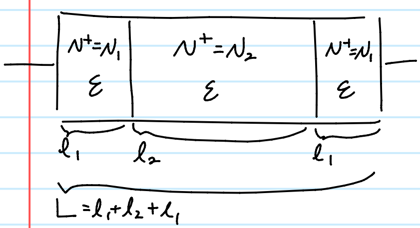
HW 15.

Tuesday, November 3, 2020 4:22 PM

20184060 Jicheol Kim



B.C. : $\phi_{(0)} = \phi_{(L)} = V_T \ln\left(\frac{n_i}{N_1}\right)$

$n_{(0)} = n_{(L)} = N_1$

$\left(V_T = \frac{k_B T}{q},\ n_i = 1.075\times 10^{16}\ m^{-3},\ T = 300\ K\right)$

Residues

$$\begin{cases} [R_\phi]_i = \frac{\varepsilon}{\varepsilon_0}\left(\phi_{i-1} - 2\phi_i + \phi_{i+1}\right) + \frac{(\Delta x)^2}{\varepsilon_0} q \left(N^+ - n_i\right) \\ [R_n]_i = \frac{n_{i+1}+n_i}{2}\cdot\frac{\phi_{i+1}-\phi_i}{\Delta x} - V_T\frac{n_{i+1}-n_i}{\Delta x} - \frac{n_i+n_{i-1}}{2}\cdot\frac{\phi_i-\phi_{i-1}}{\Delta x} + V_T\frac{n_i-n_{i-1}}{\Delta x} \end{cases}$$

Jacobians

$$\begin{cases} \partial_{\phi_i}[R_\phi]_i = -2\frac{\varepsilon}{\varepsilon_0},\ \partial_{\phi_{i+1}}[R_\phi]_i = \frac{\varepsilon}{\varepsilon_0},\ \partial_{\phi_{i-1}}[R_\phi]_i = \frac{\varepsilon}{\varepsilon_0} \\ \partial_{n_i}[R_\phi]_i = -\frac{(\Delta x)^2}{\varepsilon_0} q \\ \partial_{\phi_i}[R_n]_i = -\frac{n_{i+1}+n_i}{2\Delta x} - \frac{n_i+n_{i-1}}{2\Delta x},\ \partial_{\phi_{i+1}}[R_n]_i = \frac{n_{i+1}+n_i}{2\Delta x},\ \partial_{\phi_{i-1}}[R_n]_i = \frac{n_i+n_{i-1}}{2\Delta x} \\ \partial_{n_i}[R_n]_i = \frac{\phi_{i+1}-\phi_i}{2\Delta x} - \frac{\phi_i-\phi_{i-1}}{2\Delta x} + \frac{2V_T}{\Delta x},\ \partial_{n_{i+1}}[R_n]_i = \frac{\phi_{i+1}-\phi_i}{2\Delta x} - \frac{V_T}{\Delta x},\ \partial_{n_{i-1}}[R_n]_i = -\frac{\phi_i-\phi_{i-1}}{2\Delta x} - \frac{V_T}{\Delta x} \end{cases}$$

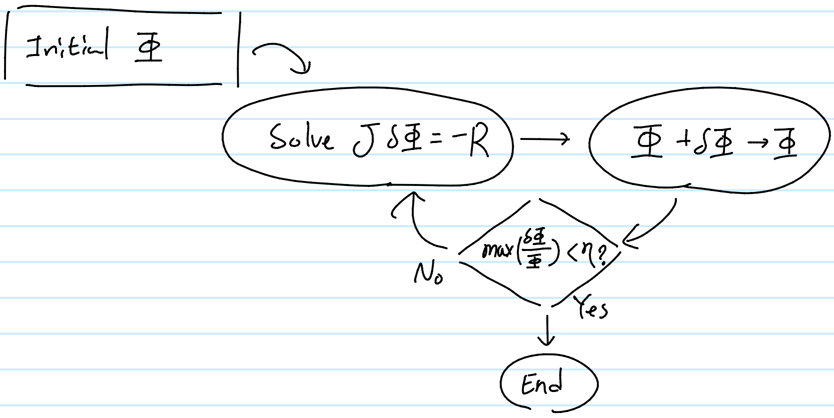
Poisson + Continuity eq. $\Longrightarrow$

Residue vector $R = \left(R_{\phi_1}, R_{n_1}, R_{\phi_2}, R_{n_2}, \cdots, R_{\phi_N}, R_{n_N}\right)^T$

Jacobian matrix $J = \begin{pmatrix} \frac{\partial R_{\phi_1}}{\partial \phi_1} & \frac{\partial R_{\phi_1}}{\partial n_1} & \cdots & & \\ \frac{\partial R_{n_1}}{\partial \phi_1} & \frac{\partial R_{n_1}}{\partial n_1} & \cdots & & \vdots \\ \vdots & & \ddots & & \frac{\partial R_{\phi_N}}{\partial n_N} \\ \vdots & & \cdots & \frac{\partial R_{n_N}}{\partial \phi_N} & \frac{\partial R_{n_N}}{\partial n_N} \end{pmatrix}$

Solution Vector $\Phi = \left(\phi_1, n_1, \cdots, \phi_N, n_N\right)^T$

* Algorithm : R과 J로 Newton method 이용하여 Φ를 구한다.

