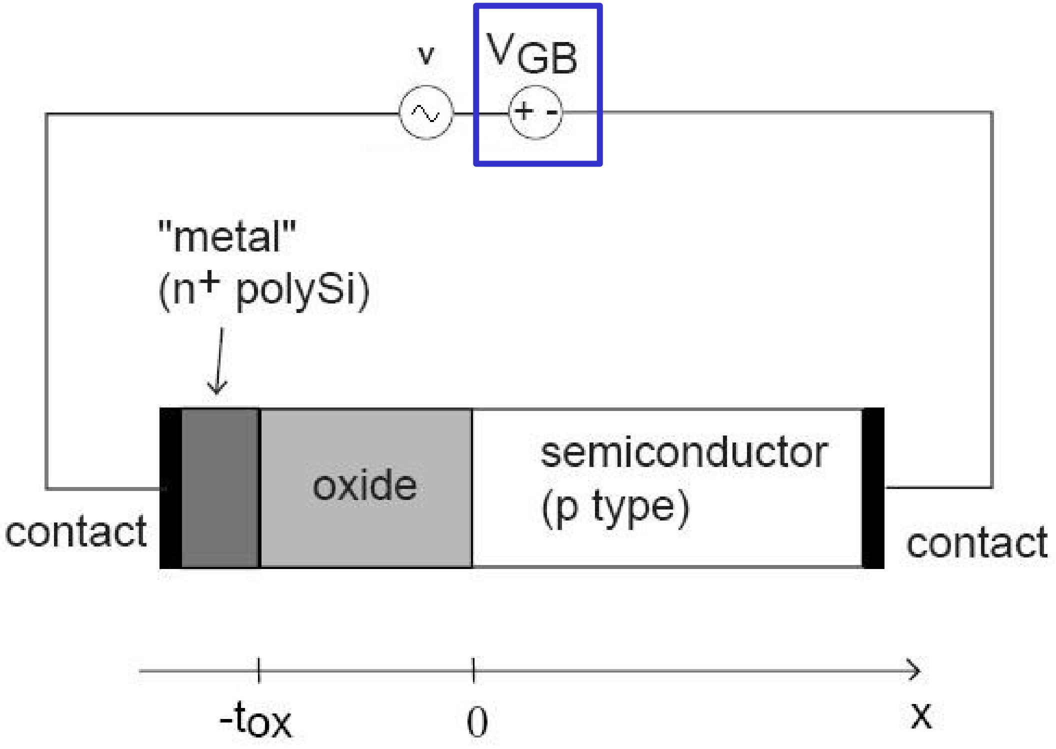
Juntura MOS

Curva Capacidad-Tensión

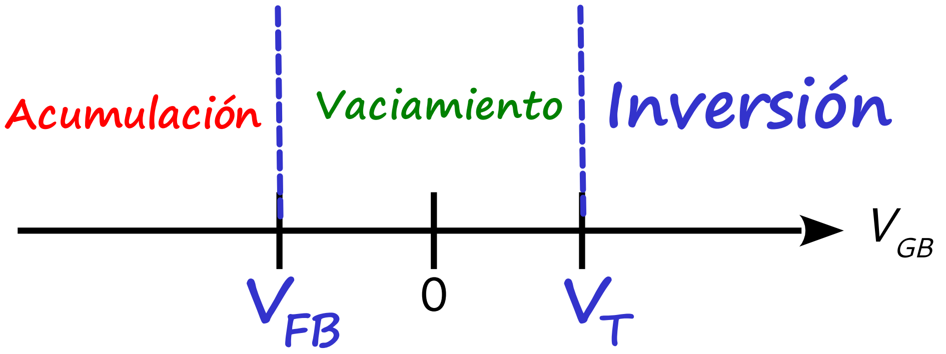
Una estructura MOS con *Gate* de Polisilicio N^{++} y sustrato tipo P con densidad de dopantes $N_A = 10^{17}$ cm^{-3} y parámetros $V_T = 0.547$ V, $\gamma^2 = 0.545$ V y $C'_{OX} = 246$ nF/cm^2.

- Hallar la curva de capacidad tensión del dispositivo indicando todos sus valores característicos.



