Assignment 6
E3225
Art of Compact Modeling

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1 Problem 1

Plot analytical expression of Inversion Charge (using Charge Sheet Approximation)(Eq. 2.5.7) and numerically calculated Inversion Charge, as a function of Gate Voltage, on the same graph and compare.

Solution: Numerically calculated:

$$q_i(y) = qn_0 e^{\frac{\psi(y)}{\phi_t}} \; ; n_0 = \frac{n_i^2}{N_a} \, . \tag{1}$$

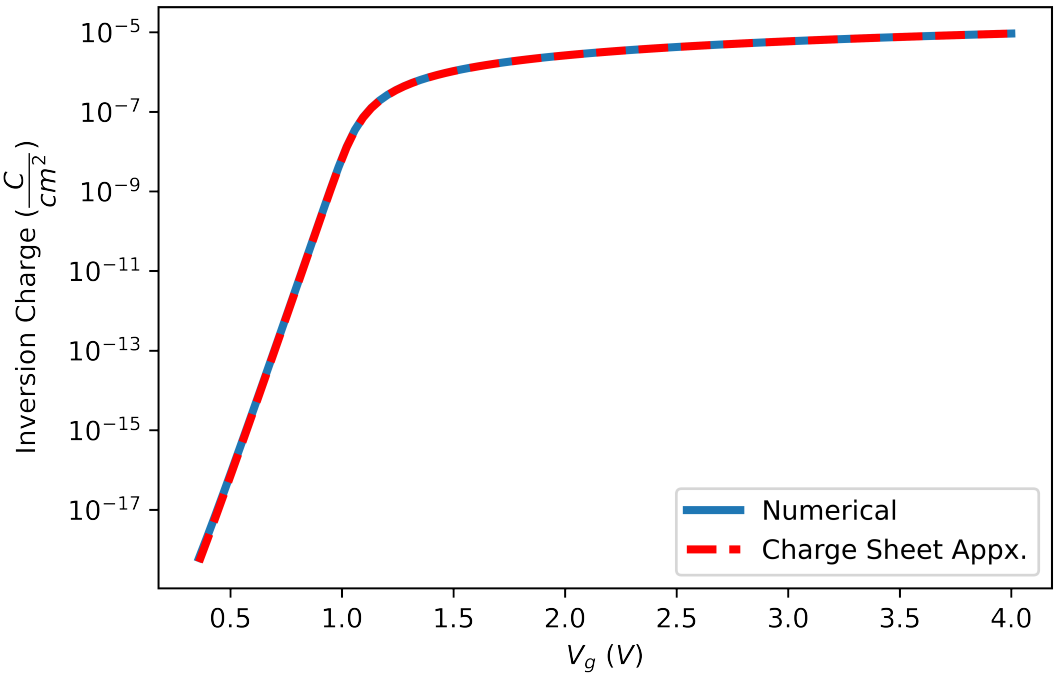
$$Q_i = \int_0^{t_{Si}} q_i(y) \, dy \, . \tag{2}$$

Charge Sheet Approximation:

$$Q_i = n_i q = -\sqrt{2qN_a\epsilon_s}[\sqrt{\psi(y) + \phi_t e^{\frac{\psi(y)-2\phi_f}{\phi_t}}} - \sqrt{\psi(y)}] \, . \tag{3}$$

Parameters used:

$$\psi(y) \; calculated \; numerically \; from \; previous \; assignment$$
$$\phi_t = 26 \; meV$$
$$n_i = 10^{10} \; cm^{-3}$$
$$N_A = 10^{16} \; cm^{-3}$$
$$t_{Si} = 100 \; nm$$



Both matches perfectly in the region from weak inversion to strong inversion, i.e $V_g \geq \phi_f$.

