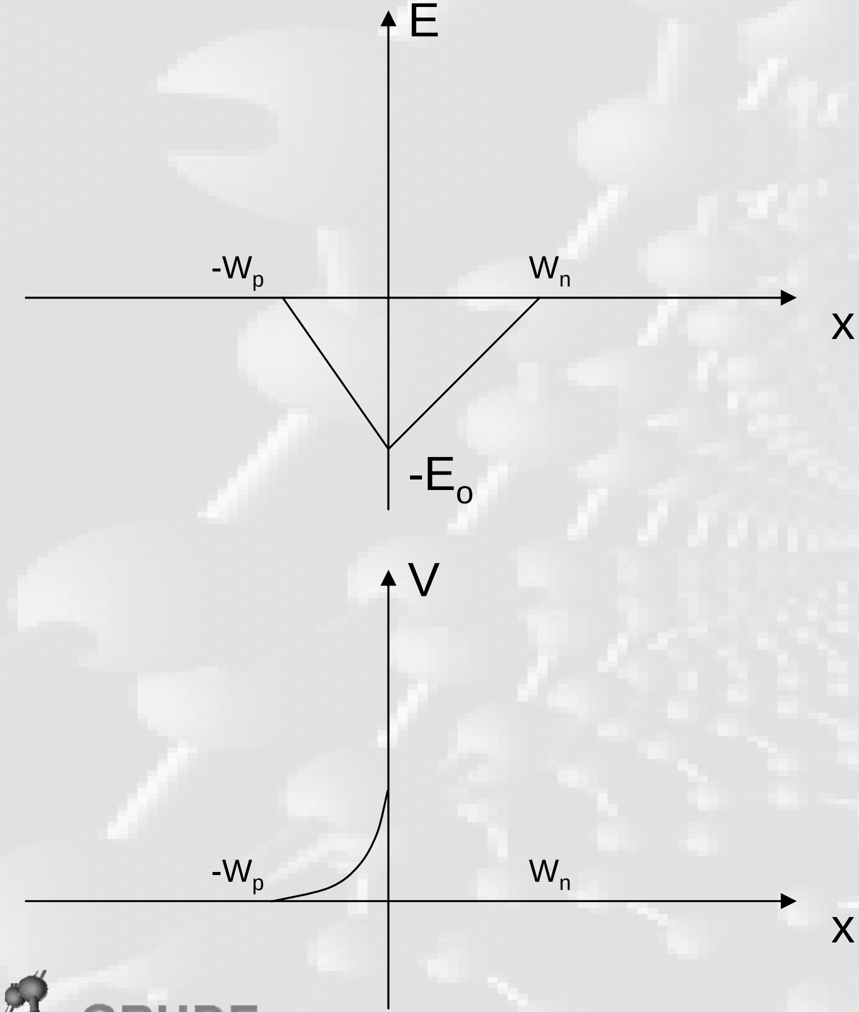


$$\nabla \cdot \vec{E} = \frac{\rho(\vec{r})}{\varepsilon}$$

$$E(\vec{r}) = \frac{1}{\varepsilon} \int_{-W_p}^{r} \rho(\vec{r})\, d\vec{r}$$

$$E_0 = -\frac{qN_d W_n}{\varepsilon} = -\frac{qN_a W_p}{\varepsilon}$$

Potencial Elétrico 1

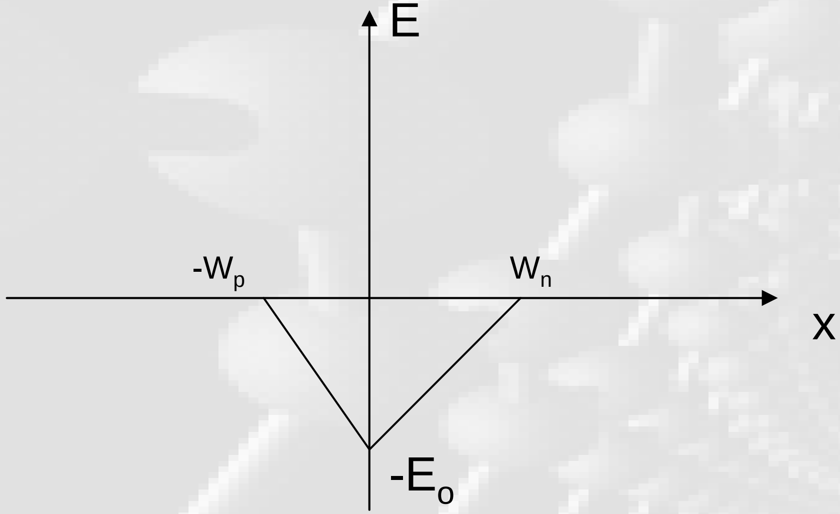


