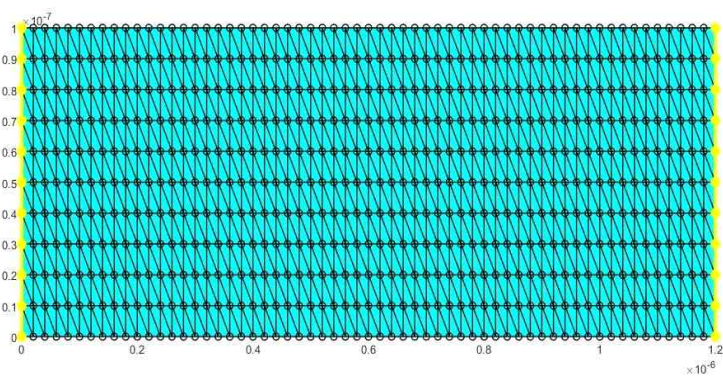
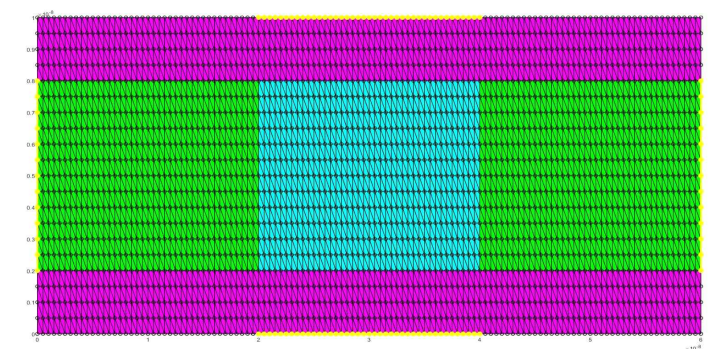


HW20

20221060 한성민

structure

homogeneous sample	profile
	<p>전체 cyan : silicon 좌측 yellow line : source contact 우측 yellow line : drain contact x length : 1200nm y length : 100nm device width : $1\mu m$ N-type doping : $2E23(/m^3)$ $V_{cathode} = 0V$ $V_{anode} = 0V$</p>
Double gate MOSFET	region & contact
	<p>상단 magenta : gate oxide1 하단 magenta : gate oxide2 좌측 green : source region 우측 green : drain region 중앙 blue : silicon region 상단 yellow line : gate contact1 하단 yellow line : gate contact2 좌측 yellow line : source contact 우측 yellow line : drain contact</p>
<p>gate oxide thickness : 2nm silicon thickness : 6nm source / drain length : 20nm channel length : 20nm total x length : 60nm total y length : 10nm device width : $1\mu m$</p>	<p>N-type doping : $5E26(/m^3)$ P-type doping : $2E21(/m^3)$ gate workfunction : 4.3eV e mobility : 1417E-4 p mobility : 580E-4</p>

(과제 설명)

기존의 2D homogeneous sample에 green function을 적용한다. 3개의 식, poisson equation, electron continuity, hole continuity equation에 대하여 perturbed 된 case를 나누어 \vec{r}_0 를 변화시켰을 때 G parameter를 확인해보고 결과를 비교해본다.

perturbed	potential	electron	hole
Poisson equation	$G_{\phi\phi}(\vec{r}, \vec{r}_0)$	$G_{n\phi}(\vec{r}, \vec{r}_0)$	$G_{p\phi}(\vec{r}, \vec{r}_0)$
electron continuity	$G_{\phi n}(\vec{r}, \vec{r}_0)$	$G_{nn}(\vec{r}, \vec{r}_0)$	$G_{pn}(\vec{r}, \vec{r}_0)$
hole continuity	$G_{\phi p}(\vec{r}, \vec{r}_0)$	$G_{np}(\vec{r}, \vec{r}_0)$	$G_{pp}(\vec{r}, \vec{r}_0)$

(equation)

- Poisson equation perturbed

$$\rightarrow \nabla^2 (\epsilon G_{\phi\phi}(\vec{r}, \vec{r}_0)) + q(G_{p\phi}(\vec{r}, \vec{r}_0) - G_{n\phi}(\vec{r}, \vec{r}_0) + N_{dop}) = \delta(\vec{r}, \vec{r}_0)$$