2 Problem 2

Plot Surface Potential as a function of Gate Voltage (Eq. 2.5.15) using NR method (use asymptotes as initial guess mentioned in the class) and compare with previous numerically calculated ψ_s vs V_g plot (using BVP). (Plot both in left y-axis on same graph).
Solution: Solved with initial guess as the following asymptotes:

For V_{GB} from depletion to moderate inversion:

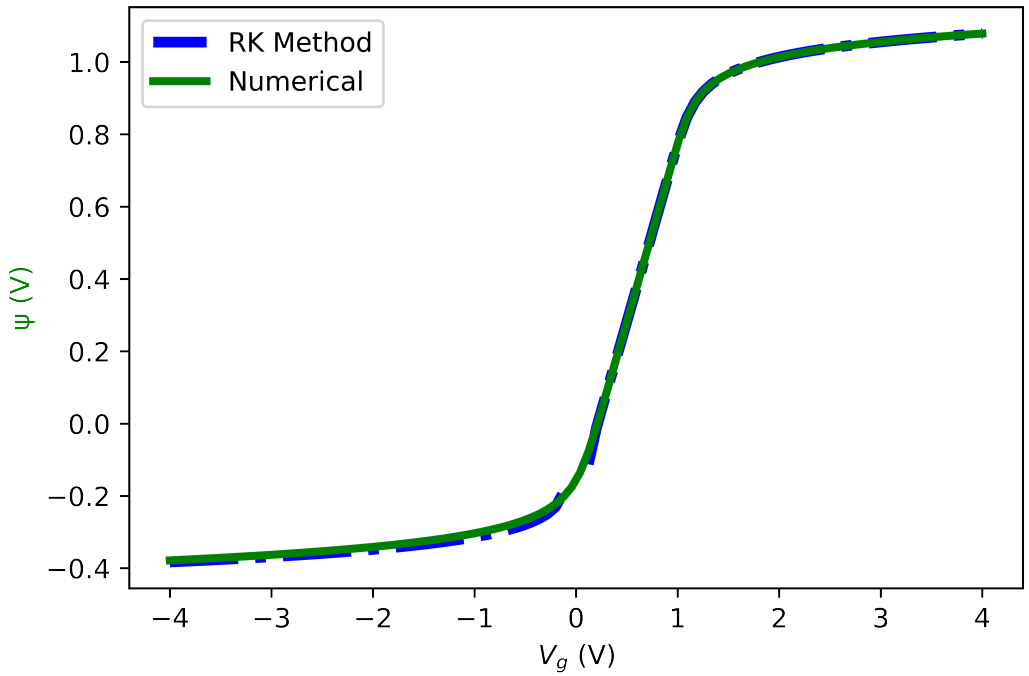
$$\psi_s = [-\frac{\gamma}{2} + \sqrt{(\frac{\gamma}{2})^2 - (V_{FB} - V_g)}]^2 \,. \tag{4}$$

For V_{GB} beyond strong inversion:

$$\psi_s = 2[\phi_f + \phi_t ln(\frac{V_g - V_{FB}}{\gamma\sqrt{\phi_t}})] \,. \tag{5}$$

For V_{GB} in accumulation:

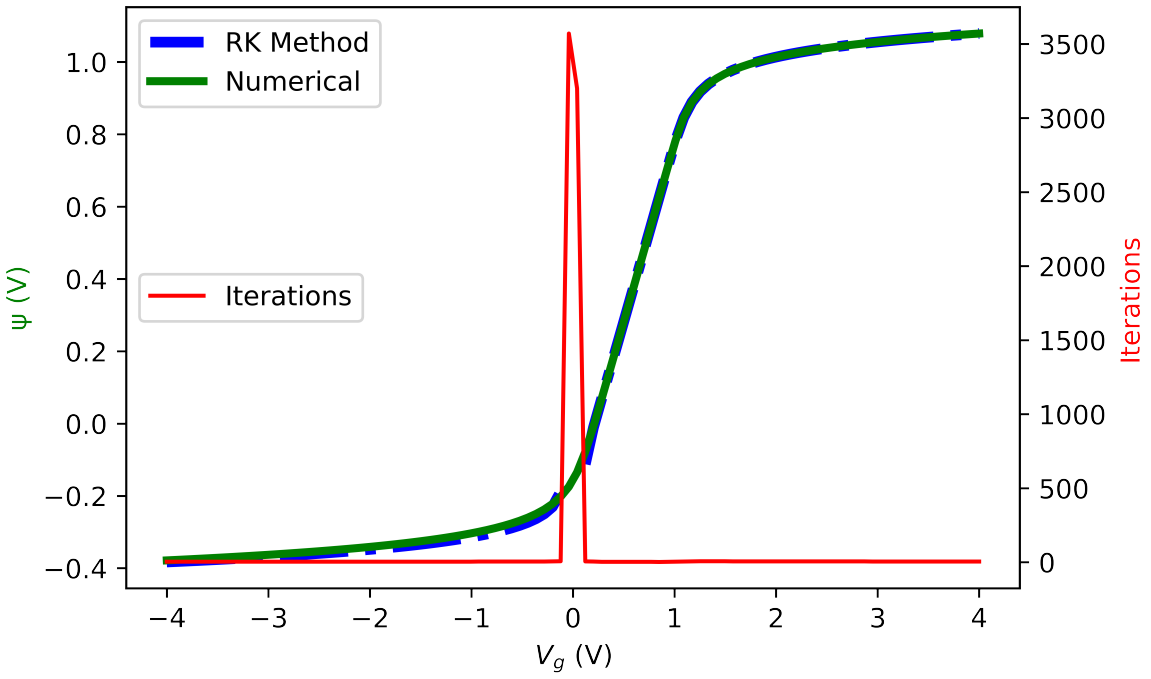
$$\psi_s = -2\phi_t ln(\frac{V_g - V_{FB}}{\gamma\sqrt{\phi_t}}) \,. \tag{6}$$