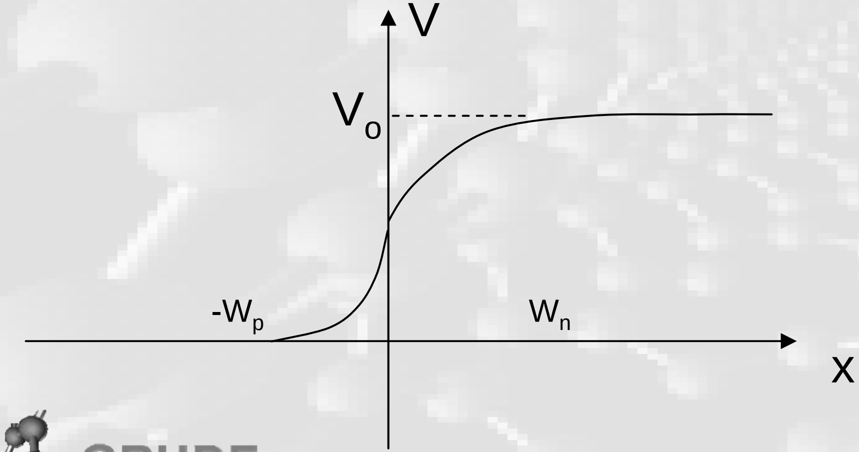
$$-\nabla V = \vec{E}$$

$$V(\vec{r}) = -\int_{-W_p}^{r} E(\vec{r})\,d\vec{r}$$

Outra ACUMULAÇÃO

Potencial Elétrico 2



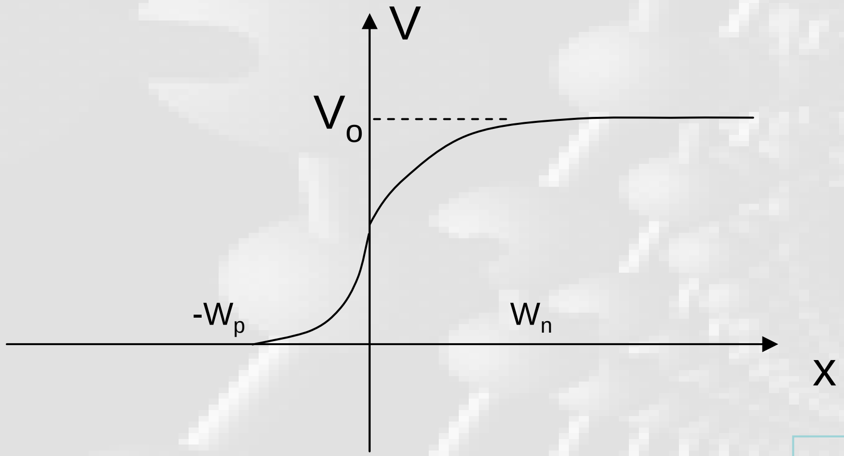


$$-\nabla V = \vec{E}$$

$$V_0 = \int_{-W_p}^{0} \frac{E_o r}{W_p} d\vec{r} - \int_{0}^{W_n} \frac{E_o r}{W_n} d\vec{r}$$