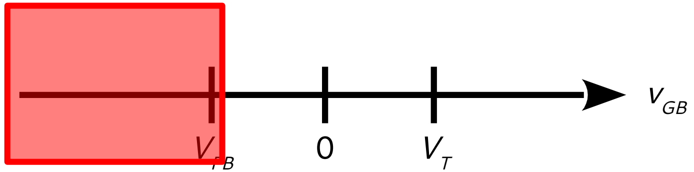
$$C'_{GB} = \left.\frac{\partial Q'(v_{GB})}{\partial v_{GB}}\right|_{V_{GB}}$$

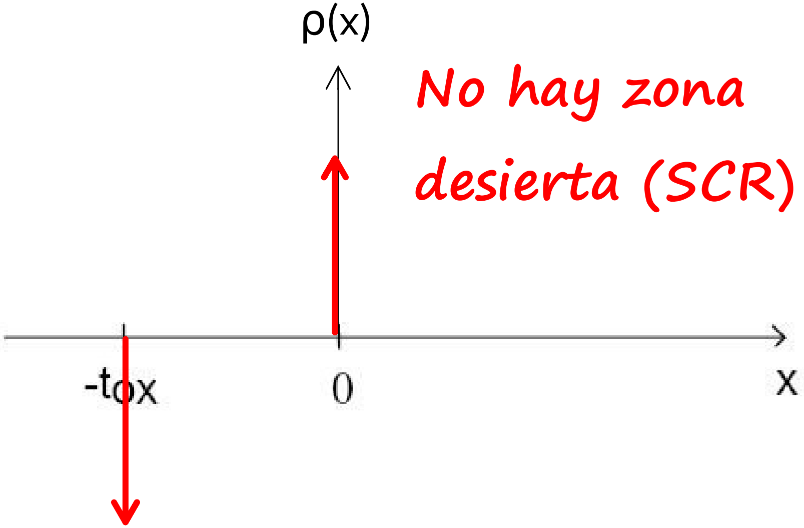
$Q'(v_{GB}) =$?? Depende del régimen



Acumulación

$$V_{GB} < V_{FB}$$





Datos
Poly-N^{++}; Sust-P
$N_A = 10^{17}$ cm^{-3}
$V_T = 0.547$ V
$\gamma^2 = 0.545$ V
$C'_{OX} = 246$ nF/cm^2.

Del ejercicio anterior:
$\Phi_{Gate} = -0.42$ V
$\Phi_{Bulk} = -0.42$ V
$V_{FB} = -0.97$ V

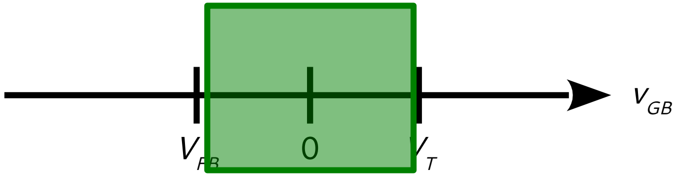
$$x_d = 0$$

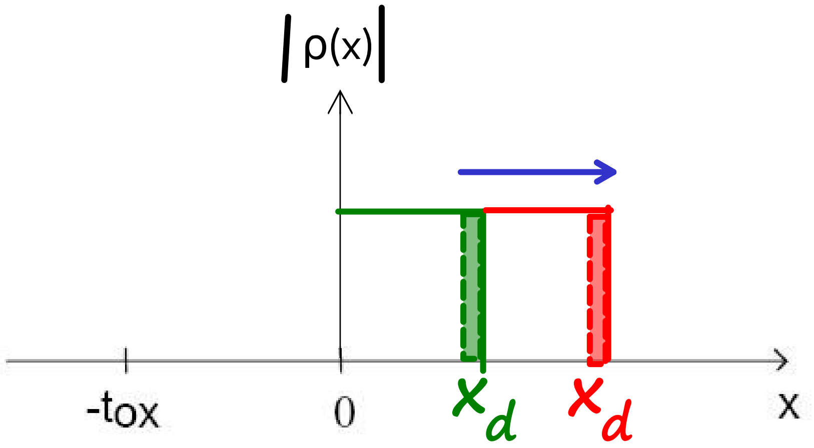
$$Q'_{Bulk} = 0$$

$$Q'_{acum} = -C'ox\,(VGB-VFB) \rightarrow C' = C'ox$$

Vaciamiento

$$V_{FB} < V_{GB} < V_T$$





Datos
Poly-N++; Sust-P
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$V_T = 0.547$ V
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Del ejercicio anterior:
$\Phi_{Gate} = -0.42$ V
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$$x_d = \frac{\epsilon_{Si}}{C'_{OX}} \left[\sqrt{1 + \frac{4(\phi_B + v_{GB})}{\gamma^2}} - 1 \right]$$

