Sentaurus TCAD Tutorial

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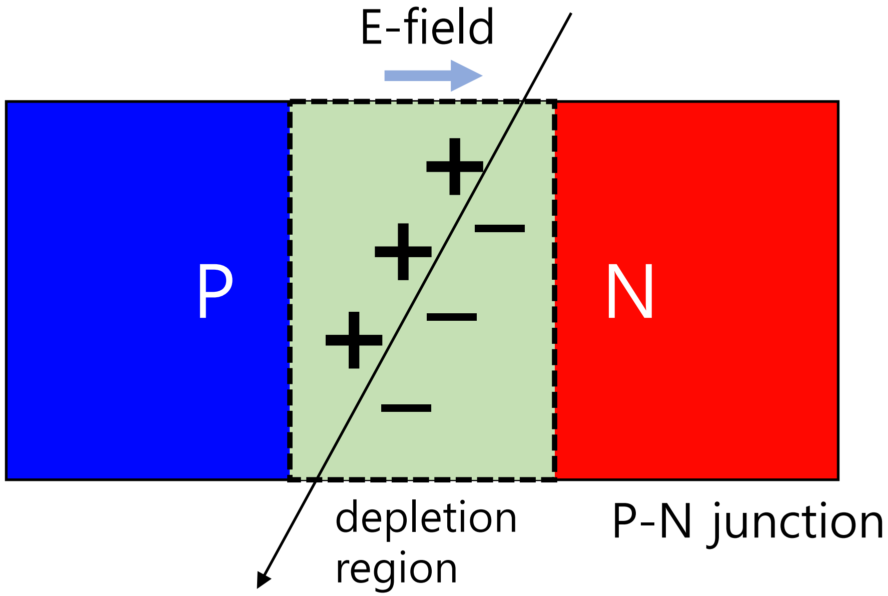
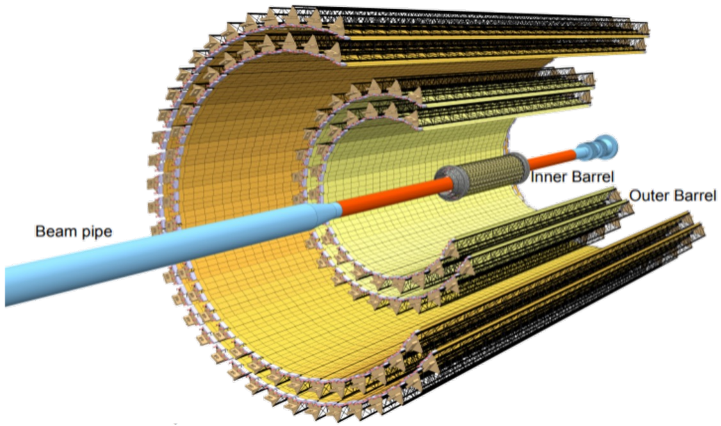
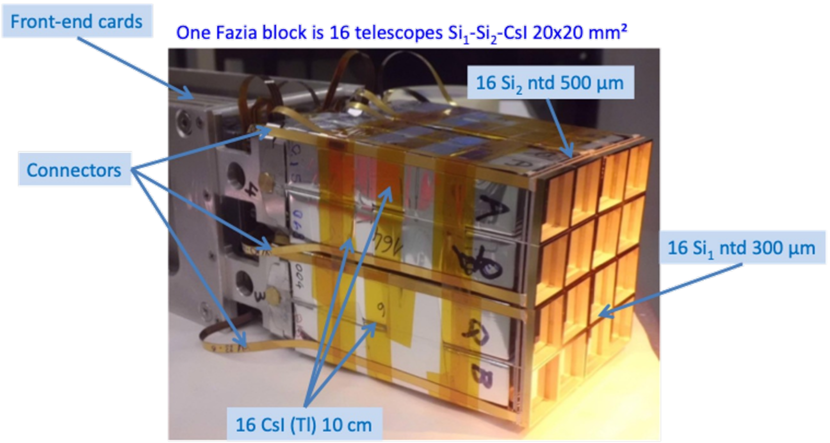
- Introduction to semiconductor detector
- Summary of TCAD tool
- Design of PiN sensor
- Silicon sensor fabrication
- Hands on session

Introduction to semiconductor detectors

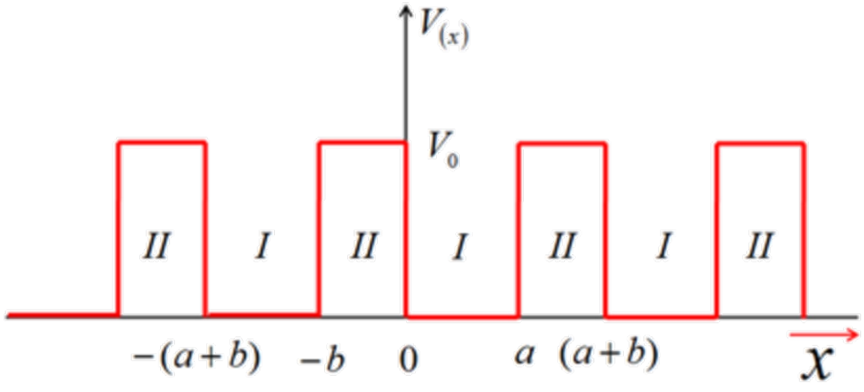
- Semiconductor detectors have good energy resolution, so these detectors are widely used in high-energy collision experiments.
- When charged particles pass through the depletion region, they create electron-hole pairs.
- The created electron-hole pairs drifted in the electric field, thereby generating the signal.
- To increase the depletion region, reverse bias voltage is applied to the device.







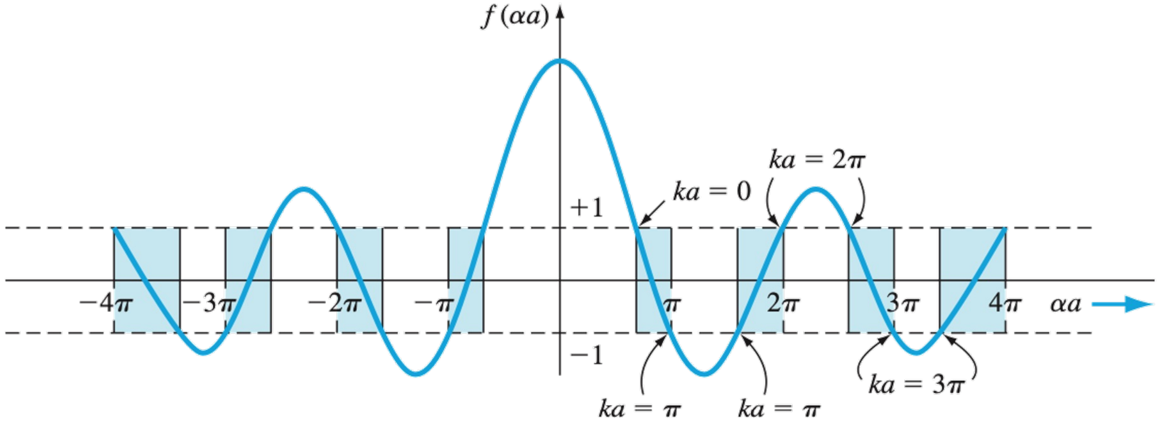
Band gap

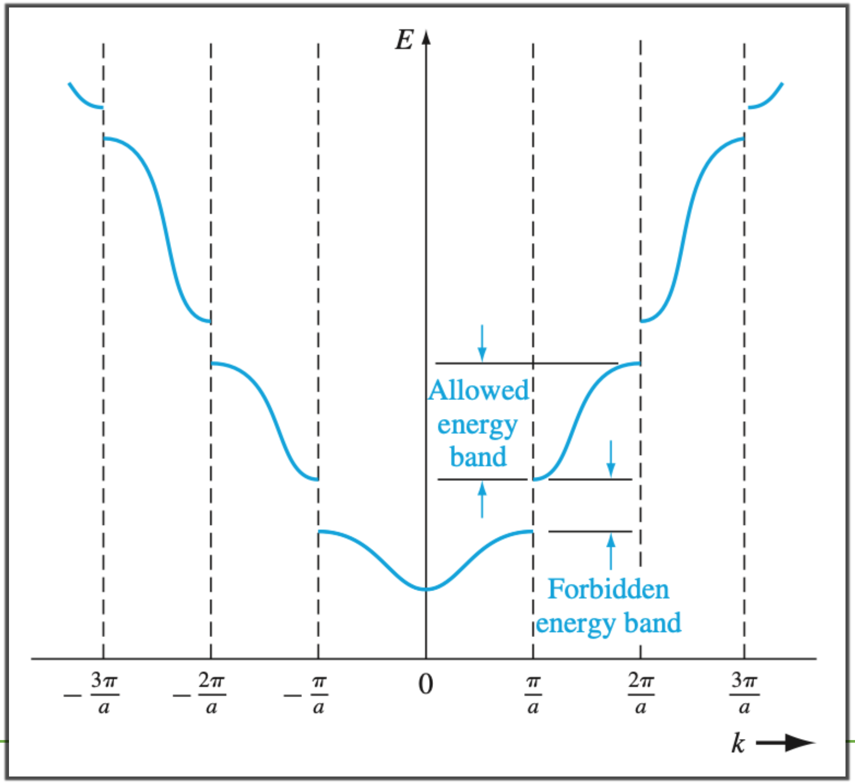


$$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + U\psi = E\psi$$

Using Bloch's function

$$\Psi(x, t) = u(x)e^{j(kx-(E/\hbar)t)}$$





Density of state

$$\frac{2mE}{\hbar^2} = k^2 = k_x^2 + k_y^2 + k_z^2 = (n_x^2 + n_y^2 + n_z^2)\left(\frac{\pi^2}{a^2}\right)$$

$$V_k = \left(\frac{\pi}{a}\right)^3$$

~ free electron

$V(x, y, z) = 0$ for $0 < x < a$, $0 < y < a$, $0 < z < a$

$V(x, y, z) = \infty$ elsewhere

one octant

$$g_T(k)\,dk = 2\left(\frac{1}{8}\right)\frac{4\pi k^2\,dk}{\left(\frac{\pi}{a}\right)^3}$$

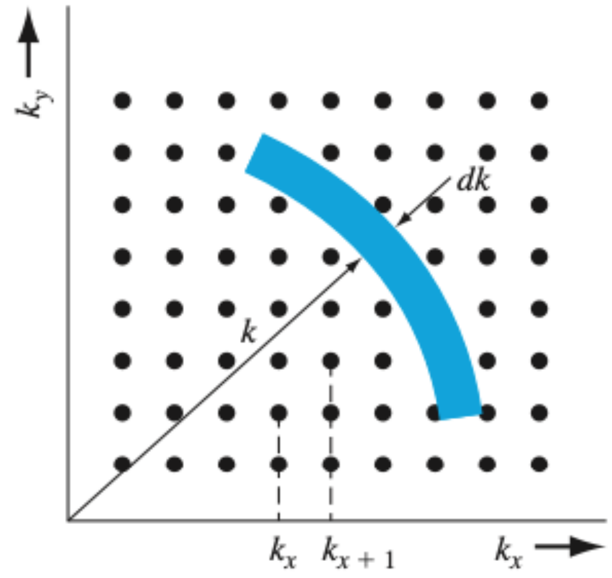
Spin

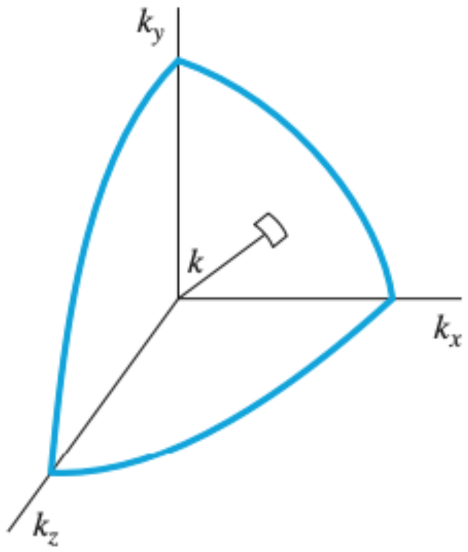
Total state in k-space

$$g_T(E)\,dE = \frac{4\pi a^3}{h^3}\cdot(2m)^{3/2}\cdot\sqrt{E}\,dE$$

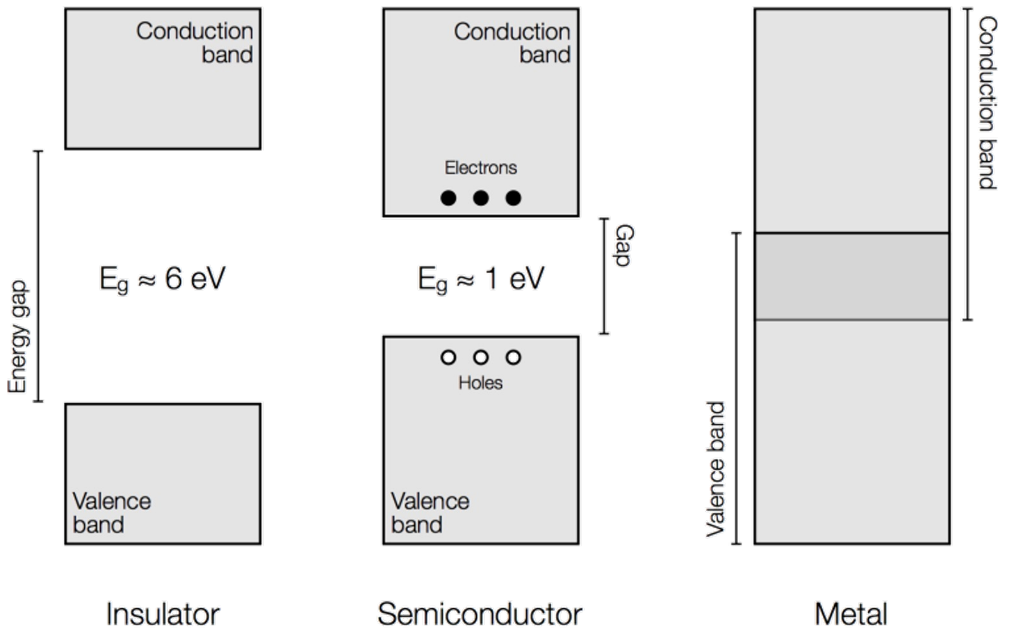
$$g(E) = \frac{4\pi(2m)^{3/2}}{h^3}\sqrt{E}$$