$$V_0 = \tfrac{1}{2}\left(E_0 W_p\Big|_p + E_0 W_n\Big|_n\right)$$

Potencial Elétrico 3



$$V_0 = \tfrac{1}{2}\left(E_0 W_p\Big|_p + E_0 W_n\Big|_n\right)$$

$$E_0 = -\frac{qN_d W_n}{\varepsilon} = -\frac{qN_a W_p}{\varepsilon}$$

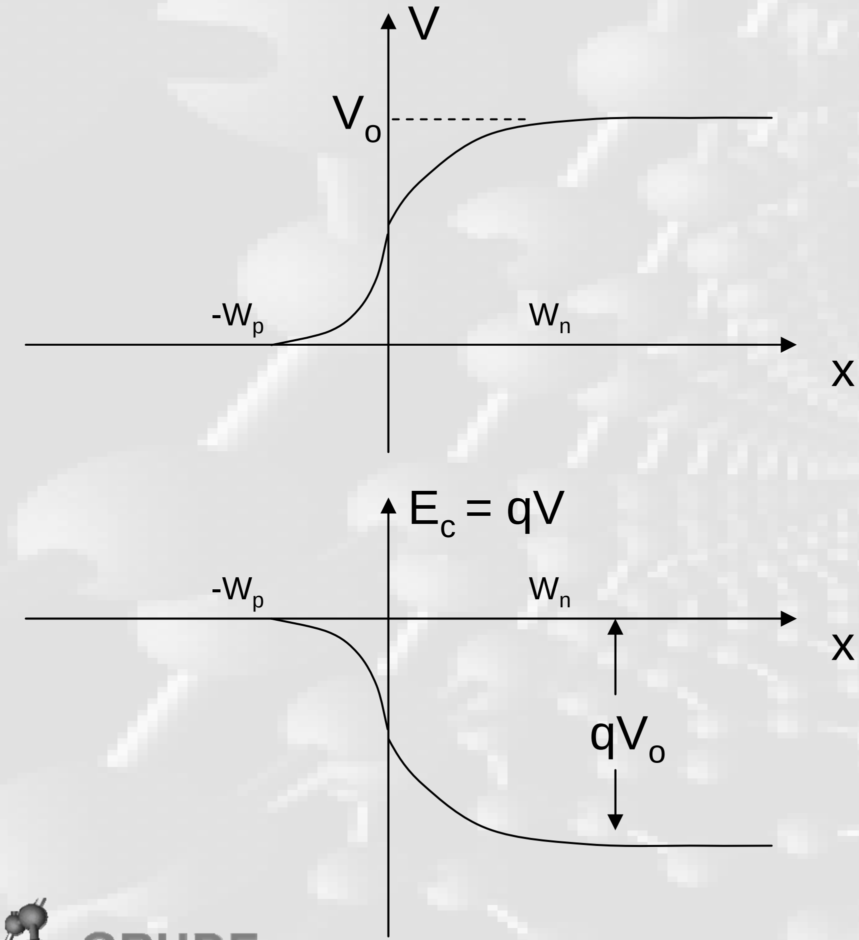
$$V_0 = \frac{q}{2\varepsilon}\left(N_a W_p^{\ 2} + N_d W_n^{\ 2}\right)$$

$$W_p = W_0 \frac{N_d}{N_a + N_d}$$

$$W_n = W_0 \frac{N_a}{N_a + N_d}$$

$$V_0 = \frac{qW_0}{2\varepsilon}\frac{N_a N_d}{N_a + N_d}$$

Banda de Condução



$$n(\varepsilon) \propto e^{-\frac{\varepsilon}{k_B T}}$$

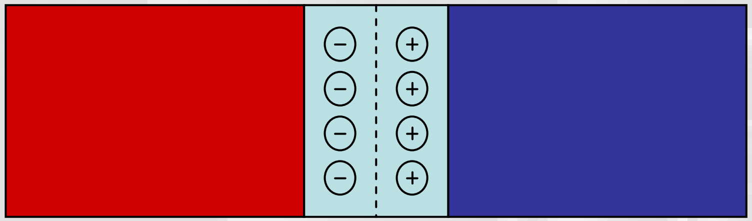
$$\frac{n_{p0}}{n_{n0}} = e^{-\frac{qV_0}{k_B T}}, \frac{p_{n0}}{p_{p0}} = e^{-\frac{qV_0}{k_B T}}$$

$$V_0 = \frac{k_B T}{q} \ln\left(\frac{n_{n0}}{n_{p0}}\right) = \frac{k_B T}{q} \ln\left(\frac{p_{p0}}{p_{n0}}\right)$$

