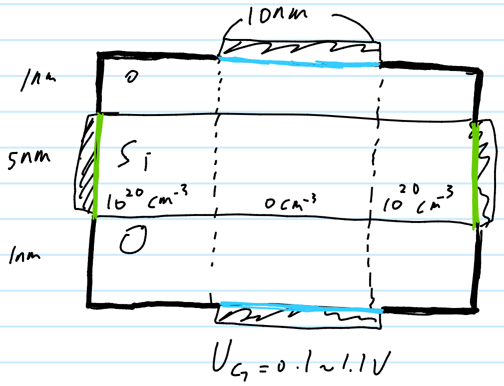
HW 10. 2d - Poisson

2020년 10월 7일 수요일 오후 5:49

$$\frac{\partial}{\partial x}\left(\epsilon(x,y)\frac{\partial \phi}{\partial x}\right)+\frac{\partial}{\partial y}\left(\epsilon(x,y)\frac{\partial \phi}{\partial y}\right)=-\rho$$
$$=q\left(N_{acc}+2n_i\sinh(q\phi/kT)\right)$$



- Boundaries
  - Black lines : Neumann Boundary conditions.
    ex) left top : $\frac{\epsilon_{ox}}{2}(\phi_{0,1}+\phi_{1,0})-\epsilon_{ox}\phi_{0,0}=0.$
  - Blue lines : $\phi=0.33374+V_G$, $0\le V_G\le1.1$
  - Green lines : $\phi=\operatorname{arcsinh}(N^+/2n_i)kT/q$

- Inside

$$\epsilon\left(\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial y^2}\right)=\rho \rightarrow \int\epsilon\left(\frac{\partial\phi}{\partial x}+\frac{\partial\phi}{\partial y}\right)\cdot d\vec{a}=\int\rho\, dr$$

$$\epsilon\left(\frac{\phi_{i+1,j}-\phi_{i,j}}{\Delta}\cdot\Delta+\frac{\phi_{i-1,j}-\phi_{i,j}}{\Delta}\cdot\Delta+\frac{\phi_{i,j+1}-\phi_{i,j}}{\Delta}\cdot\Delta+\frac{\phi_{i,j-1}-\phi_{i,j}}{\Delta}\right)=\int\rho\, dr$$

$$\epsilon\left(\phi_{i+1,j}+\phi_{i-1,j}+\phi_{i,j+1}+\phi_{i,j-1}-4\phi_{i,j}\right)=\int\rho\, dr$$
$$=q\left(N_{acc}+2n_i\sinh(q\phi/kT)\right),\ Si$$
$$=0,\ ox$$

- Interfaces bet. Si & Ox.

$$\frac{O\quad \epsilon_{ox}}{Si\quad \epsilon_{si}}\ :\ \frac{\epsilon_1+\epsilon_2}{2}\cdot\left(\phi_{i+1,j}+\phi_{i-1,j}-4\phi_{i,j}\right)+\epsilon_1\phi_{i,j-1}+\epsilon_2\phi_{i,j+1}=\int\rho\, dr$$

- I gave densities on the interface.

- Newton-Raphson method.

$$\tilde{A}\tilde{\phi}=\tilde{b}\ \dots\quad \text{residue}=\tilde{A}\tilde{\phi}-\tilde{b}$$
$$\text{Jaco}=\tilde{A}-\frac{d}{d\phi}(\tilde{b})$$

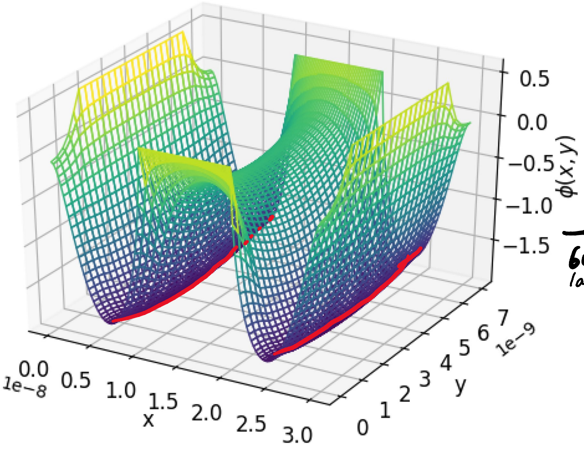
$$\rightarrow \text{Jaco}\ \delta\phi=-r,\quad \phi^{(n+1)}=\phi^{(n)}+\delta\phi$$

- We only need to consider 'ρ' to make $\frac{d}{d\phi}(\tilde{b})$ matrix.