- electron continuity perturbed

$$\rightarrow jwG_{nn}(\vec{r}, \vec{r}_0) - \frac{1}{q} \nabla \cdot (-q\mu_n G_{nn}(\vec{r}, \vec{r}_0) \nabla \phi_{DC} - q\mu_n n_{DC} \nabla G_{\phi n}(\vec{r}, \vec{r}_0) + qD_n \nabla G_{nn}(\vec{r}, \vec{r}_0)) = \delta(\vec{r}, \vec{r}_0)$$

- hole continuity perturbed

$$\rightarrow jwG_{pp}(\vec{r}, \vec{r}_0) + \frac{1}{q} \nabla \cdot (-q\mu_p G_{pp}(\vec{r}, \vec{r}_0) \nabla \phi_{DC} - q\mu_p p_{DC} \nabla G_{\phi p}(\vec{r}, \vec{r}_0) - qD_p \nabla G_{pp}(\vec{r}, \vec{r}_0)) = \delta(\vec{r} - \vec{r}_0)$$

- \vec{r}_0 change, $x = \vec{r}_0$ 에서 residue=1

Homogeneous sample

기존	$\text{solution matrix} = \begin{pmatrix} \mathbf{A} \\ \text{matrix} \end{pmatrix}^{-1} \times \begin{pmatrix} \mathbf{b} \\ \text{matrix} \end{pmatrix}$
수정	$\text{solution matrix} = \begin{pmatrix} \mathbf{A} \\ \text{matrix} \end{pmatrix}^{-1} \times \begin{pmatrix} \text{identity} \\ \text{matrix} \end{pmatrix}$

solution matrix의 우변의 b matrix를 boundary condition을 적용한 identity matrix를 사용하여 모든 node에서의 perturbed 한 case를 비교해보았다. 각 열은 어떤 equation이 perturbed 되었는지를 나타내며, 해당 equation이 perturbed 되었을 때, 행은 parameter를 나타낸다.