$$Q'_{Bulk} = -q\ N_A\ x_d(v_{GB})$$

$$C'(V_{GB}) = q\ N_A \frac{\partial x_d}{\partial v_{GB}} = \frac{C'_{OX}}{\sqrt{1 + \frac{4(\phi_B + V_{GB})}{\gamma^2}}}$$

$$C'(V_{GB} = V_{FB}) = C'_{OX}$$

$$C'_0(V_{GB} = 0) = 87.6\ \text{nF/cm}^2$$

$$C'_{min}(V_{GB} = V_T) = 70.9\ \text{nF/cm}^2$$

Cuentas auxiliares

VFB = - phi_B

$$\frac{\partial x_d}{\partial v_{GB}} = \frac{\partial}{\partial v_{GB}}\left\{\frac{\epsilon_{Si}}{C'_{OX}}\left[\left(1+\frac{4(\phi_B+v_{GB})}{\gamma^2}\right)^{1/2}-1\right]\right\}$$

$$\frac{\partial x_d}{\partial v_{GB}} = \frac{\epsilon_{Si}}{C'_{OX}}\frac{1}{2}\frac{1}{\left(1+\frac{4(\phi_B+v_{GB})}{\gamma^2}\right)^{1/2}}\frac{4}{\gamma^2}$$

$$C'(V_{GB}) = q\,N_A\frac{\partial x_d}{\partial v_{GB}} = q\,N_A\frac{\epsilon_{Si}}{C'_{OX}}\frac{2}{\gamma^2}\frac{1}{\left(1+\frac{4(\phi_B+V_{GB})}{\gamma^2}\right)^{1/2}}$$

2 gamma

C'ox

$$C'(V_{GB}) = \frac{C'_{OX}}{\sqrt{1+\frac{4(\phi_B+V_{GB})}{\gamma^2}}}$$

$$C'(V_{GB}=V_{FB}) = \frac{C'_{OX}}{\sqrt{1+\frac{4(\phi_B+V_{FB})}{\gamma^2}}} = C'_{OX}$$

$$C'_0(V_{GB}=0) = \frac{C'_{OX}}{\sqrt{1+\frac{4\,\phi_B}{\gamma^2}}} = 87.6\ \mathrm{nF/cm^2}$$

$$C'_{min}(V_{GB}=V_T) = \frac{C'_{OX}}{\sqrt{1+\frac{4(\phi_B+V_T)}{\gamma^2}}} = 70.9\ \mathrm{nF/cm^2}$$

Cuentas auxiliares

¡¡Otra forma de calcular C'_{min}!!

$$C'_{Bulk,min} = \frac{\epsilon_{Si}}{x_{d,max}}$$

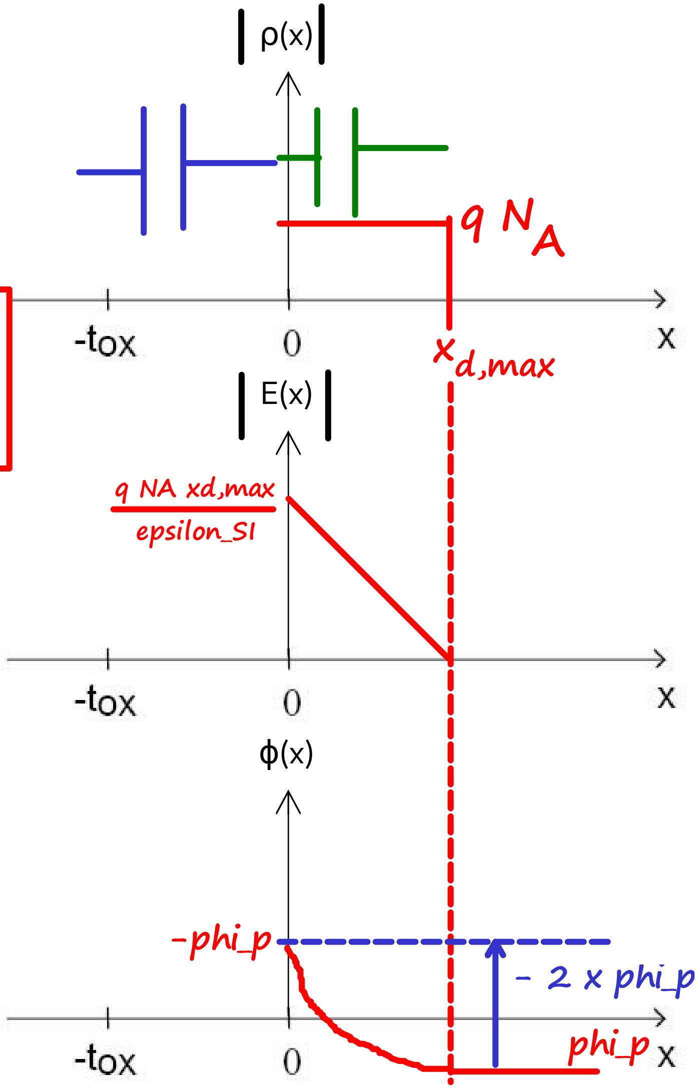
$$-2\,\phi_{Bulk} = \frac{q\,N_A\,x_{d,max}^2}{2\,\epsilon_{Si}}$$