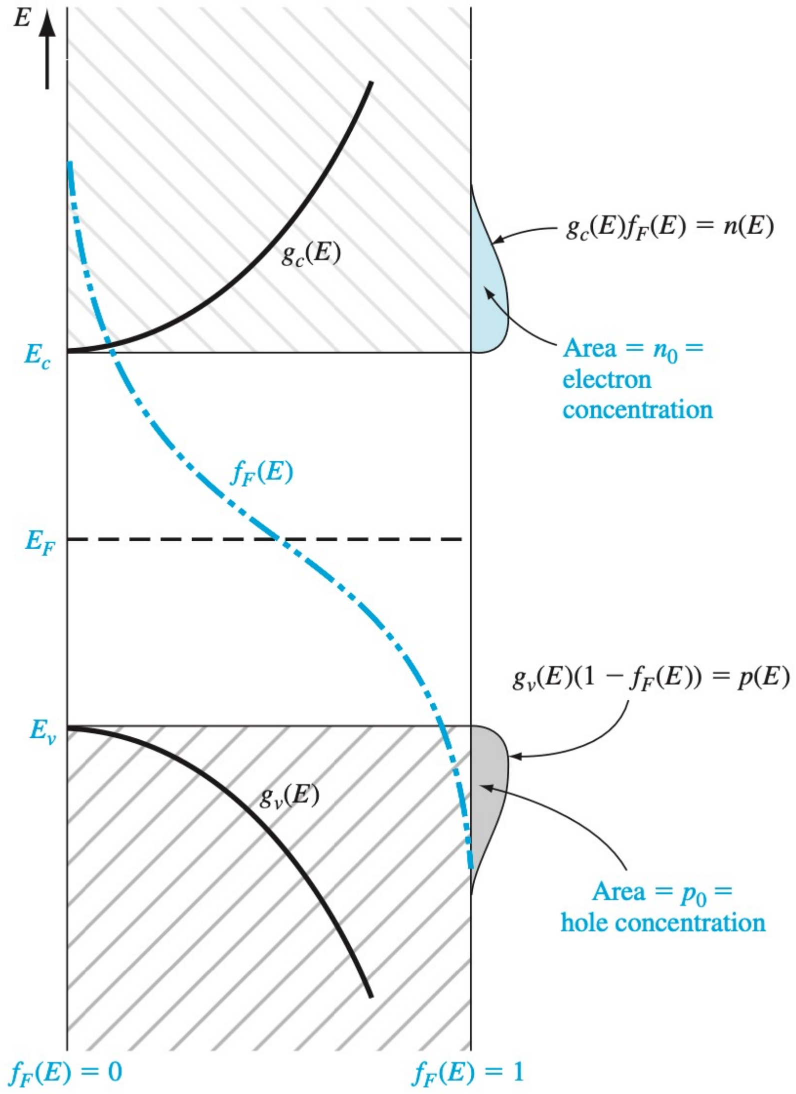
Energy density of state





Intrinsic semiconductor





$n(E)dE = g(E)f(E)dE$, $g(E)$: density of state

$p(E)dE = g(E)[1 - f(E)]dE$ $f(E)$: Fermi-Dirac function

$n(E) = N_c exp\left(\frac{E_F - E_c}{kT}\right)$, E_F : fermi energy

$p(E) = N_v exp\left(\frac{E_v - E_F}{kT}\right)$ N_c, N_v : effective density of state

n=p => $np = n_i^2$ .from intrinsic semiconductor

Intrinsic semiconductor

Intrinsic silicon detector에서의 S/N

실리콘에 입자가 지나갔을 때 생기는 signal과 background를 계산해보자.

Mean ionization energy $I_0 = 3.62$ eV,
$dE/dx = 3.87$ MeV/cm,
$n_i \sim 1.45 \cdot 10^{10} cm^{-3}$ at $T = 300$ K (Ge는 대략 $1.5 \cdot 10^{13} cm^{-3}$)

⊙ 두께 $d = 300 \mu m$, 면적 $A = 1 cm^2$의 검출기에 MIP 입자가 지나간다면,

$$\frac{dE/dx \cdot d}{I_0} = \frac{3.87 \cdot 10^6 eV/cm \cdot 0.03cm}{3.62eV} \approx 3.2 \cdot 10^4 e^- h^+ pairs$$

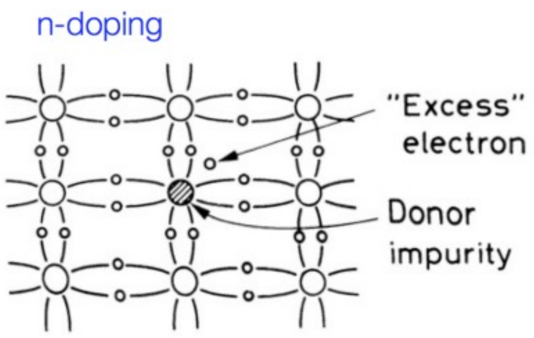
⊙ 같은 검출기 부피 내의 intrinsic charge carrier (T=300 K),

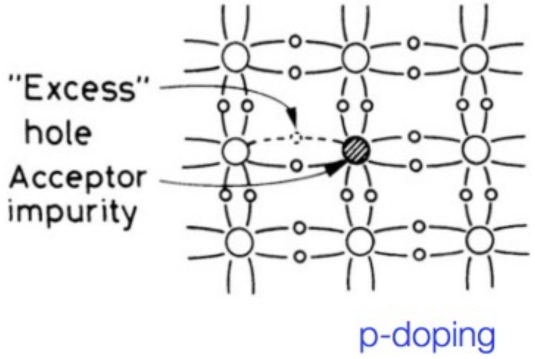
$$n_i dA = 1.45 \cdot 10^{10} cm^{-3} \cdot 0.03cm \cdot 1cm^2 \approx 4.35 \cdot 10^8 e^- h^+ pairs$$

Thermal $e^- h^+$ 쌍의 수가 MIP 입자 signal 보다 만배정도나 더 많다!

⇒ 실리콘을 이용해 검출기를 만들려면 "depletion zone in reverse biased pn junctions"이 필요하다. Doping이 필요하다.