3 Problem 3

Plot Number of iterations in NR method (right y-axis) vs Gate Voltage on same graph.

Solution: Iterations inceases in the region from onset of accumulation to ϕ_f, since deviation from guess value is huge :

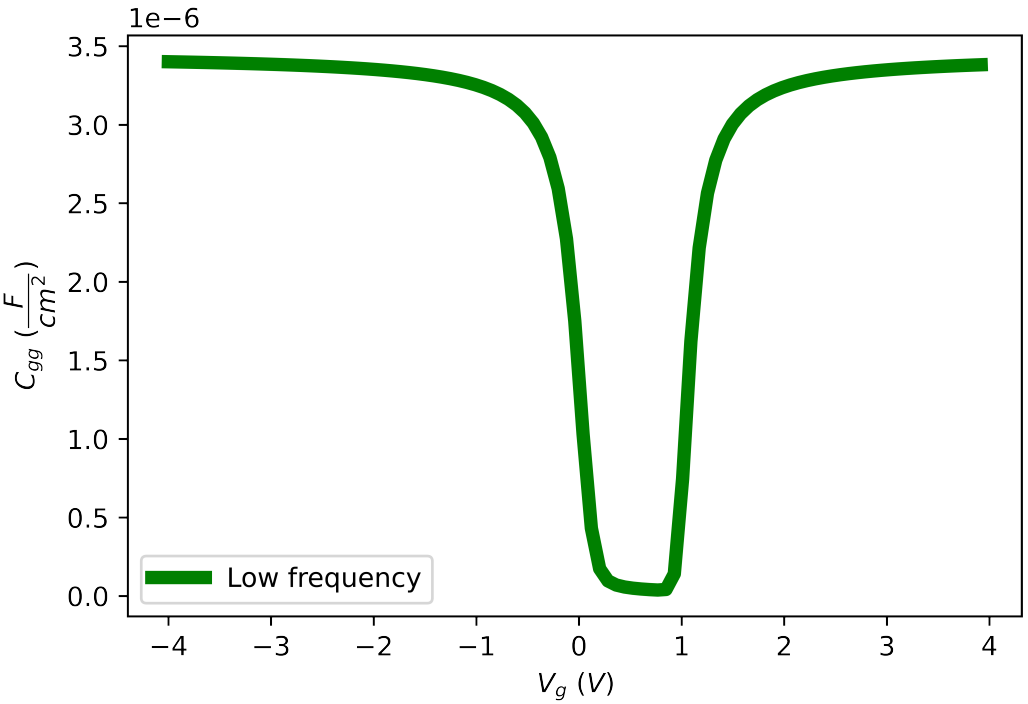


4 Problem 4

Plot capacitance (C_{gg}) characteristic at low frequency using surface potential calculated from Poisson's Equation.

Solution: Low Frequency Capacitance C_{gg} is given by:

$$C_{gg} = C_{ox}(1 - \frac{\partial \psi}{\partial V_{gs}}) \,. \tag{7}$$



C_{gg} almost regain its value at low frequency when sweeps from accumulation to strong inversion.