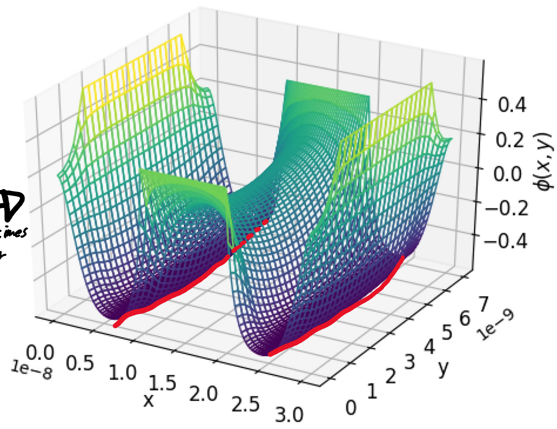
$$\left(\begin{aligned}\rho&=q\left(N_{acc}+2n_i\sinh(q\phi_i/kT)\right)\\ \frac{d\rho}{d\phi}&=q2n_i\frac{q}{kT}\cosh(q\phi_i/kT)\end{aligned}\right)$$

- Result

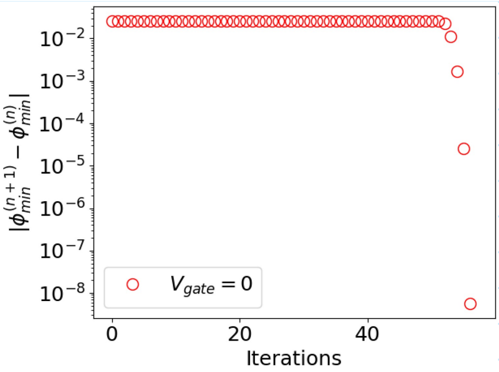
1. $V_G = 0$.



60 times later

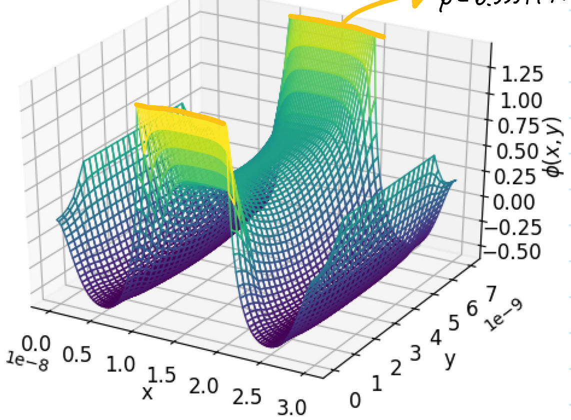


- Left figure shows the result of $\phi^{(1)} = \phi^{(0)} + \delta\phi$
- Right one shows $\phi^{(60)}$.
- It looks like there is global min on the red lines.
  This global min shows most largest change.
  → ϕ_{min} is criteria to conclude $\phi^{(n)} = \phi^{(n-1)} + \delta\phi$ iterations are converged.

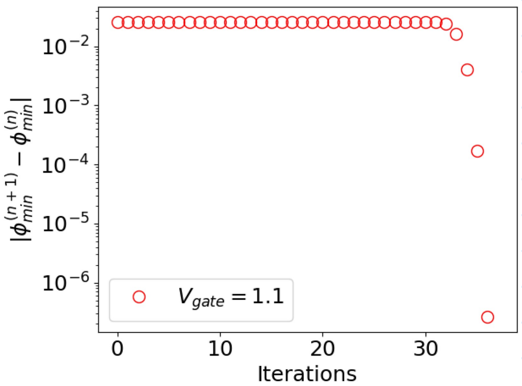


2. $V_G = 1.1V$

$\phi = 0.33374 + V_G$



- It show similar form but ϕ at the gate voltage goes up.



- $\phi^{(n)}$ are converged at n=34.