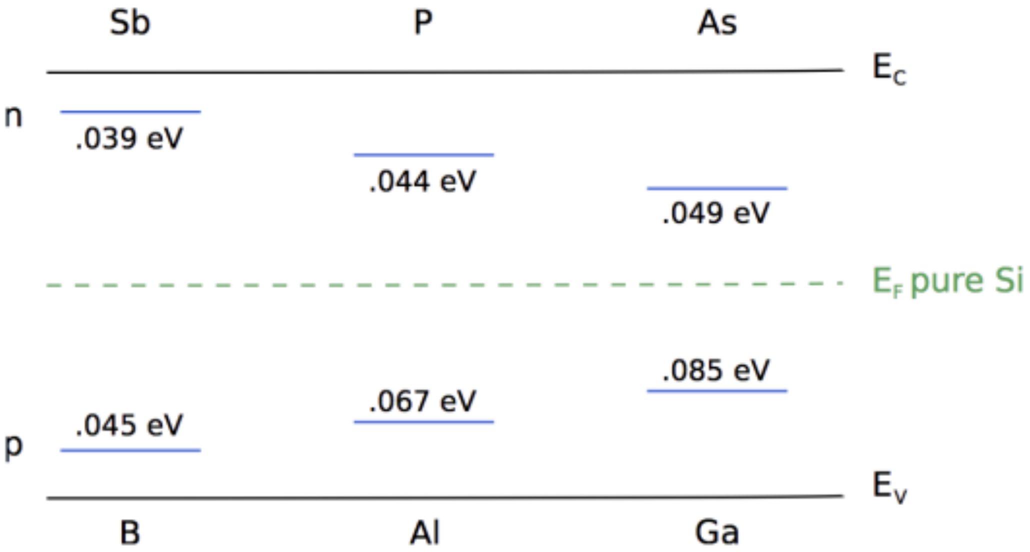
Extrinsic semiconductor

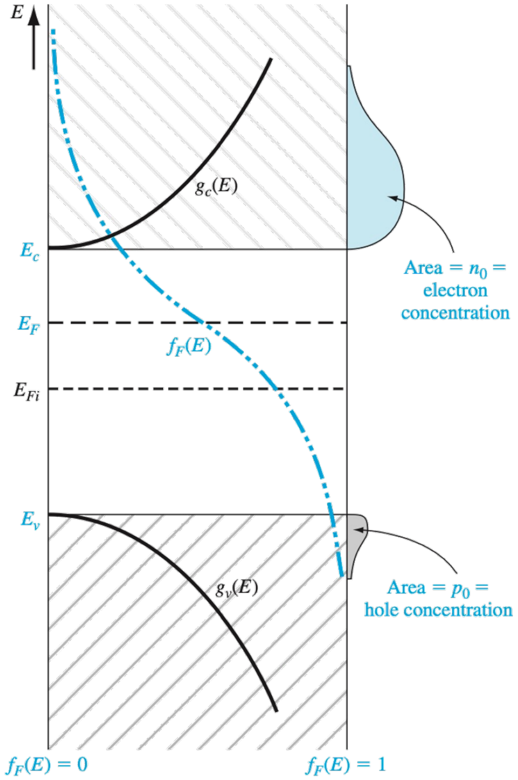




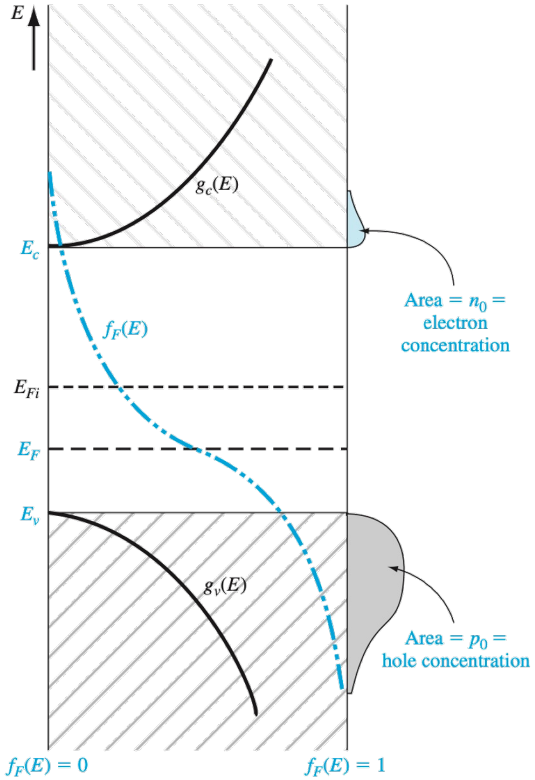
Doping group 5 atoms
: P, Ar, Sb

Doping group 3 atoms
: B, Al, Ga, In



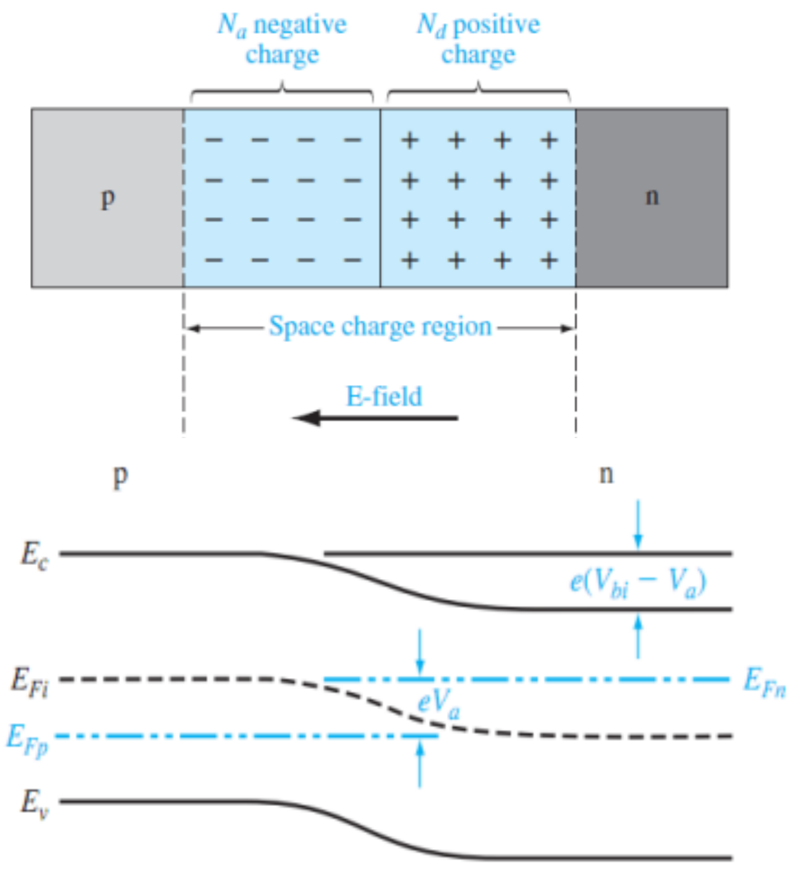


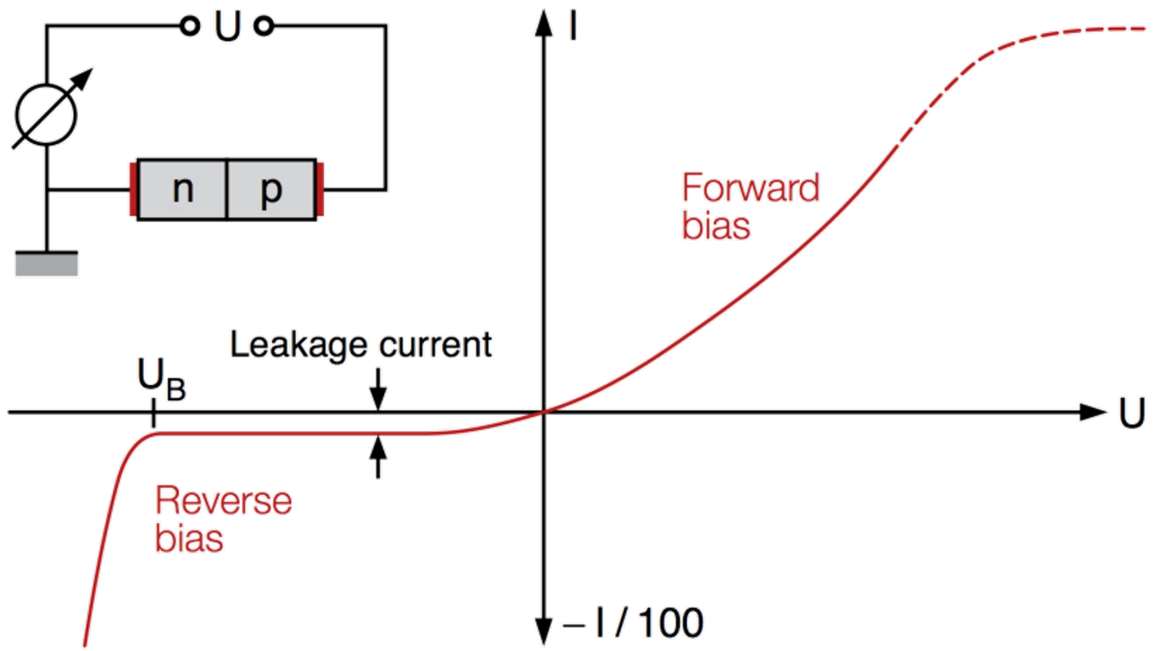
n-doping

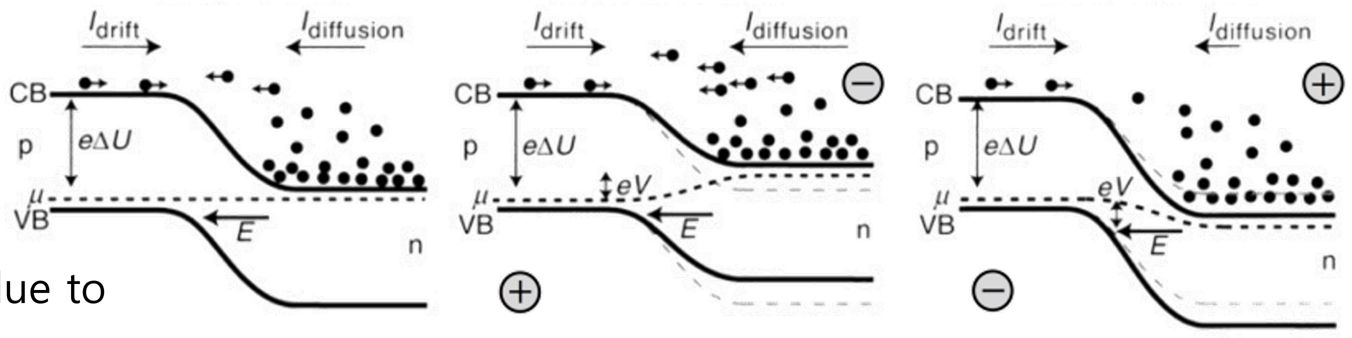


p-doping

The p-n junction



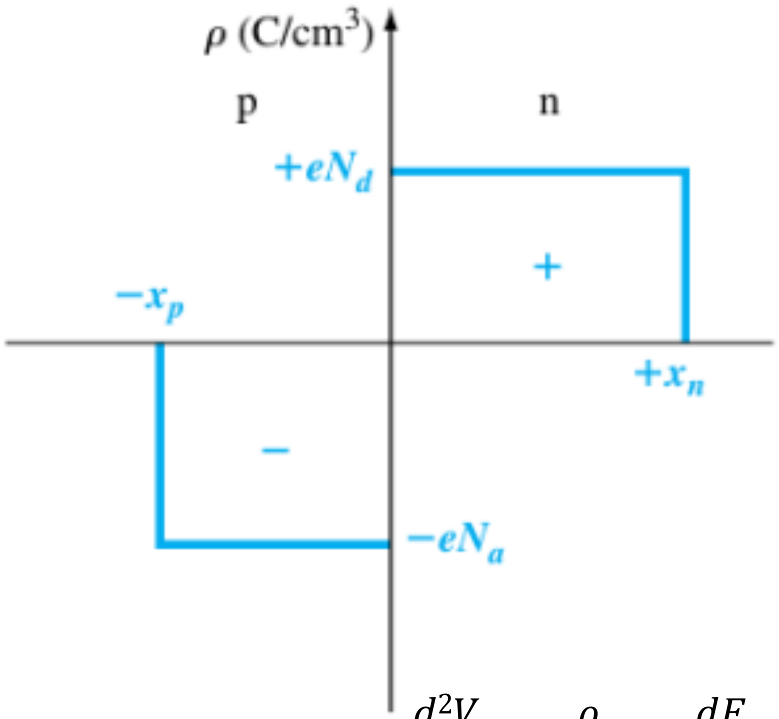




Intrinsic electric field structure of semiconductor due to the diffusion of majority carrier at the junction

equilibrium   Forward bias   reverse bias

The p-n junction



$$\frac{d^2V}{dx^2} = -\frac{\rho}{\epsilon} = -\frac{dE}{dx}$$

Poisson e.q

overall region, space-charge neutral

$$\rho(x) = \begin{cases} 0 & x > x_n \\ eN_D & 0 < x < x_n \\ -eN_A & -x_p < x < 0 \\ 0 & x < -x_p \end{cases}$$

$$\frac{dV}{dx} = \begin{cases} -eN_D/\epsilon \cdot x + C_n & 0 < x < x_n \\ eN_A/\epsilon \cdot x + C_p & -x_p < x < 0 \end{cases}$$

$$= \begin{cases} -eN_D/\epsilon \cdot (x - x_n) & 0 < x < x_n \\ eN_A/\epsilon \cdot (x + x_p) & -x_p < x < 0 \end{cases}$$

as electric field E = -dV/dx must vanish for

$x = x_n$ and $x = -x_p$

$$W_{scr} = \left[\frac{2\epsilon(V_{bi} + V_0)}{e}\left(\frac{N_a + N_d}{N_a N_d}\right)\right]^{1/2}$$

$N_d << N_a$

$$W_{scr} \approx 0.53\sqrt{\rho V_0}\,, (\mu m)$$

$N_a << N_d$

$$W_{scr} \approx 0.32\sqrt{\rho V_0}\,, (\mu m)$$

The p-n junction

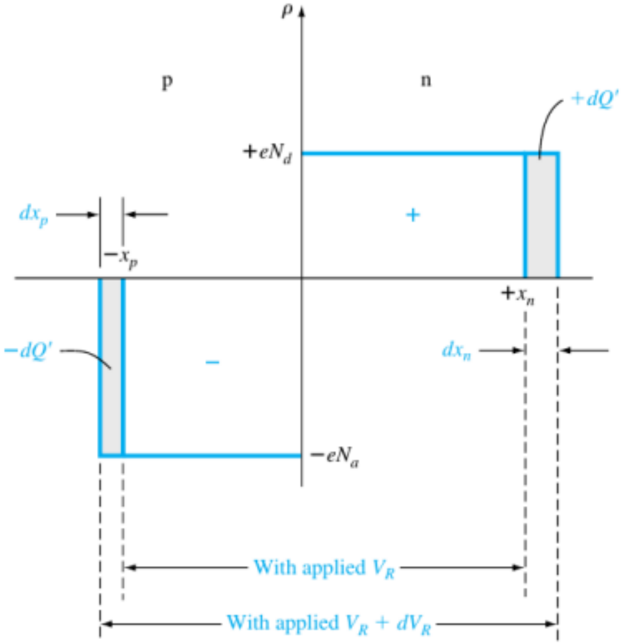
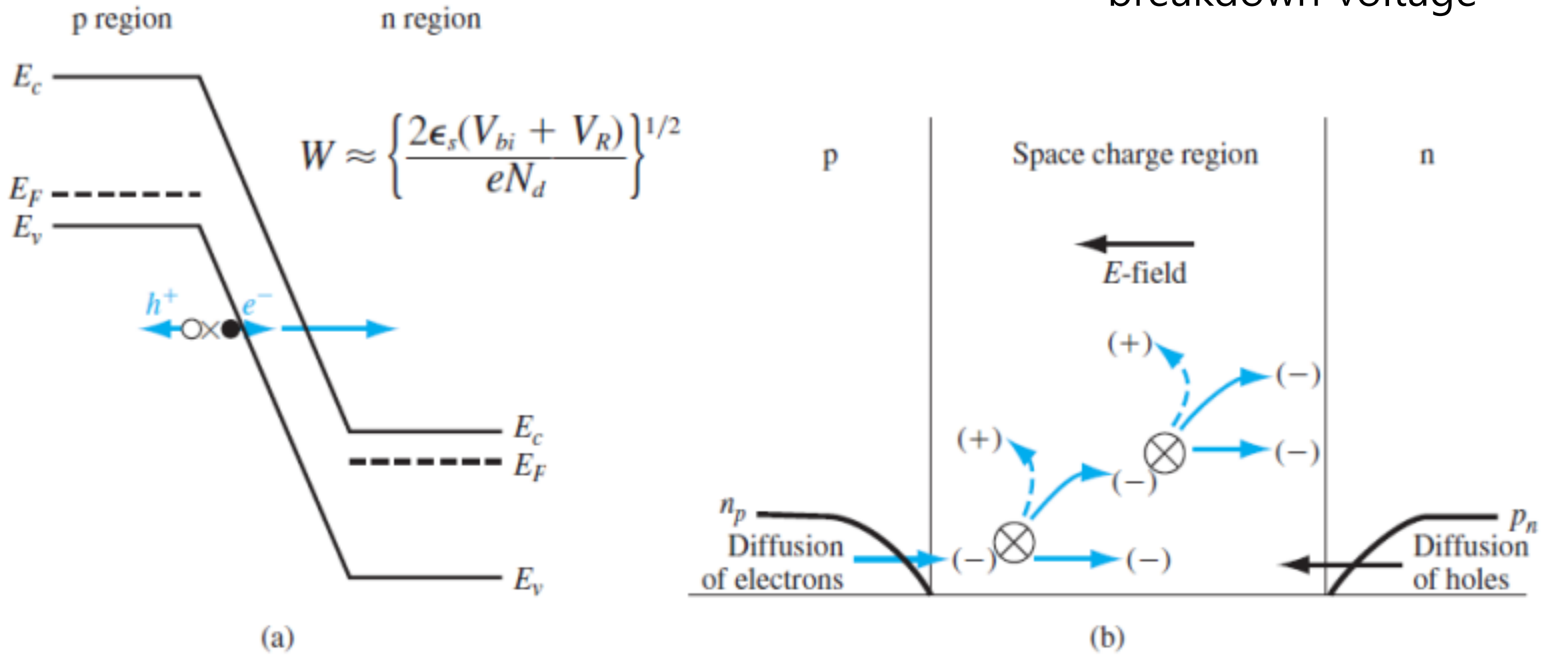