3i-2 열 : Poisson equation perturbed

- 3i-2행 : $G_{\phi\phi}(\vec{r}, \vec{r}_0)$

- 3i-1행 : $G_{n\phi}(\vec{r}, \vec{r}_0)$

- 3i행 : $G_{p\phi}(\vec{r}, \vec{r}_0)$

3i-1 열 : electron continuity equation perturbed

- 3i-2행 : $G_{\phi n}(\vec{r}, \vec{r}_0)$

- 3i-1행 : $G_{nn}(\vec{r}, \vec{r}_0)$

- 3i행 : $G_{pn}(\vec{r}, \vec{r}_0)$

3i 열 : hole continuity equation perturbed

- 3i-2행 : $G_{\phi p}(\vec{r}, \vec{r}_0)$

- 3i-1행 : $G_{np}(\vec{r}, \vec{r}_0)$

- 3i행 : $G_{pp}(\vec{r}, \vec{r}_0)$

Homogeneous sample result

2019x2019 complex_double																									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
1	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	
2	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	
3	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	
4	5.7698e-19	-5.7698e-19	-5.7698e-19	-0.0309 - 0.28068e-04	3.4866e-04	-0.0060 - 0.18838e-04	1.8173e-04	-0.0032 - 0.14010e-04	1.3445e-04	-0.0026 - 0.11757e-04	1.1648e-04	-0.0023 - 0.10602e-04	1.0599e-04	-0.0022 - 0.99382e-05	9.9414e-05	-0.0021 - 0.95115e-05	9.5121e-05	-0.0020 - 0.91515e-05	8.8243e-05	3.5069e-05	1.16580e-05	9.9723e-06	1.0647e-06	8.8816e-07	4.7157e-07
5	-9.8291e-19	-9.8291e-19	-9.8291e-19	-2.0692e-04	-1.4586e-04	1.0169e-02	-1.8048e-04	-1.2722e-04	-9.9438e-05	-1.6404e-04	-1.1563e-04	-8.4583e-05	-1.4717e-04	-9.9916e-05	-1.6270e-04	-6.9235e-05	-3.8336e-05	-1.5945e-05	-1.1240e-05	4.7687e-06	1.2583e-06	8.8966e-07	8.8243e-07	3.5069e-07	1.16580e-07
6	3.0894e-08	3.0894e-08	3.0894e-08	3.9671e+00	-1.2269e+00	3.3346e+02	1.0780e+00	1.1998e+00	-3.6455e+00	6.4753e+00	1.0205e+00	-8.0799e+00	8.7489e+00	1.9631e+00	-1.1159e+00	2.4896e+00	4.6255e+00	1.0711e+00	2.2137e+00	-5.7538e+00	6.0621e+00	-4.8816e+00	-1.0647e+00	5.9723e+00	-1.6580e+00
7	1.1522e-18	1.1522e-18	1.1522e-18	-0.0060 - 0.18838e-04	1.8173e-04	-0.0341 - 0.42079e-04	4.8311e-04	-0.0086 - 0.30595e-04	2.9822e-04	-0.0055 - 0.24612e-04	2.4044e-04	-0.0047 - 0.21695e-04	2.1590e-04	-0.0044 - 0.20113e-04	2.0111e-04	-0.0042 - 0.19143e-04	1.9146e-04	-0.0040 - 0.18173e-04	1.7173e-04	1.5173e-04	1.3173e-04	1.1173e-04	9.173e-05	7.173e-05	5.173e-05
8	-3.2625e-19	-3.2625e-19	-3.2625e-19	-1.8048e-04	-1.2722e-04	-9.9438e-05	-2.0856e-04	-1.4702e-04	9.3229e-05	-1.8189e-04	-1.2822e-04	-1.1571e-04	-1.6502e-04	-1.1632e-04	-8.4966e-05	-1.4190e-04	-1.0003e-04	-1.5793e-04	-9.6957e-05	-6.8346e-05	-2.9512e-05	-1.2438e-05	-8.7675e-06	-4.7157e-06	1.3265e-06
9	1.4653e-07	1.4653e-07	1.4653e-07	1.0780e+00	1.1998e+00	-3.6455e+00	3.9736e+00	-1.1249e+00	3.2538e+02	1.1635e+00	1.3961e+00	-4.7614e+00	8.9649e+00	1.0252e+00	-7.9728e+00	8.9703e+00	1.9056e+00	-1.0553e+00	2.4408e+00	3.5608e+00	1.1309e+00	2.0479e+00	-5.6898e+00	5.9122e+00	-4.9596e+00
10	1.7129e-18	1.7129e-18	1.7129e-18	-0.0332 - 0.14010e-04	1.3445e-04	-0.0060 - 0.30595e-04	2.9822e-04	-0.0365 - 0.52609e-04	5.8910e-04	-0.0108 - 0.40533e-04	3.9763e-04	-0.0076 - 0.34124e-04	3.3556e-04	-0.0067 - 0.30900e-04	3.0769e-04	-0.0063 - 0.29073e-04	2.9077e-04	-0.0061 - 0.28046e-04	2.7173e-04	2.5173e-04	2.3173e-04	2.1173e-04	1.9173e-04	1.7173e-04	1.5173e-04