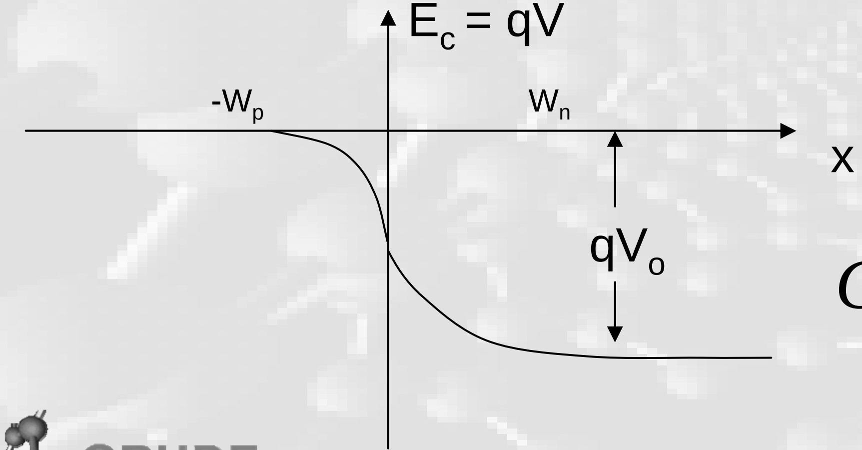
$$p_{n0} n_{n0} = ni^2 \rightarrow p_{n0} = ni^2 \big/ n_{n0} = ni^2 / N_d$$

$$\boxed{V_0 = \frac{k_B T}{q} \ln\left(\frac{N_a N_d}{ni^2}\right)}$$

Zona de Depleção



$$V_0 = \frac{k_B T}{q} \ln\left(\frac{N_a N_d}{ni^2}\right)$$



$$W_0 = \left[\frac{2\varepsilon}{q}\frac{\left(N_a + N_d\right)}{N_a N_d} V_0\right]^{1/2}$$

$$C_A = \varepsilon W_0^{-1} = \left[\frac{2}{q\varepsilon}\frac{\left(N_a + N_d\right)}{N_a N_d} V_0\right]^{-1/2}$$