Figure 7.9 | Differential change in the space charge width with a differential change in reverse-biased voltage for a uniformly doped pn junction.

junction capacitance

$$C = \frac{\epsilon A}{W_{scr}}$$

breakdown voltage

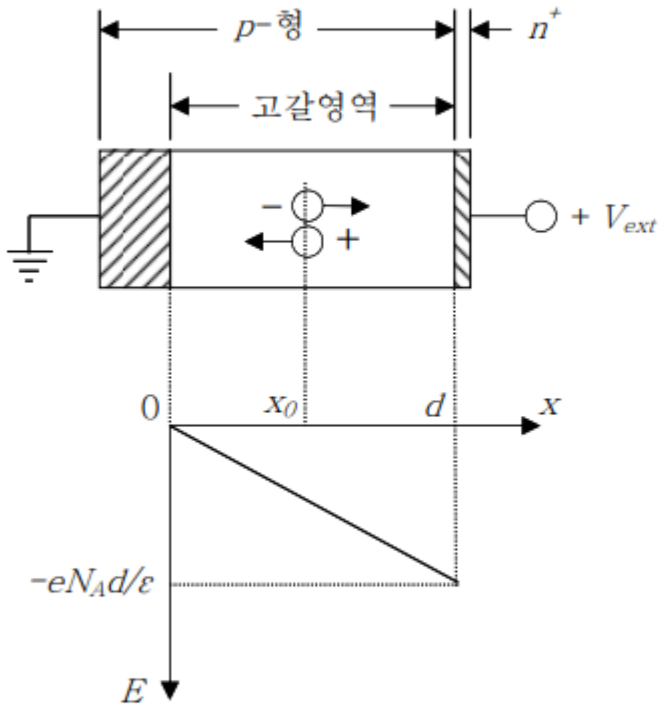


$$W \approx \left\{\frac{2\epsilon_s(V_{bi} + V_R)}{eN_d}\right\}^{1/2}$$

Figure 7.12 | (a) Zener breakdown mechanism in a reverse-biased pn junction; (b) avalanche breakdown process in a reverse-biased pn junction.

Zener breakdown : high doped
Avalanche breakdown : high electric field

Signal



ehp 한 쌍이 생겨났을 경우의 시그널

$$J_{drft} \approx e\mu_p N_A E = \sigma E = \frac{1}{\rho} E$$

$$\frac{d^2V}{dx^2} = -\frac{\rho}{\epsilon} = -\frac{dE}{dx}$$

Poisson e.q

n⁺p 다이오드 내부 전기장 :

$$E = -\frac{eN_A d}{\epsilon} x = -\frac{x}{\mu_p \tau}\ , \ \tau = \frac{\epsilon}{\sigma}$$

전자의 속도

$$v = \frac{dx}{dt} = -\mu_n E$$

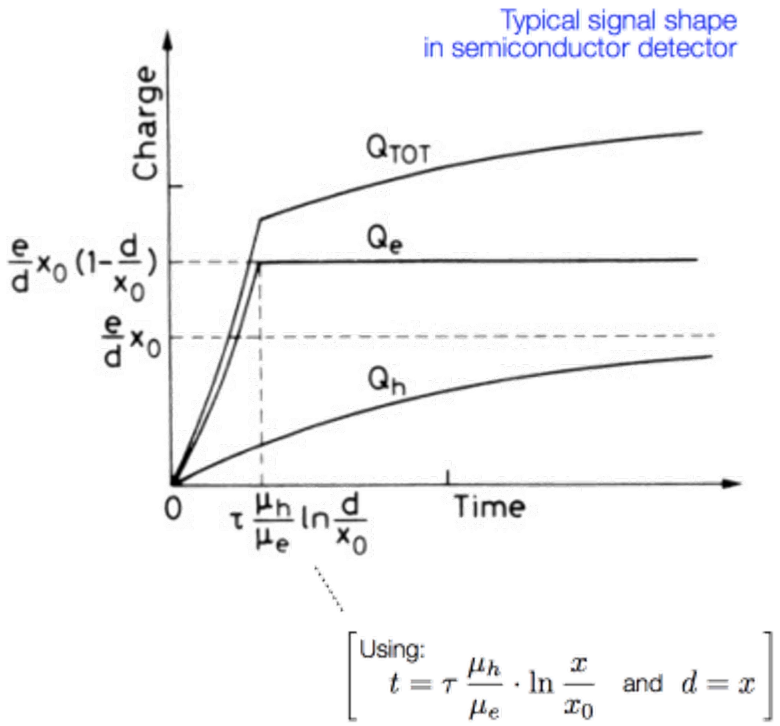
전극에 유도되는 전하

$$dQ = \frac{q}{d} dx$$

$$Q_n = \frac{e}{d} x_0 (1 - \exp \frac{\mu_n t}{\mu_p \tau})$$

$$Q_p = -\frac{e}{d} x_0 (1 - \exp \frac{-t}{\tau})$$

$$Q_{tot} = Q_n + Q_p = -e$$



Signal

	ε_0 [@ 300 K]	ε_0 [@ 77 K]	E_{gap}
Si	3.6 eV	2.8 eV	1.1 eV
Ge	–	2.9 eV	0.7 eV

ε_0: mean energy per electron-hole pair

on average

$E_x\sigma_x = E_i\sigma_i$

$\sigma_i = \sqrt{N_i}, \sigma_x = \sqrt{N_x}$

energy conservation

$E_0 = E_i \cdot N_i + E_x \cdot N_x$

$E_i \cdot \Delta N_i + E_x \cdot \Delta N_x = 0$

E_0=const

$$\sigma_i = \frac{E_x}{E_i}\sqrt{\frac{E_0}{E_x} - \frac{E_i}{E_x}N_i}\ , \qquad N_i = \frac{E_0}{\epsilon_0}$$

$$\sigma_i = \sqrt{N_i F}\ \ , F = \sqrt{\frac{E_x}{E_i}(\frac{\epsilon_0}{E_i} - 1)}$$

: fano factor, 실리콘의 경우(300K) ~0.1

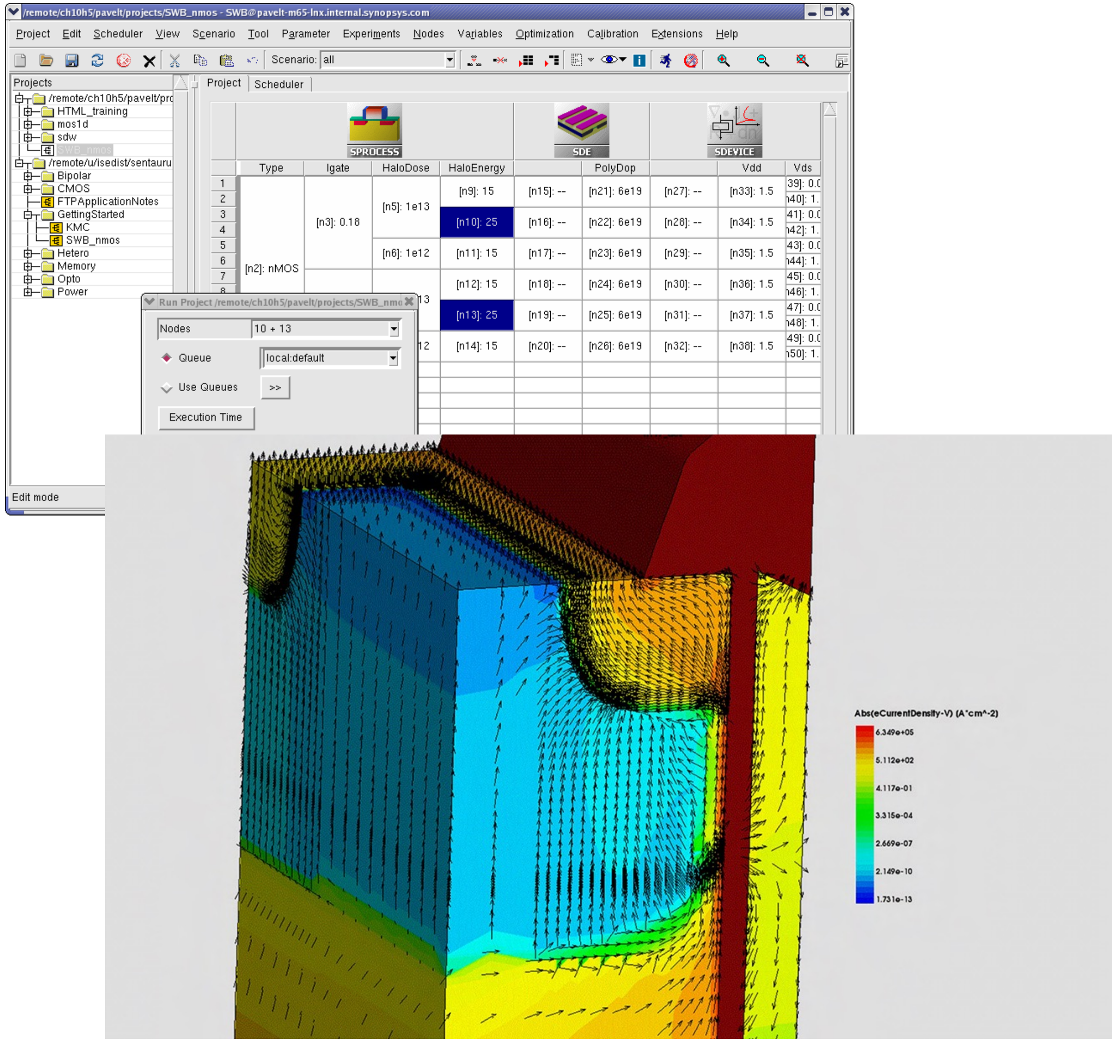
E_i : ionization energy

E_x : phonon excitation

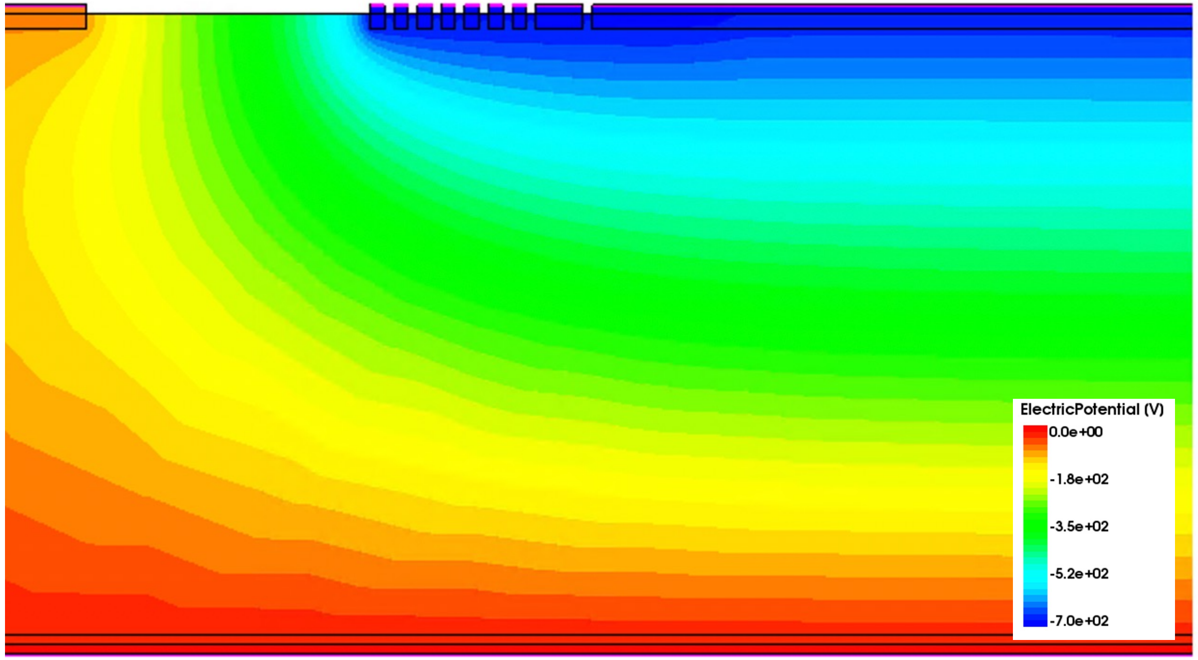
TCAD(Technology Computer Aided Design) simulation

- TCAD simulators calculate the Poisson equation of the semiconductor properties in the numerical analysis method.