$$x_{d,max} = \sqrt{\frac{-4\,\phi - B\,\epsilon_{Si}}{q\,N_A}}$$

$$x_{d,max} = \frac{\epsilon_{Si}}{C'_{OX}}\left[\sqrt{1+\frac{4(\phi_B+V_T)}{\gamma^2}}-1\right] = 104\text{ nm}$$

$$C'_{min} = C'_{OX} \text{ en serie } C'_{Bulk,min}$$

$$C'_{min} = \frac{C'_{OX}\,C'_{Bulk,min}}{C'_{OX}+C'_{Bulk,min}} = 70.9\text{ nF/cm}^2$$

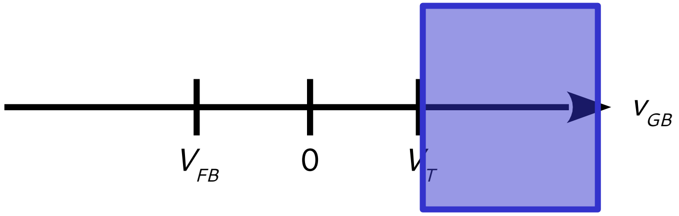


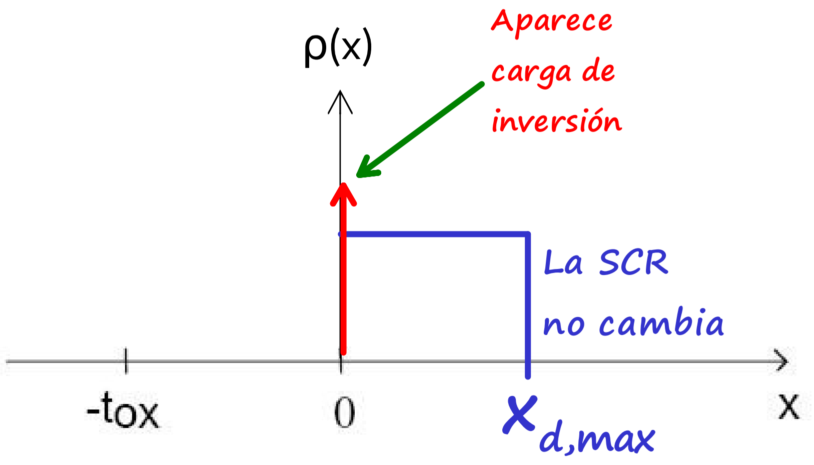
Inversión

Datos
Poly-N^{++}; Sust-P
$N_A = 10^{17}\ cm^{-3}$
$V_T = 0.547$ V
$\gamma^2 = 0.545$ V
$C'_{OX} = 246\ nF/cm^2$.