11	2.1545e-04	2.1545e-04	2.1545e-04	-1.6404e-04	-1.1563e-04	-8.4583e-05	-1.8189e-04	-1.2822e-04	-1.1571e-04	-2.0857e-04	-1.4703e-04	-9.9310e-05	-1.8190e-04	-1.2822e-04	-1.1534e-04	-1.6501e-04	-1.1631e-04	-8.4882e-05	-1.8190e-04	-1.2822e-04	-1.1534e-04	-1.6501e-04	-1.1631e-04	-8.4882e-05	-1.8190e-04
12	2.3660e-07	2.3660e-07	2.3660e-07	6.4753e+00	1.0205e+00	-8.0799e+00	1.1655e+00	1.3961e+00	-4.7614e+00	3.9761e+00	-1.1244e+00	3.2549e+02	1.1678e+00	1.3903e+00	-4.7008e+00	8.9161e+00	1.0241e+00	-7.9649e+00	8.9537e+00	1.9062e+00	-1.0568e+00	2.4402e+00	3.6176e+00	1.1257e+00	2.0337e+00
13	2.2710e-18	2.2710e-18	2.2710e-18	-0.0026 - 0.11757e-04	1.1648e-04	-0.0055 - 0.24612e-04	2.4044e-04	-0.0108 - 0.40533e-04	3.9763e-04	-0.0385 - 0.62192e-04	6.8422e-04	-0.0128 - 0.49738e-04	4.8967e-04	-0.0095 - 0.43083e-04	4.2516e-04	-0.0087 - 0.39647e-04	3.9542e-04	-0.0114 - 0.51636e-04	5.1069e-04	-0.0165 - 0.66836e-04	6.6083e-04	-0.0441 - 0.87892e-04	9.4122e-04	-0.0183 - 0.81544e-04	9.9154e-05
14	-1.9347e-19	-1.9347e-19	-1.9347e-19	-1.4174e-04	-9.9916e-05	-1.6270e-04	-6.9235e-05	-1.6502e-04	-1.1632e-04	-8.4966e-05	-1.8190e-04	-1.2822e-04	-1.1534e-04	-1.6501e-04	-1.1631e-04	-8.4882e-05	-1.8190e-04	-1.2822e-04	-1.1534e-04	-1.6501e-04	-1.1631e-04	-8.4882e-05	-1.8190e-04	-1.2822e-04	-1.1534e-04
15	1.2978e-07	1.2978e-07	1.2978e-07	8.7489e+00	1.9631e+00	-1.1159e+00	8.9649e+00	1.0252e+00	-7.9728e+00	1.1678e+00	1.3903e+00	-4.7008e+00	3.9761e+00	-1.1245e+00	3.2549e+02	1.1676e+00	1.3904e+00	-4.7023e+00	8.9153e+00	1.0242e+00	-7.9674e+00	8.9543e+00	1.9063e+00	-1.0568e+00	2.4401e+00
16	2.8251e-18	2.8251e-18	2.8251e-18	-0.0023 - 0.10602e-04	1.0599e-04	-0.0047 - 0.21695e-04	2.1590e-04	-0.0076 - 0.34124e-04	3.3556e-04	-0.0128 - 0.49738e-04	4.8967e-04	-0.0405 - 0.71151e-04	7.7381e-04	-0.0147 - 0.58485e-04	5.7715e-04	-0.0114 - 0.51636e-04	5.1069e-04	-0.0147 - 0.58485e-04	5.7715e-04	-0.0114 - 0.51636e-04	5.1069e-04	-0.0147 - 0.58485e-04	5.7715e-04	-0.0114 - 0.51636e-04	5.1069e-04
17	6.4043e-04	6.4043e-04	6.4043e-04	-9.8291e-19	-9.8291e-19	-9.8291e-19	-3.8336e-05	-1.4190e-04	-1.0003e-04	-1.5793e-04	-9.6957e-05	-6.8346e-05	-2.9512e-05	-1.2438e-05	-8.7675e-06	-4.7157e-06	1.3265e-06	-1.8190e-04	-1.2822e-04	-1.1534e-04	-1.6501e-04	-1.1631e-04	-8.4882e-05	-1.8190e-04	-1.2822e-04
18	1.1384e-08	1.1384e-08	1.1384e-08	2.4896e+00	4.6255e+00	1.0711e+00	8.9703e+00	1.9056e+00	-1.0553e+00	8.9161e+00	1.0241e+00	-7.9669e+00	1.1678e+00	1.3904e+00	-4.7023e+00	3.9761e+00	-1.1245e+00	3.2549e+02	1.1676e+00	1.3904e+00	-4.7023e+00	8.9154e+00	1.0242e+00	-7.9674e+00	8.9543e+00
19	3.3877e-18	3.3877e-18	3.3877e-18	-0.0022 - 0.99382e-05	9.9414e-05	-0.0044 - 0.20113e-04	2.0111e-04	-0.0087 - 0.30900e-04	3.0769e-04	-0.0095 - 0.43083e-04	4.2516e-04	-0.0107 - 0.51636e-04	5.7715e-04	-0.0128 - 0.79704e-04	8.9594e-04	-0.0165 - 0.66836e-04	6.6083e-04	-0.0441 - 0.87892e-04	9.4122e-04	-0.0183 - 0.81544e-04	9.9154e-05	-1.0683e-04	6.6083e-04	-0.0132 - 0.66836e-04	6.6083e-04