- TCAD simulators can visualize physical characteristics of semiconductors, such as electric field, potential, and current density.



Synopsys TCAD tool



- Electrostatic Potential

$$\nabla \cdot (\varepsilon \nabla \phi + \vec{P}) = -q(p - n + N_D - N_A) - \rho_{trap}$$

- Carrier transport model

$$\nabla \cdot \overrightarrow{J_{n(p)}} = q(R_{net,n(p)} - G_{net,n(p)}) + q\frac{\partial n(p)}{\partial t}$$

- Drift-diffusion model

$$\overrightarrow{J_{n(p)}} = -n(p)\mu_{n(p)} \nabla \Phi_{n(p)}$$ by Einstein relation

ε : electrical permittivity

$\vec{P}$: ferroelectric polarization

n(p) : electron(hole) density

q : elementary charge

$\mu_{n(p)}$: electron(hole) carrier mobility

$R_{net,n(p)}$: electron(hole) net recombination rate

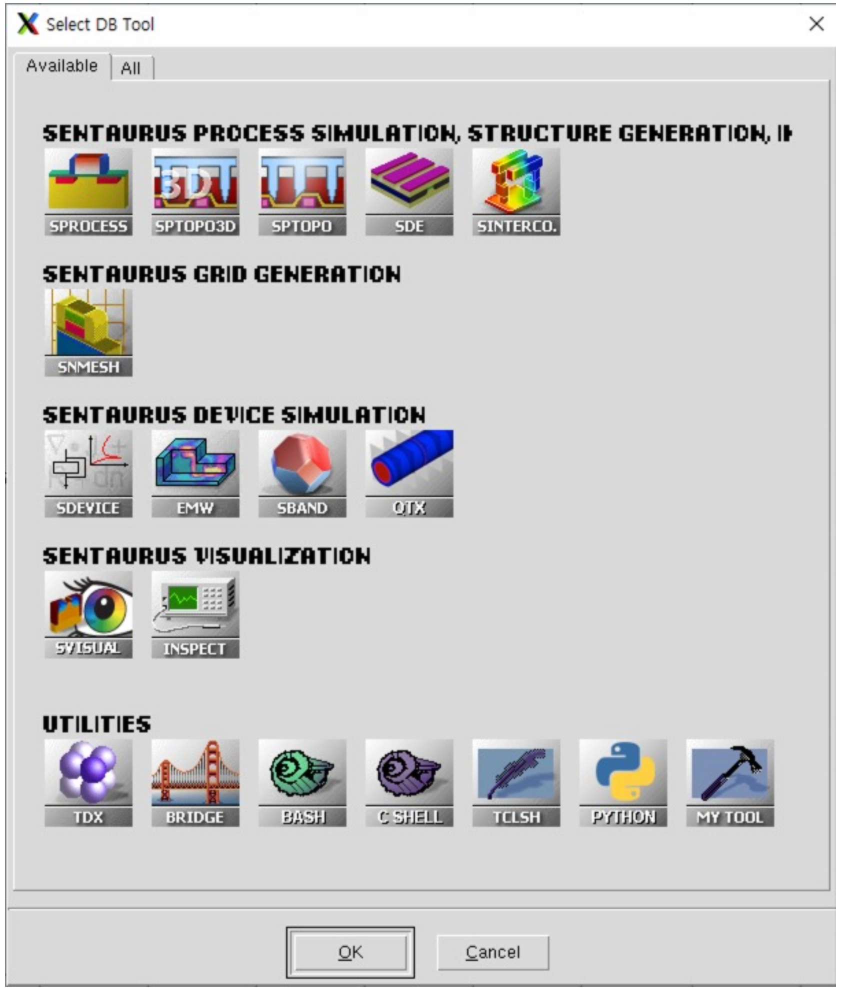
$G_{net,n(p)}$: electron(hole) net generation rate

$\overrightarrow{J_{n(p)}}$: electron(hole) current density

$\Phi_{n(p)}$: electron(hole) quasi_Fermi potential

N_D (N_A) : concentration of ionized donors(acceptors)

Synopsys TCAD tool



Senstaurus tools

Sentaurus process

- An advanced 1D, 2D, and 3D process simulator
- Equipped with a set of advanced process models, which include default parameters calibrated with data from equipment vendors

Sentaurus structure editor

- Tools for creating geometric structures for TCAD simulation
- Direct CAD operations can be used to create 2D and 3D structures

Sentaurus device

- An advanced multidimensional (1D/2D/3D) devic e simulator
- Characterize electrical, thermal and optical behavi or of semiconductor devices

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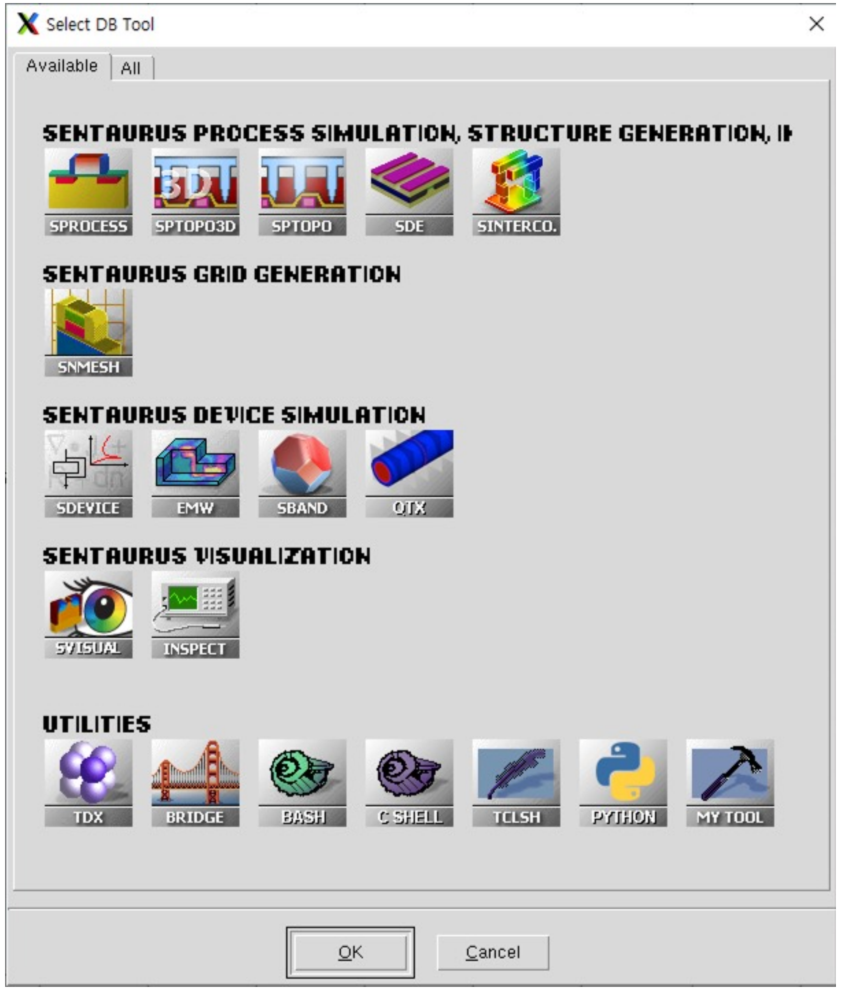

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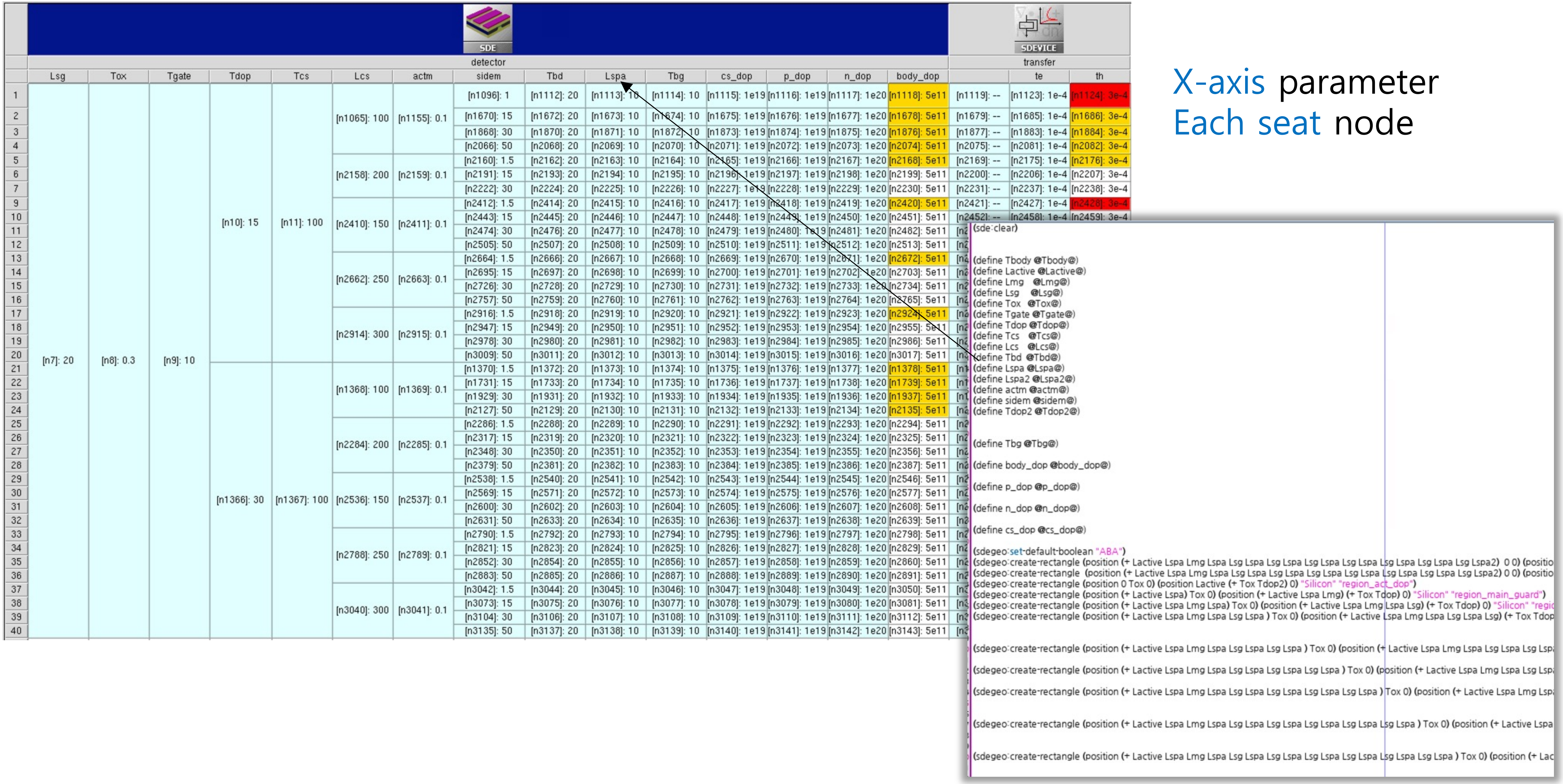
SWB (Sentaurus WorkBench)



