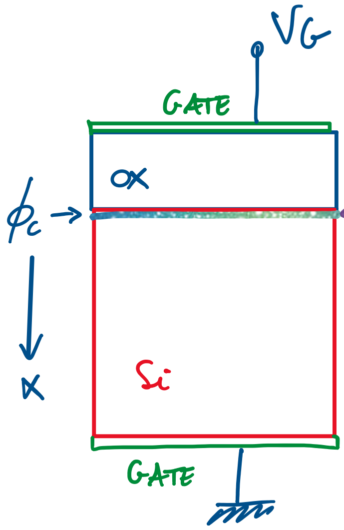
QUANTUM CAPACITANCE

Friday, 23 November 2018 09:00

$$Q = C \cdot V$$

$$C = \frac{\delta Q}{\delta V}$$

MOS STRUCTURE



2DEG if above threshold

$$\boxed{C_Q = \frac{\delta Q_{2DEG}}{\delta \phi_C}}$$

$$n = \sum_i^N |\varphi_i(x)|^2 \frac{\sqrt{m_y m_z}\, k_B T}{\pi \hbar^2} \ln\left[1 + \exp\left(-\frac{\mathcal{E}_i - E_F}{k_B T}\right)\right]$$

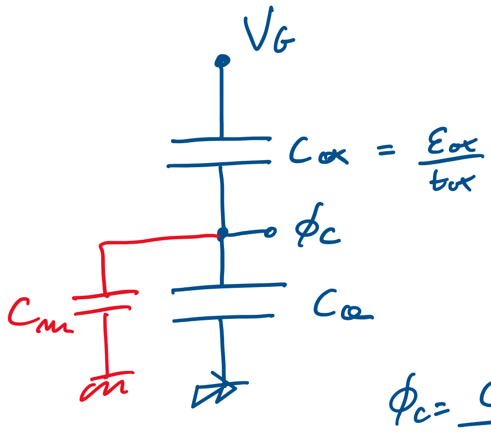
$$\int n\, dx \Rightarrow n_{2DEG} = \sum_i^N \frac{\sqrt{m_y m_z}}{\pi \hbar^2} k_B T \ln\left[1 + \exp\left(-\frac{\mathcal{E}_i - E_F}{k_B T}\right)\right]$$

$$C_Q = \frac{\delta}{\delta \phi_C}\, q\, \frac{\sqrt{m_y m_z}}{\pi \hbar^2} k_B T \ln\left[1 + \exp\left(-\frac{\mathcal{E}_i - E_F}{k_B T}\right)\right]$$

$$\mathcal{E}_i \simeq -q\phi_C + \text{Const}$$

$$C_Q = q^2 \frac{\sqrt{m_y m_z}}{\pi \hbar^2} \cancel{k_B T} \frac{\cancel{q/k_B T}\, \exp\left(-\frac{\mathcal{E}_i - E_F}{k_B T}\right)}{1 + \exp\left(-\frac{\mathcal{E}_i - E_F}{k_B T}\right)} \simeq 1$$

$$\boxed{C_Q = \frac{\sqrt{m_y m_z}}{\pi \hbar^2} q^2} = \boxed{DOS_{2D} \cdot q^2}$$

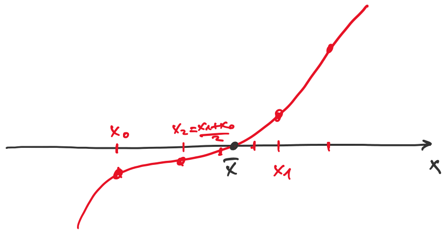


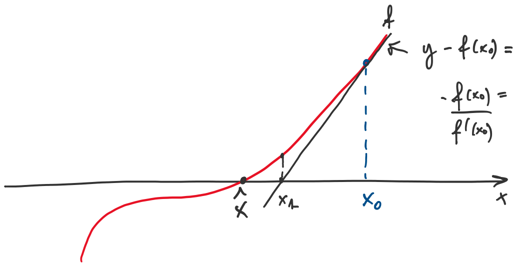
$$\phi_c = \frac{C_{ox}}{C_{ox} + C_Q} \phi_c$$

NEWTON METHOD

Friday, 23 November 2018 09:28

$$f(\bar{x}) = 0$$





$$y - f(x_0) = f'(x_0)(x - x_0)$$

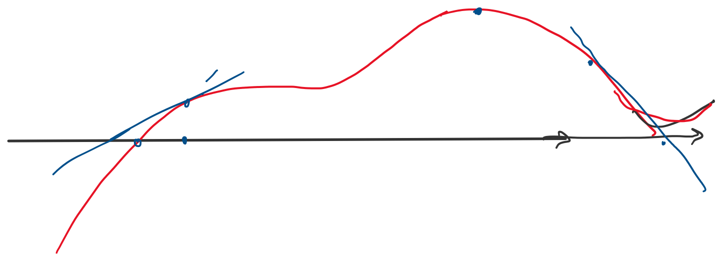
$$-\frac{f(x_0)}{f'(x_0)} = x_1 - x_0 \Rightarrow x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}$$

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

$$\begin{cases} f_1(\phi_1, \phi_2 \ldots\ldots \phi_{NP}) = 0 \\ f_2(\phi_1, \phi_2 \ldots\ldots \phi_{NP}) = 0 \\ \vdots \\ f_{NP}(\phi_1, \phi_2, \ldots\ldots \phi_{NP}) = 0 \end{cases}$$

$$\vec{f}(\vec{\phi}) : \mathbb{R}^n \to \mathbb{R}^n$$

$$f_i \to \quad J(\phi) = \begin{pmatrix} \frac{\partial f_1}{\partial \phi_1} & \frac{\partial f_2}{\partial \phi_1} & \cdots & \frac{\partial f_{NP}}{\partial \phi_1} \\ \frac{\partial f_2}{\partial \phi_1} & \frac{\partial f_2}{\partial \phi_1} & \cdots & \\ \vdots & & & \\ \frac{\partial f_1}{\partial \phi_{NP}} & \cdots & \cdots & \frac{\partial f_{NP}}{\partial \phi_{NP}} \end{pmatrix}$$



$$\vec{f}(\vec{\tilde{\phi}}) = 0$$

exact solution

$$\vec{\phi}_k$$

trial solution

$$\vec{f}(\vec{\phi}_k) = \vec{\xi}_k \leftarrow \text{residual}$$

$$\vec{\tilde{\phi}} = \vec{\phi}_k + d\vec{\phi}_k$$

$$\vec{f}(\vec{\tilde{\phi}}) = \vec{f}(\vec{\phi}_k + d\vec{\phi}_k) = 0 \qquad \| d\vec{\phi}_k \| \ll \| \vec{\phi}_k \|$$

$$\vec{f}(\vec{\phi}_k + d\vec{\phi}_k) = \underbrace{\vec{f}(\vec{\phi}_k)}_{\vec{\xi}_k} + J(\vec{\phi}_k) \cdot d\vec{\phi}_k = 0$$

$$\boxed{J(\vec{\phi}_k) \cdot d\vec{\phi}_k = -\vec{\xi}_k} \Rightarrow d\vec{\phi}_k = -J^{-1}(\vec{\phi}_k) \cdot \vec{\xi}_k$$

$$\boxed{\vec{\phi}_{k+1} = \vec{\phi}_k + d\vec{\phi}_k}$$

NUMERICAL RECIPES $\begin{cases} \text{IN FORTRAN 77} \\ \text{IN C} \end{cases}$