20	-1.2360e-19	-1.2360e-19	-1.2360e-19	-1.5945e-05	-1.1240e-05	4.7687e-06	-1.9631e-05	-6.8346e-05	-2.9512e-05	-1.4187e-05	-1.0006e-05	-1.5799e-05	-1.6501e-05	-8.4882e-06	-1.8190e-05	-1.2822e-05	-1.1534e-05	-2.0857e-05	-4.7023e-05	9.3199e-06	-1.8190e-05	-1.2822e-05	-1.1534e-05	-2.0857e-05	-1.6501e-05
21	7.2300e-08	7.2300e-08	7.2300e-08	2.2137e+00	-5.7538e+00	6.0621e+00	1.2440e+00	3.5608e+00	1.1309e+00	8.9537e+00	1.9062e+00	-1.0568e+00	8.9153e+00	1.0242e+00	-7.9674e+00	1.1676e+00	1.3904e+00	-4.7023e+00	3.9761e+00	-1.1245e+00	3.2549e+02	1.1676e+00	1.3904e+00	-4.7023e+00	8.9154e+00
22	3.9538e-18	3.9538e-18	3.9538e-18	-0.0021 - 0.95115e-05	9.5121e-05	-0.0042 - 0.19143e-04	1.9146e-04	-0.0063 - 0.29073e-04	2.9077e-04	-0.0087 - 0.39647e-04	3.9542e-04	-0.0114 - 0.51636e-04	5.1069e-04	-0.0165 - 0.66836e-04	6.6083e-04	-0.0441 - 0.87892e-04	9.4122e-04	-0.0183 - 0.81544e-04	9.9154e-05	-1.0683e-04	6.6083e-04	-0.0132 - 0.66836e-04	6.6083e-04	-0.0132 - 0.66836e-04	6.6083e-04
23	-2.3984e-19	-2.3984e-19	-2.3984e-19	1.2583e-06	8.8966e-07	8.8243e-07	-1.2438e-06	-8.7675e-06	4.7157e-06	-9.6889e-06	-6.8298e-06	-2.9983e-06	-1.4187e-06	-1.0000e-06	-1.5799e-06	-1.6501e-06	-1.1631e-06	-8.4882e-06	-1.8190e-06	-1.2822e-06	-1.1534e-06	-2.0857e-06	-4.7023e-06	9.3199e-06	-1.8190e-06
24	8.0594e-08	8.0594e-08	8.0594e-08	-4.8816e-06	-1.0647e-06	5.9723e-06	2.0479e-06	-5.6898e-06	5.9122e-06	2.4400e-06	3.6176e-06	1.1257e-06	8.9543e-06	1.0568e-06	8.9154e-06	1.0242e-06	-7.9674e-06	1.1676e+00	1.3904e+00	-4.7023e+00	3.9761e+00	-1.1245e+00	3.2549e+02	1.1676e+00	1.3904e+00
25	4.5190e-18	4.5190e-18	4.5190e-18	-0.0020 - 0.92044e-05	9.2043e-05	-0.0040 - 0.18471e-04	1.8471e-04	-0.0061 - 0.27890e-04	2.7893e-04	-0.0082 - 0.37625e-04	3.7623e-04	-0.0105 - 0.48015e-04	4.7909e-04	-0.0132 - 0.59824e-04	5.9256e-04	-0.0183 - 0.74864e-04	7.4093e-04	-0.0458 - 0.91544e-04	9.9154e-05	-1.0683e-04	6.6083e-04	-0.0132 - 0.66836e-04	6.6083e-04	-0.0132 - 0.66836e-04	6.6083e-04
26	-6.6212e-19	-6.6212e-19	-6.6212e-19	3.5069e+00	1.24721e+00	-5.3033e-04	1.3265e+00	1.93509e+00	8.3531e+00	-1.2324e-04	-6.8877e-04	4.7098e+00	-9.6887e-04	-6.8297e-04	-2.9972e-04	-1.4187e-04	-1.0000e-04	-1.5799e-04	-1.6501e-04	-1.1631e-04	-8.4882e-05	-1.8190e-04	-1.2822e-04	-1.1534e-04	-2.0857e-04
27	1.7899e-08	1.7899e-08	1.7899e-08	-1.6500e-04	6.3988 + 2.1	-1.4990e-04	-4.8998e-04	-1.0079e-04	5.4553e+00	2.0537e+00	-5.6827e-04	3.9066e+00	2.4401e+00	3.6164e+00	1.1259e+00	8.9543e+00	1.9063e+00	-1.0568e+00	8.9154e+00	1.0242e+00	-7.9674e+00	1.1676e+00	1.3904e+00	-4.7023e+00	8.9154e+00
28	5.0753e-18	5.0753e-18	5.0753e-18	-0.0020 - 0.92044e-05	9.2043e-05	-0.0040 - 0.18471e-04	1.8471e-04	-0.0061 - 0.27890e-04	2.7893e-04	-0.0082 - 0.37625e-04	3.7623e-04	-0.0105 - 0.48015e-04	4.7909e-04	-0.0132 - 0.59824e-04	5.9256e-04	-0.0183 - 0.74864e-04	7.4093e-04	-0.0458 - 0.91544e-04	9.9154e-05	-1.0683e-04	6.6083e-04	-0.0132 - 0.66836e-04	6.6083e-04	-0.0132 - 0.66836e-04	6.6083e-04
29	-6.3042e-19	-6.3																							