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	SDE detector															SDEVICE transfer		
1	[n7]: 20	[n8]: 0.3	[n9]: 10	[n10]: 15	[n11]: 100			[n1096]: 1	[n1112]: 20	[n1113]: 10	[n1114]: 10	[n1115]: 1e19	[n1116]: 1e19	[n1117]: 1e20	[n1118]: 5e11	[n1119]: --	[n1123]: 1e-4	[n1124]: 3e-4
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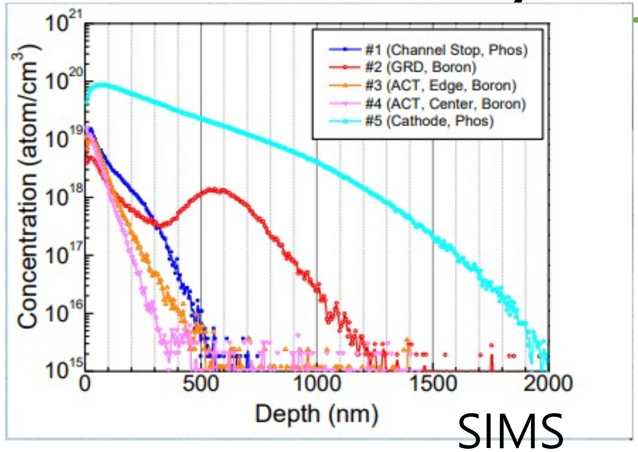
26								[n2317]: 15	[n2319]: 20	[n2320]: 10	[n2321]: 10	[n2322]: 1e19	[n2323]: 1e19	[n2324]: 1e20	[n2325]: 5e11			
27								[n2348]: 30	[n2350]: 20	[n2351]: 10	[n2352]: 10	[n2353]: 1e19	[n2354]: 1e19	[n2355]: 1e20	[n2356]: 5e11			
28								[n2379]: 50	[n2381]: 20	[n2382]: 10	[n2383]: 10	[n2384]: 1e19	[n2385]: 1e19	[n2386]: 1e20	[n2387]: 5e11			
29						[n2536]: 150	[n2537]: 0.1	[n2538]: 1.5	[n2540]: 20	[n2541]: 10	[n2542]: 10	[n2543]: 1e19	[n2544]: 1e19	[n2545]: 1e20	[n2546]: 5e11			
30								[n2569]: 15	[n2571]: 20	[n2572]: 10	[n2573]: 10	[n2574]: 1e19	[n2575]: 1e19	[n2576]: 1e20	[n2577]: 5e11			
31								[n2600]: 30	[n2602]: 20	[n2603]: 10	[n2604]: 10	[n2605]: 1e19	[n2606]: 1e19	[n2607]: 1e20	[n2608]: 5e11			
32								[n2631]: 50	[n2633]: 20	[n2634]: 10	[n2635]: 10	[n2636]: 1e19	[n2637]: 1e19	[n2638]: 1e20	[n2639]: 5e11			
33						[n2788]: 250	[n2789]: 0.1	[n2790]: 1.5	[n2792]: 20	[n2793]: 10	[n2794]: 10	[n2795]: 1e19	[n2796]: 1e19	[n2797]: 1e20	[n2798]: 5e11			
34								[n2821]: 15	[n2823]: 20	[n2824]: 10	[n2825]: 10	[n2826]: 1e19	[n2827]: 1e19	[n2828]: 1e20	[n2829]: 5e11			
35								[n2852]: 30	[n2854]: 20	[n2855]: 10	[n2856]: 10	[n2857]: 1e19	[n2858]: 1e19	[n2859]: 1e20	[n2860]: 5e11			
36								[n2883]: 50	[n2885]: 20	[n2886]: 10	[n2887]: 10	[n2888]: 1e19	[n2889]: 1e19	[n2890]: 1e20	[n2891]: 5e11			
37						[n3040]: 300	[n3041]: 0.1	[n3042]: 1.5	[n3044]: 20	[n3045]: 10	[n3046]: 10	[n3047]: 1e19	[n3048]: 1e19	[n3049]: 1e20	[n3050]: 5e11			
38								[n3073]: 15	[n3075]: 20	[n3076]: 10	[n3077]: 10	[n3078]: 1e19	[n3079]: 1e19	[n3080]: 1e20	[n3081]: 5e11			
39								[n3104]: 30	[n3106]: 20	[n3107]: 10	[n3108]: 10	[n3109]: 1e19	[n3110]: 1e19	[n3111]: 1e20	[n3112]: 5e11			
40								[n3135]: 50	[n3137]: 20	[n3138]: 10	[n3139]: 10	[n3140]: 1e19	[n3141]: 1e19	[n3142]: 1e20	[n3143]: 5e11			

```
(sde:clear)


(define Tbody @Tbody@)
(define Lactive @Lactive@)
(define Lmg   @Lmg@)
(define Lsg    @Lsg@)
(define Tox  @Tox@)
(define Tgate @Tgate@)
(define Tdop @Tdop@)
(define Tcs   @Tcs@)
(define Lcs   @Lcs@)
(define Tbd  @Tbd@)
(define Lspa @Lspa@)
(define Lspa2 @Lspa2@)
(define actm @actm@)
(define sidem @sidem@)
(define Tdop2 @Tdop2@)


(define Tbg @Tbg@)

(define body_dop @body_dop@)

(define p_dop @p_dop@)

(define n_dop @n_dop@)

(define cs_dop @cs_dop@)

(sdegeo:set-default-boolean "ABA")
(sdegeo:create-rectangle (position (+ Lactive Lspa Lmg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa2)  0 0) (positio
(sdegeo:create-rectangle  (position (+ Lactive Lspa Lmg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa2) 0 0) (positio
(sdegeo:create-rectangle (position 0 Tox 0) (position Lactive (+ Tox Tdop2) 0) "Silicon" "region_act_dop")
(sdegeo:create-rectangle (position (+ Lactive Lspa) Tox 0) (position (+ Lactive Lspa Lmg) (+ Tox Tdop) 0) "Silicon" "region_main_guard")
(sdegeo:create-rectangle (position (+ Lactive Lspa Lmg Lspa) Tox 0) (position (+ Lactive Lspa Lmg Lspa Lsg) (+ Tox Tdop) 0) "Silicon" "regio
(sdegeo:create-rectangle (position (+ Lactive Lspa Lmg Lspa Lsg Lspa ) Tox 0) (position (+ Lactive Lspa Lmg Lspa Lsg Lspa Lsg) (+ Tox Tdop


(sdegeo:create-rectangle (position (+ Lactive Lspa Lmg Lspa Lsg Lspa Lsg Lspa ) Tox 0) (position (+ Lactive Lspa Lmg Lspa Lsg Lspa Lsg Lsp

(sdegeo:create-rectangle (position (+ Lactive Lspa Lmg Lspa Lsg Lspa Lsg Lspa Lsg Lspa ) Tox 0) (position (+ Lactive Lspa Lmg Lspa Lsg Lsp

(sdegeo:create-rectangle (position (+ Lactive Lspa Lmg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa ) Tox 0) (position (+ Lactive Lspa Lmg Lsp


(sdegeo:create-rectangle (position (+ Lactive Lspa Lmg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa ) Tox 0) (position (+ Lactive Lspa


(sdegeo:create-rectangle (position (+ Lactive Lspa Lmg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa Lsg Lspa ) Tox 0) (position (+ Lac
```

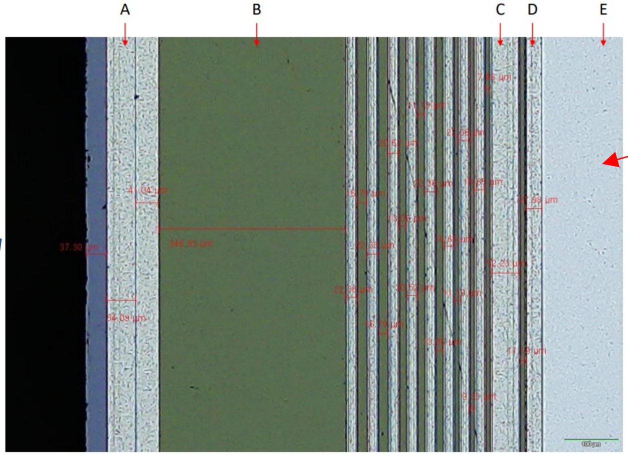
X-axis parameter
Each seat node

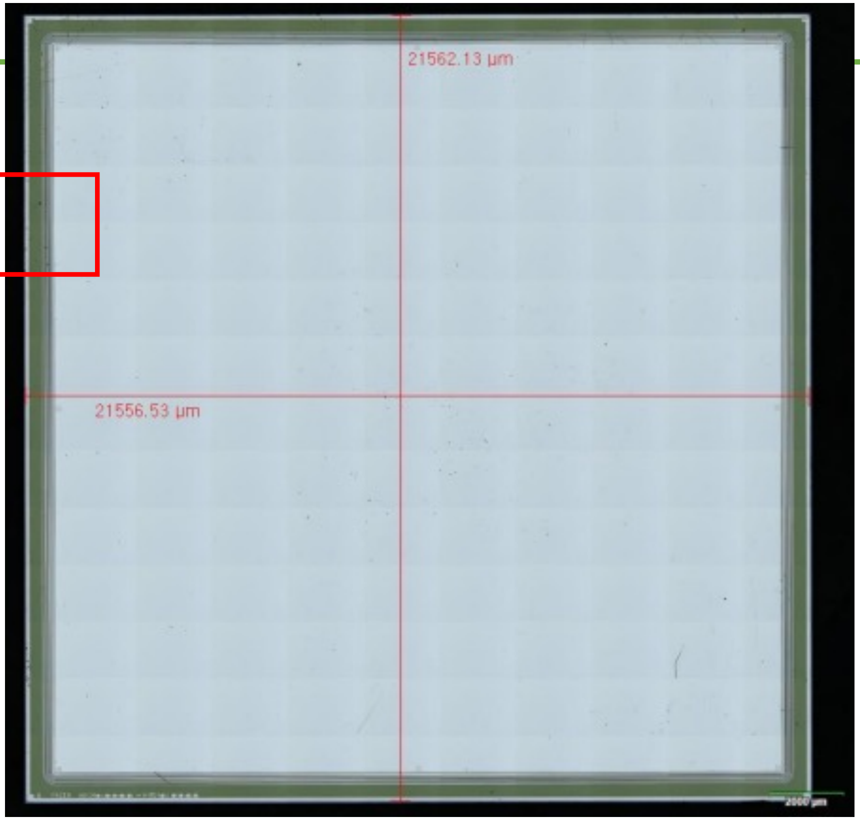
SDE & SDEVICE

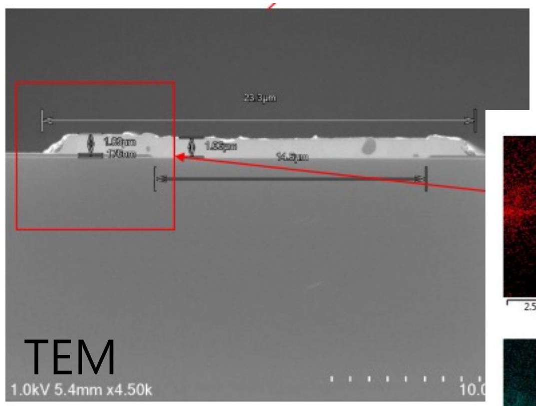
Reverse engineering target chip

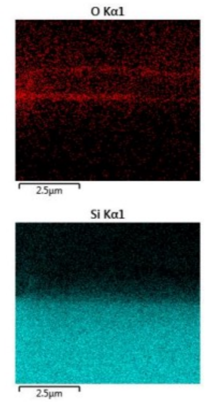


SIMS

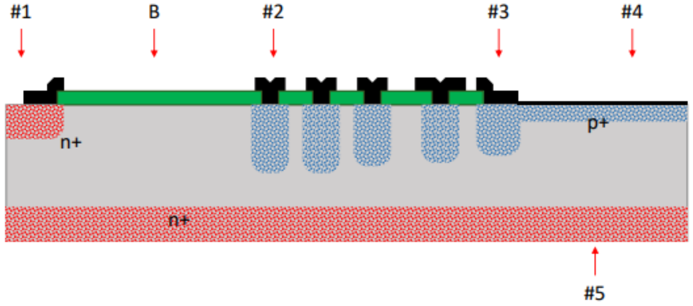




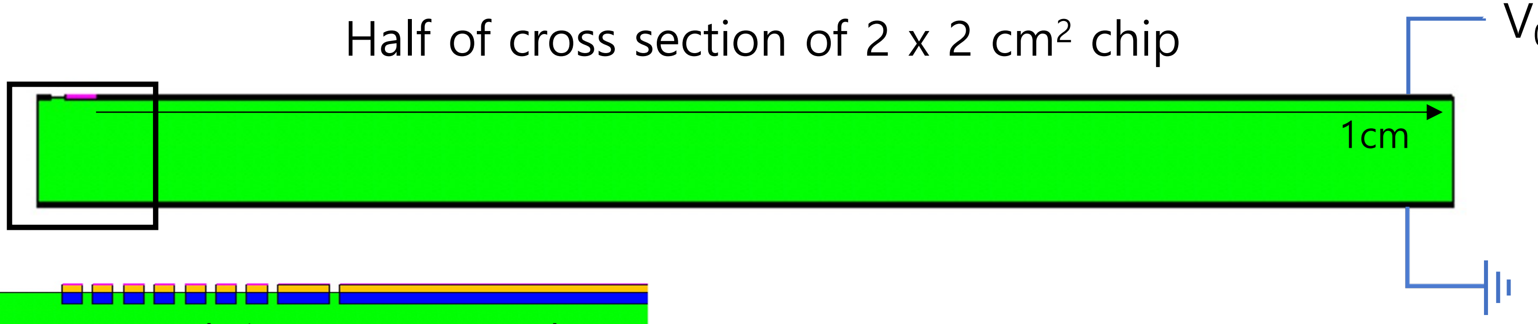




Map Sum Spectrum								
Element	Line Type	Apparent Concentration	k Ratio	Wt%	Wt% Sigma	Standard Label	Factory Standard	Standard Calibration Date
C	K series	0.09	0.00091	13.19	0.50	C Vit	Yes	
O	K series	0.40	0.00135	7.01	0.18	SiO2	Yes	
Al	K series	2.07	0.01485	18.70	0.15	Al2O3	Yes	
Si	K series	5.33	0.04221	60.34	0.38	SiO2	Yes	
Ti	K series	0.03	0.00031	0.44	0.06	Ti	Yes	
Ag	L series	0.02	0.00020	0.33	0.10	Ag	Yes	
Total:				100.00				