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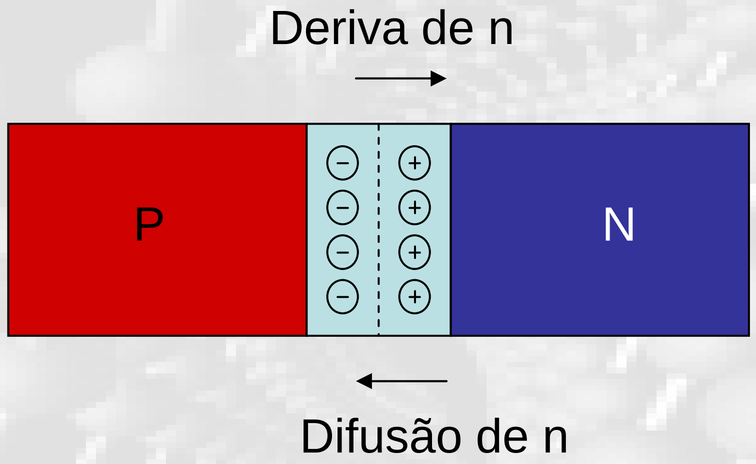
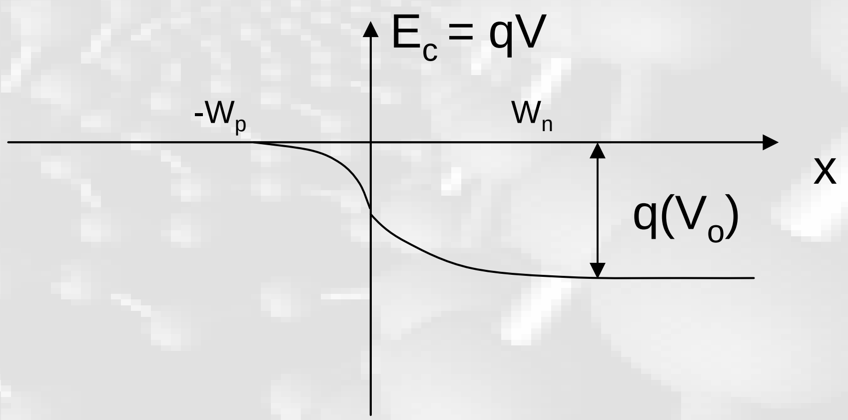
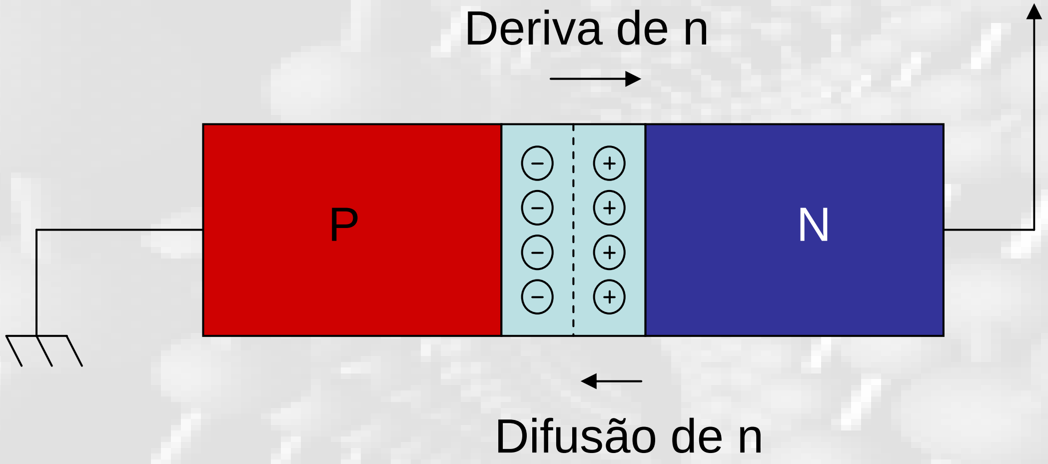
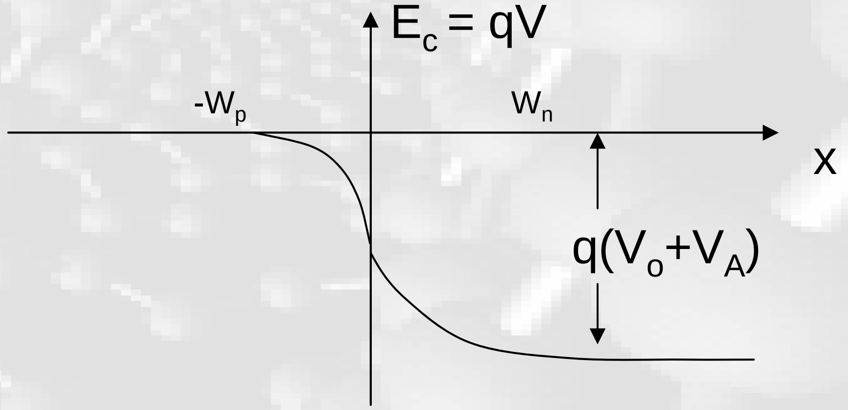
Corrente na Junção