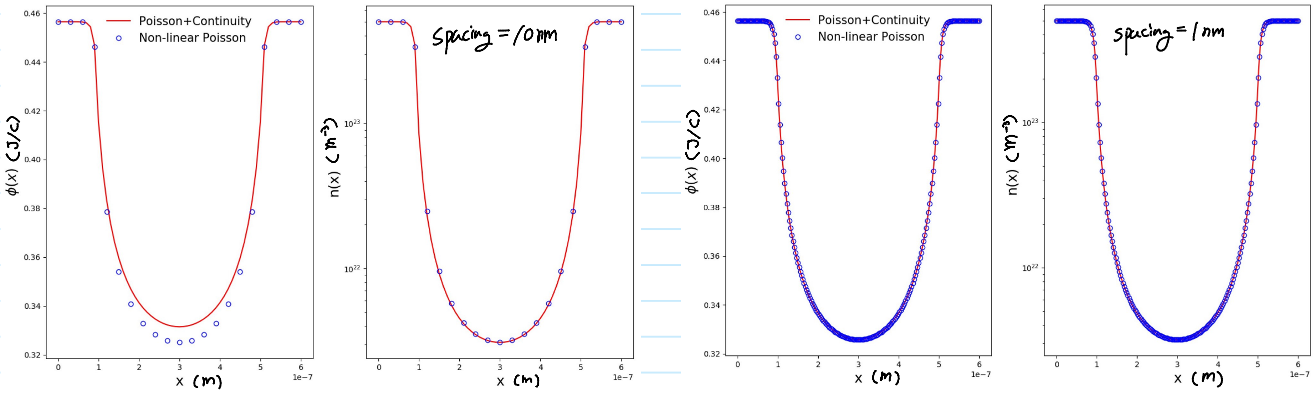


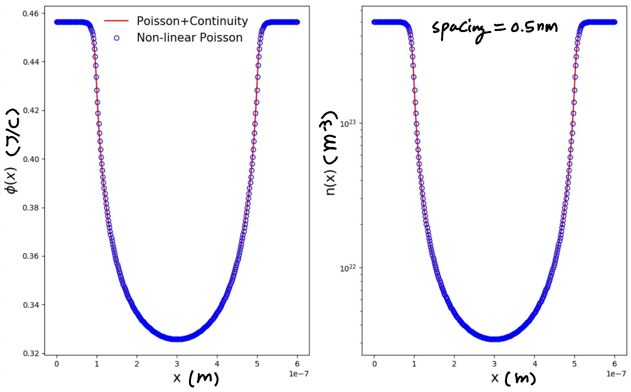
$\eta = 10^{-10}$

Results

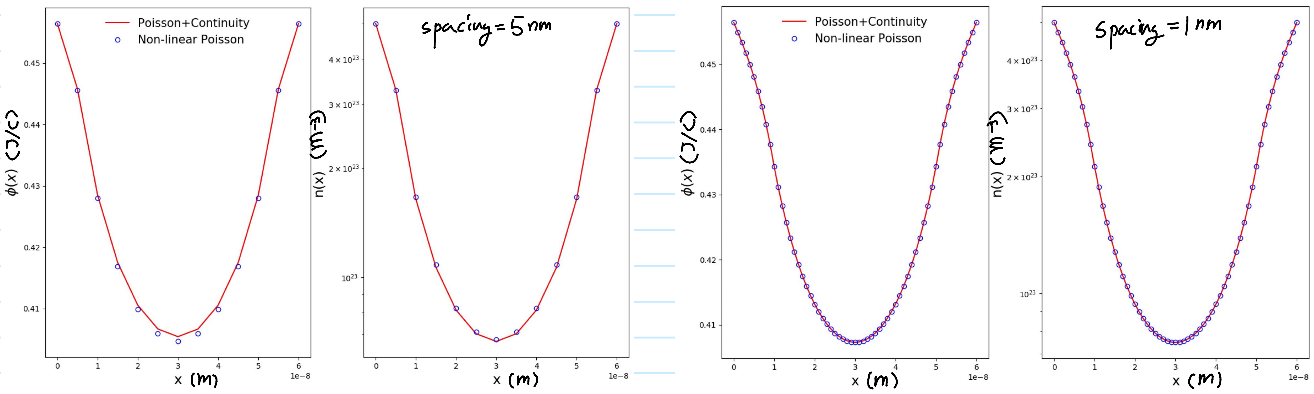
$\varepsilon = 11.7\,\varepsilon_0,\ l_1 = \frac{L}{6},\ l_2 = \frac{4}{6}L$

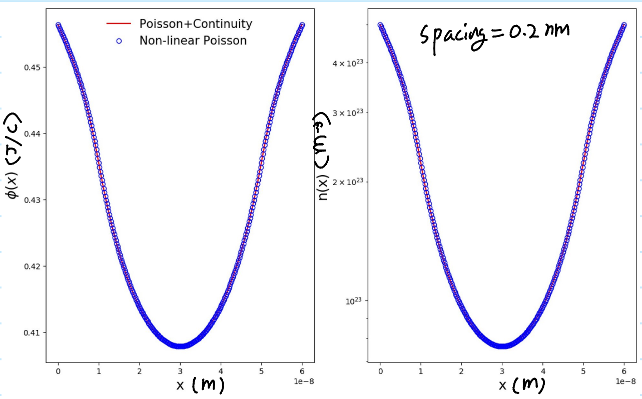
i) Long structure : $L = 600\,nm$





ii) Short structure : $L = 60\,nm$





Non-linear Poisson eq. 으로 구한 $n(x)$ 와 $\phi(x)$는 Poisson + Continuity eq. 으로 구한 $n(x)$, $\phi(x)$와 거의 차이가 없다.