Del ejercicio anterior:
$\Phi_{Gate} = -0.42$ V
$\Phi_{Bulk} = -0.42$ V
$V_{FB} = -0.97$ V
$x_{dmax} = 104$ nm

$$V_T < V_{GB}$$





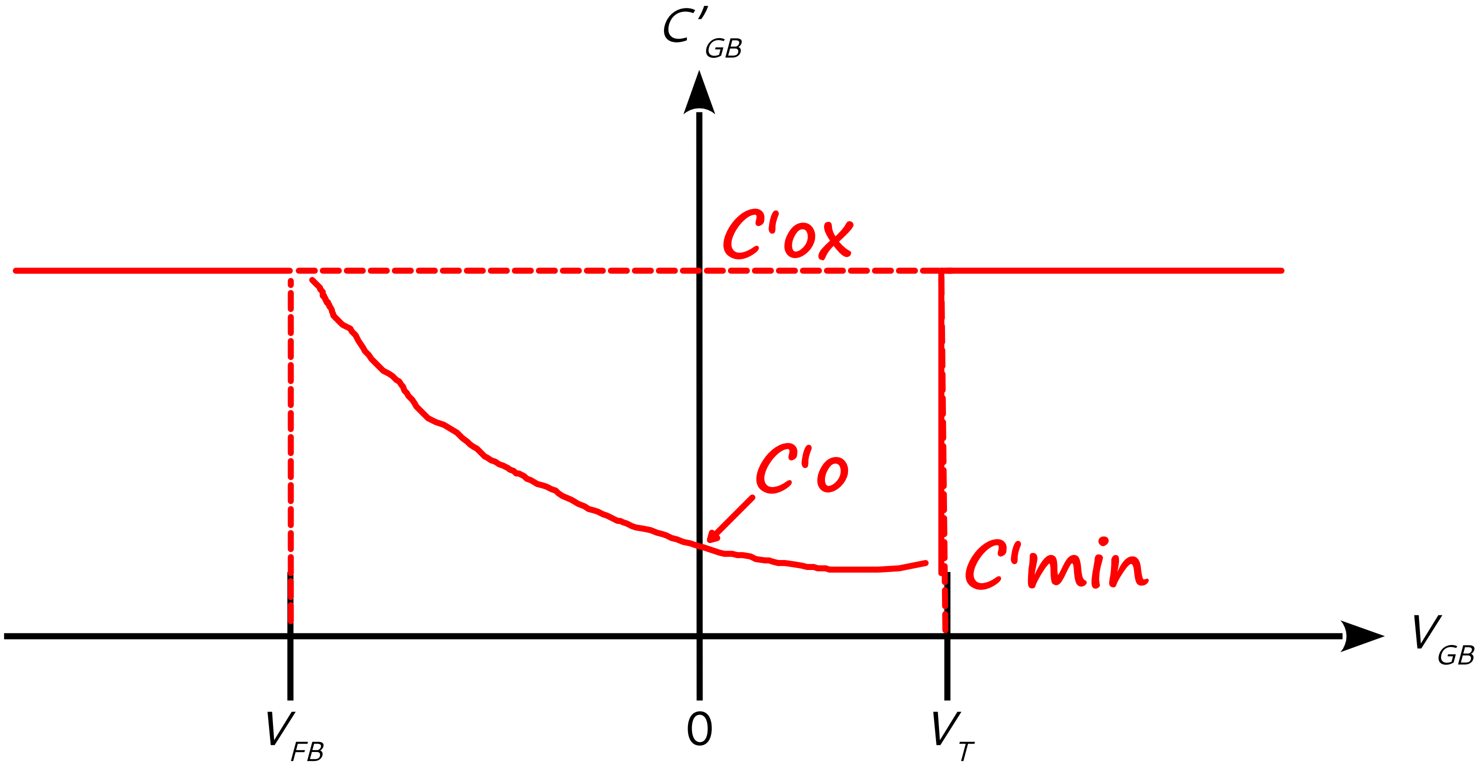
$$x_d = x_{d,max}$$

$$Q'_{Bulk} = -q\ N_A\ x_{d,max}$$

$$Q'_{inv} = -C'ox\ (VGB - VT)$$

$$C'(V_{GB}) = \frac{\partial Q'_{Bulk}}{\partial v_{GB}} + \frac{\partial Q'_{inv}}{\partial v_{GB}} = C'ox$$

Gráfico



Bonus: ¿Cómo puedo simular/medir la curva CV?

$$i_C(t) = C\frac{\partial v_C(t)}{\partial t}$$

$$v_C(t) = m\ t \Rightarrow \frac{\partial v_C(t)}{\partial t} = m = \frac{\Delta V}{\Delta t} \quad [m] = \mathrm{V/s}$$

$$\Rightarrow C' = \frac{C}{Area} = \frac{i_C(t)\ \Delta t}{\Delta V\ \ Area}$$

Bonus: ¿Cómo puedo simular/medir la curva CV?