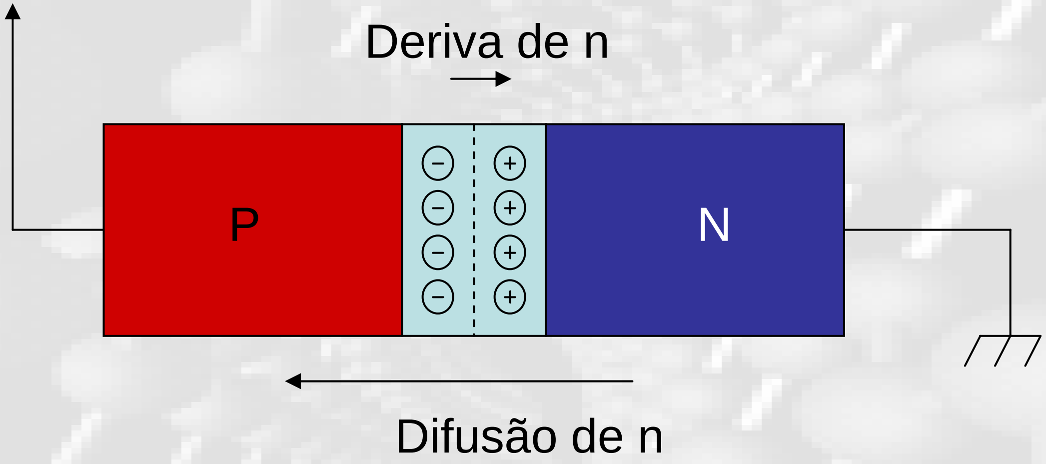


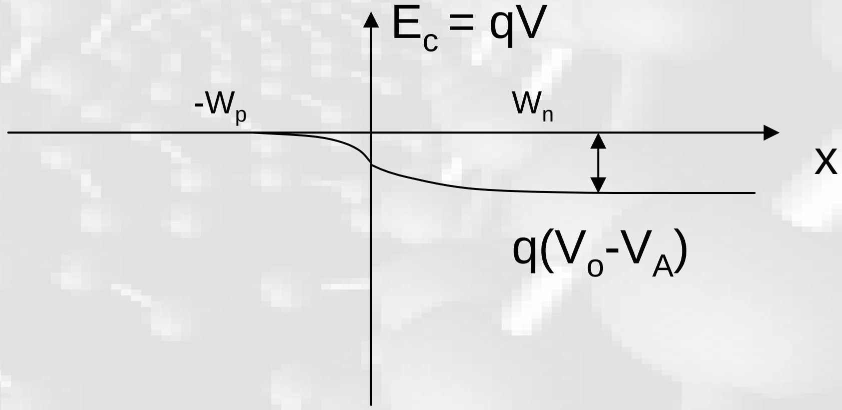
Corrente Reversa



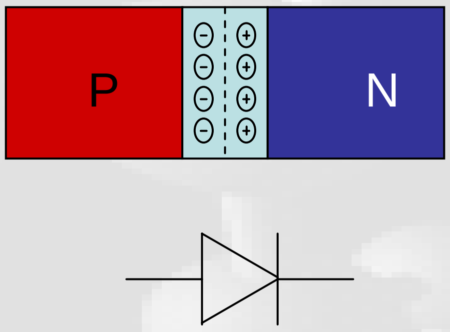


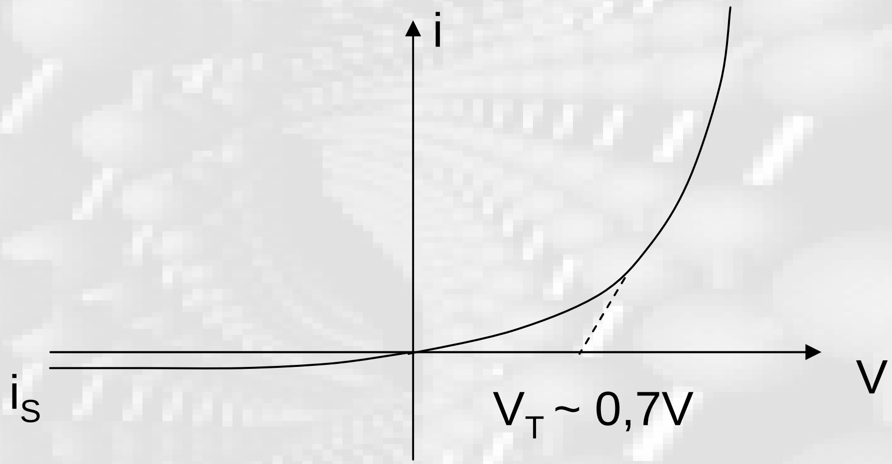
Corrente Direta





Corrente Total





$$I(V) = I_S \left[e^{\frac{qV}{k_B T}} - 1 \right]$$

Equação de Shockley