Simulation setup

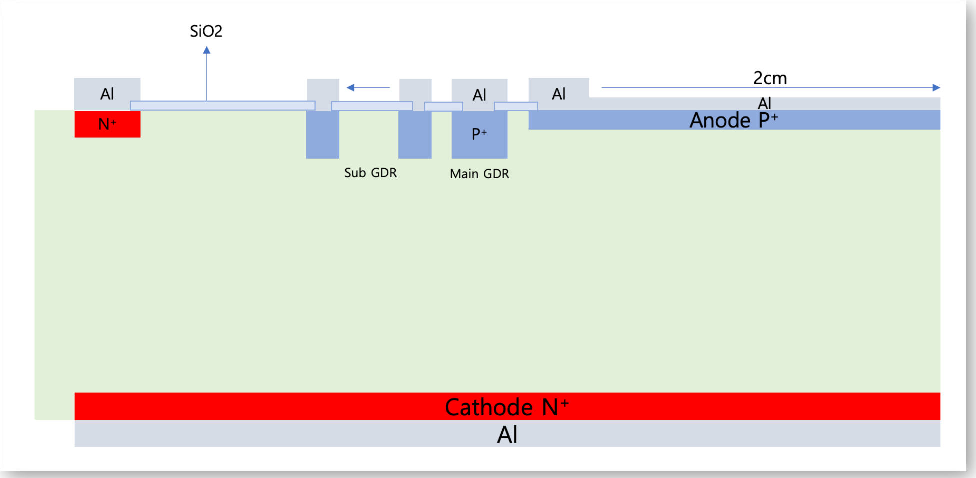


Edge of silicon sensor

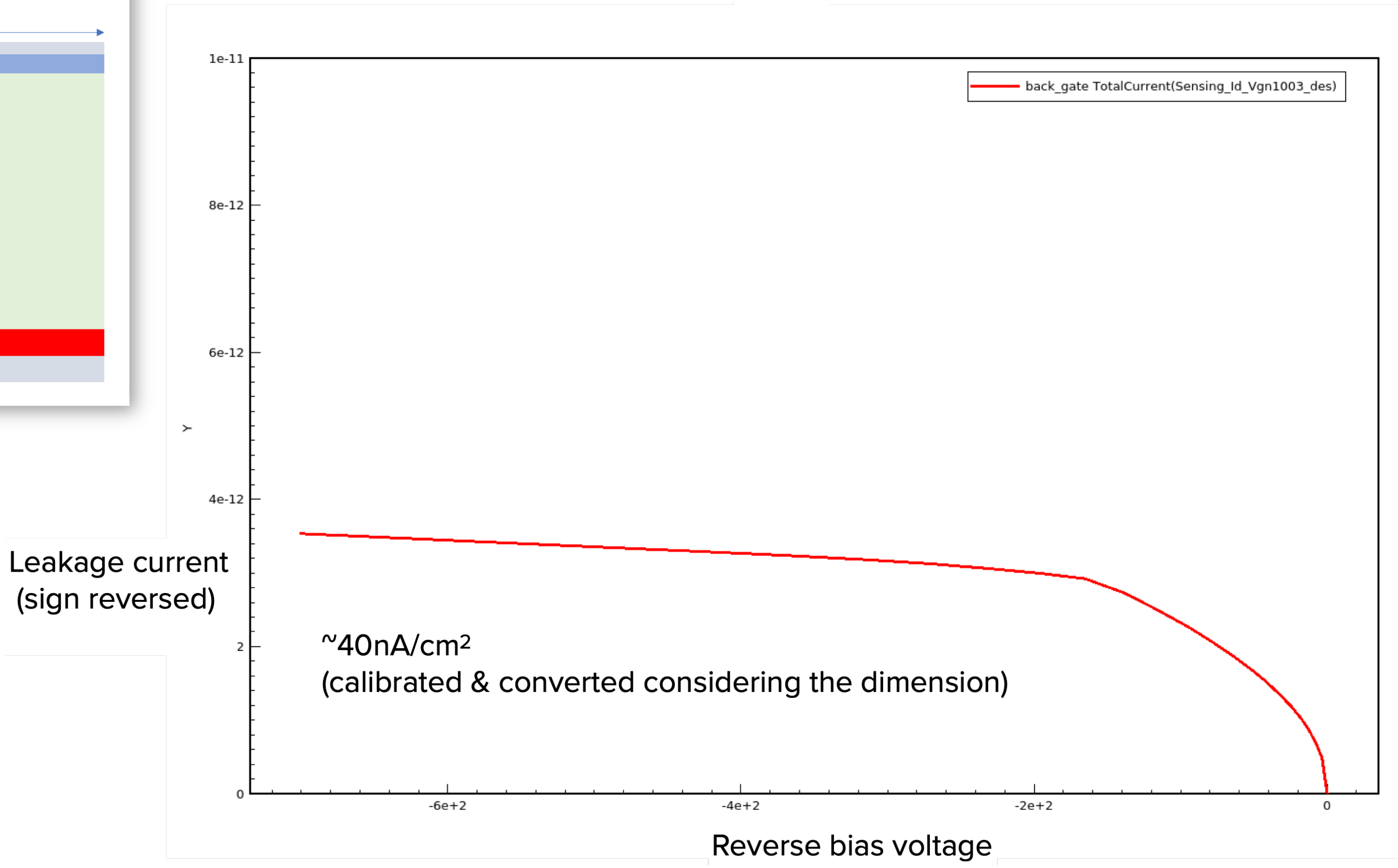
Input parameter					
Temperature	300K		Doping density		
Bias voltage	0 ~ -700V			P-type	$1x10^{19}cm^{-3}$
Carrier lifetime	electron	$1x10^{-4}s^{-1}$		N-type	$5x10^{11}cm^{-3}$
	hole	$3x10^{-4}s^{-1}$		N-type	$1x10^{20}cm^{-3}$

Design of PiN sensor using TCAD simulation

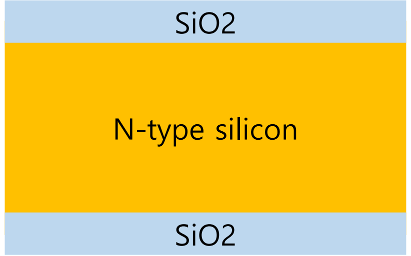
Leakage current result with the final design



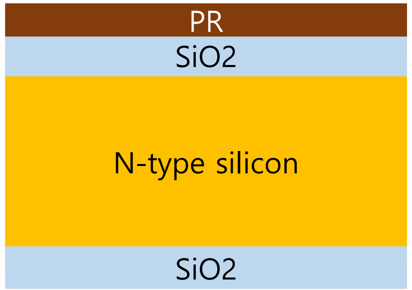
- We calculated the leakage current of the final design based on the calibrated parameters.



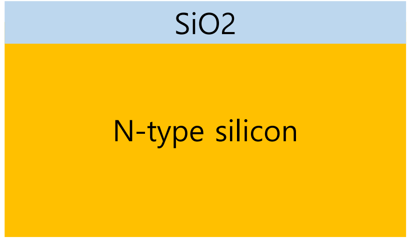
Process flow co- ETRI



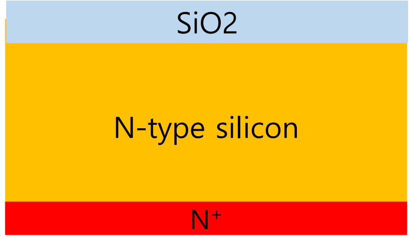
1. Oxidation [900℃, 6000Å]



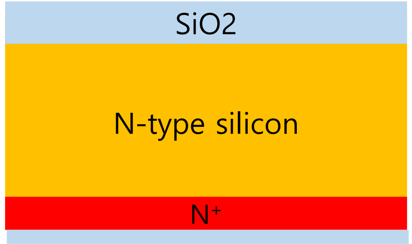
2. PR coating



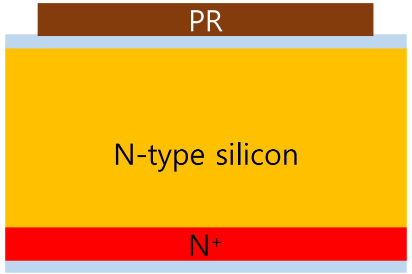
3. Backside Oxide strip
PR strip



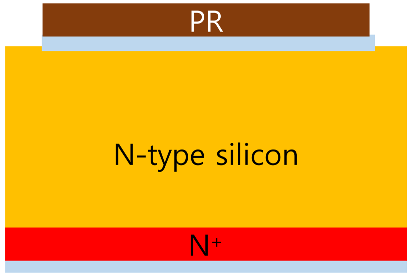
4. POCl3 Doping
Deglase PSG



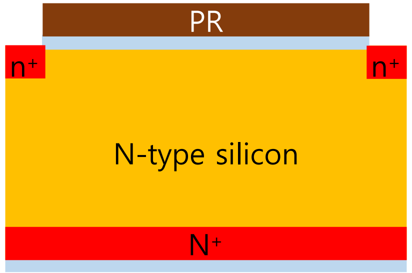
5. Oxidation [900℃, 1000Å]



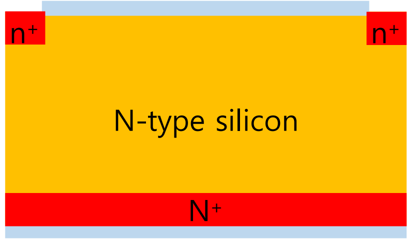
6. #Channel Stop Patterning



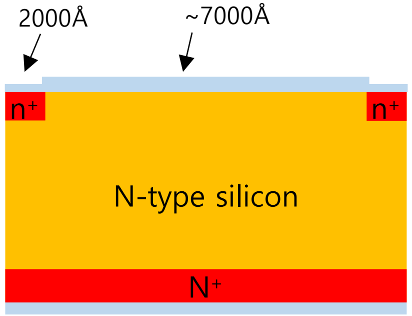
7. Oxide etch ~6000A



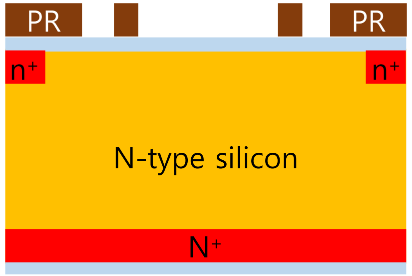
8. N^+ implant [channel stop]
P31, 50KeV, 4.0E14/cm2



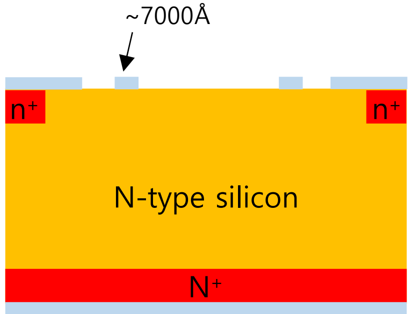
9. PR strip



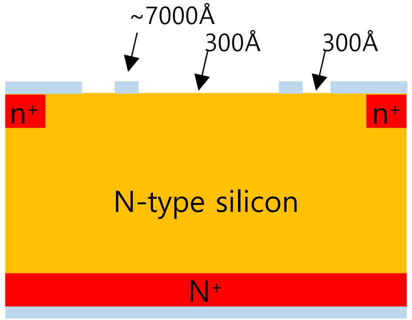
10. Oxidation [900℃, 2000Å]



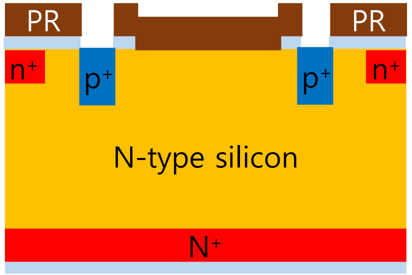
11. #Active Patterning



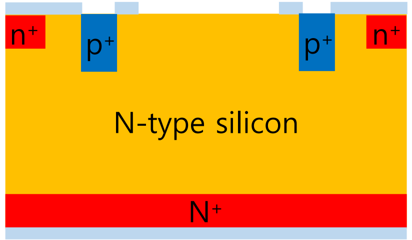
12-1. Oxide etch (Dry + Wet)
12-2. PR strip



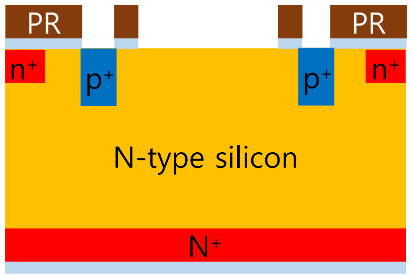
13. Oxidation [850℃, 300Å]



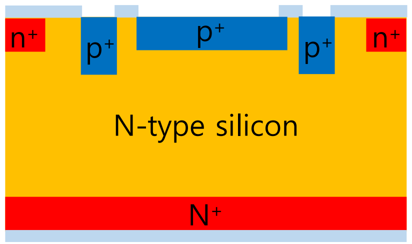
14-1. #GRD Patterning
14-2. P^+ implant [GRD]
B11, 180KeV, 1.0E14/cm2



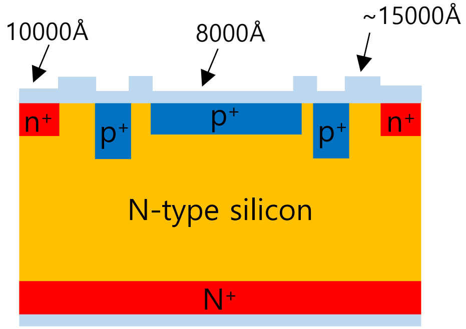
15-1. PR strip
15-2. Anneal (950℃, 60min)



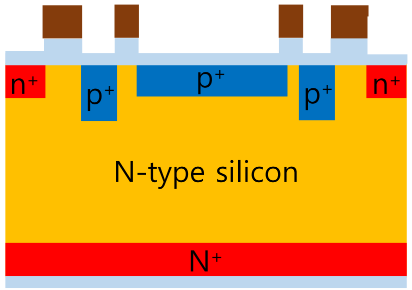
16-1. Active Patterning
16-2. P^+ implant [Active]
B11, 50KeV, 1.0E15/cm2



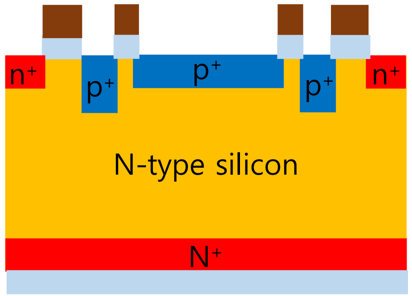
17. PR strip



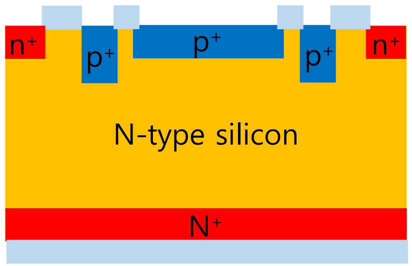
18-1. TEOS 8,000A
18-2. Anneal (950℃, 30min)



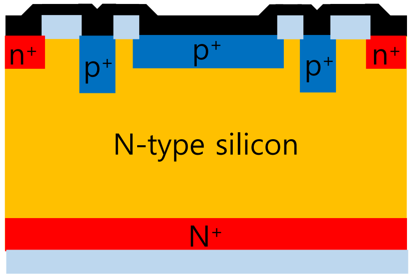
19. #CONT Patterning



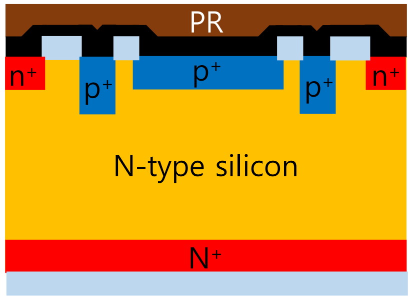
20. Oxide etch (Dry+Wet)
Target: ~10000A (oxide on n+)



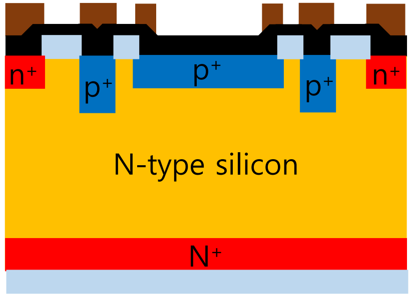
21. PR strip



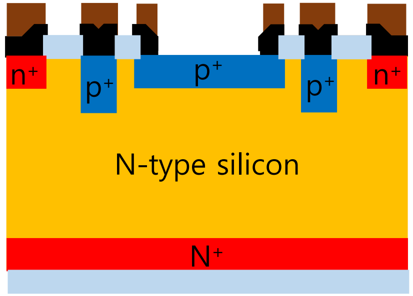
22. metal deposit
[10000Å]



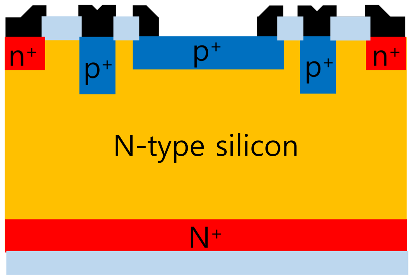
23. PR coating



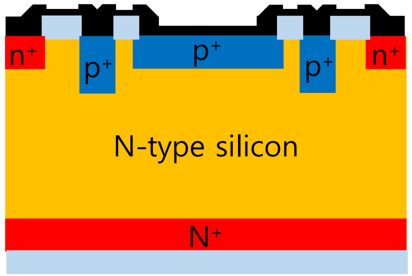
24. #GRD metal Patterning



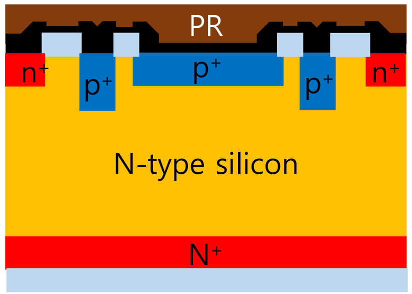
25. metal etching



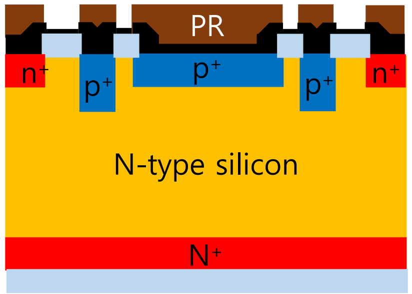
26. PR strip



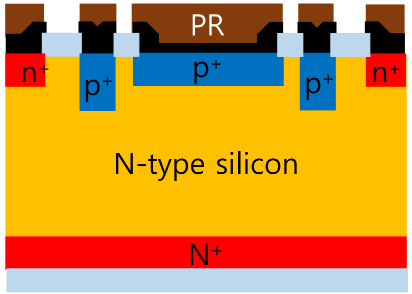
27. metal deposit[400Å]
barrier metal split



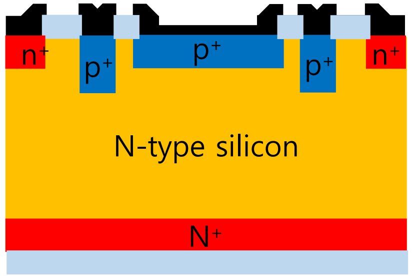
28. PR coating



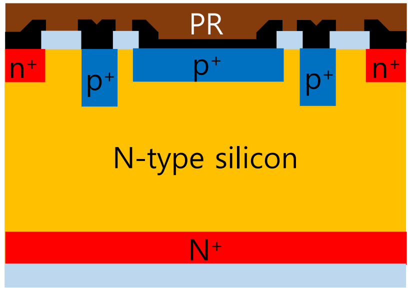
29. #ACT metal Pattering



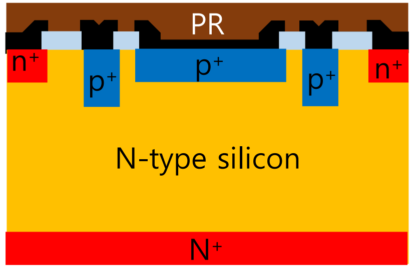
30. metal etching



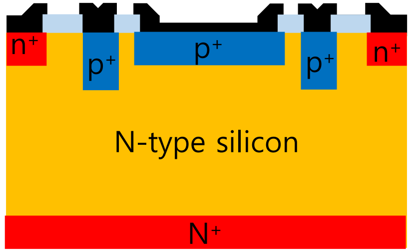
31. PR strip



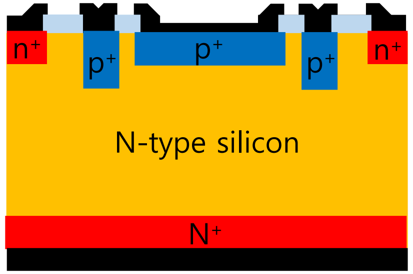
32. PR coating



33. oxide etching

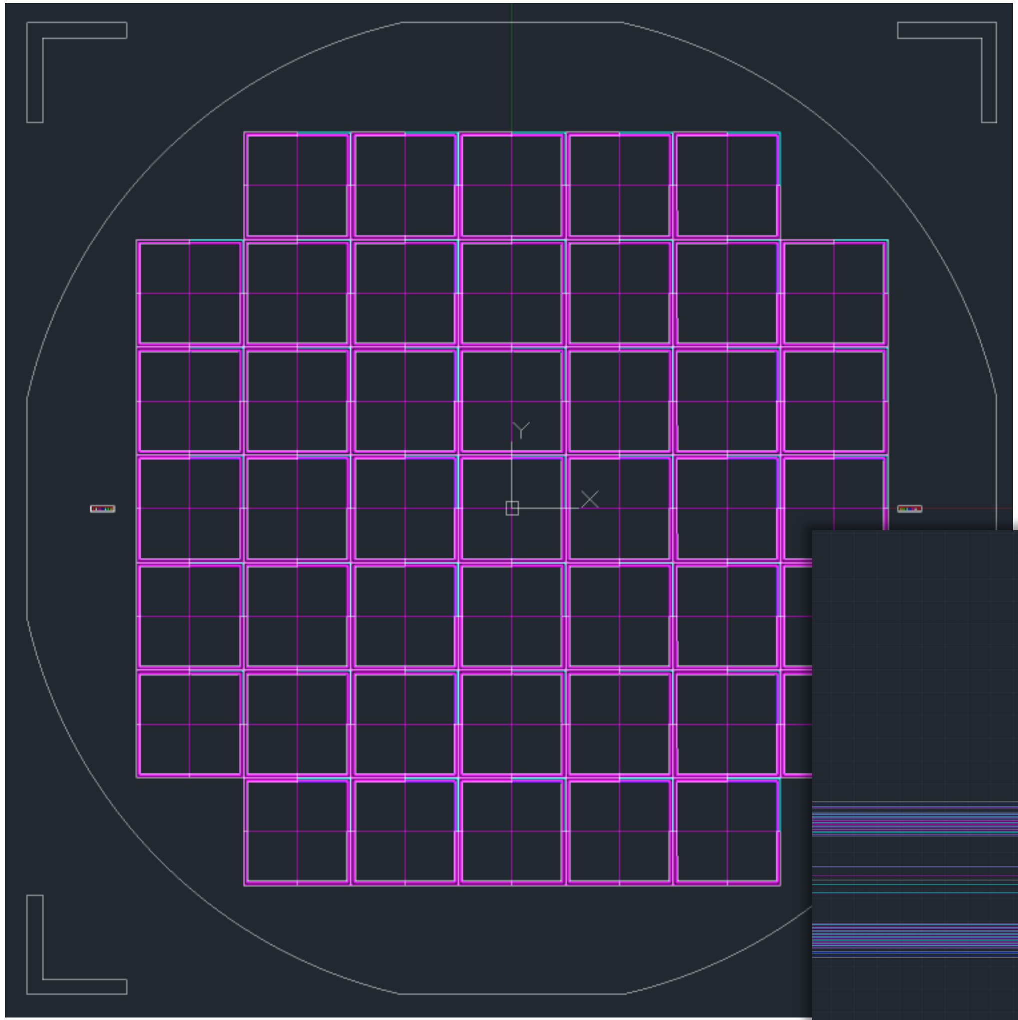


34. PR strip

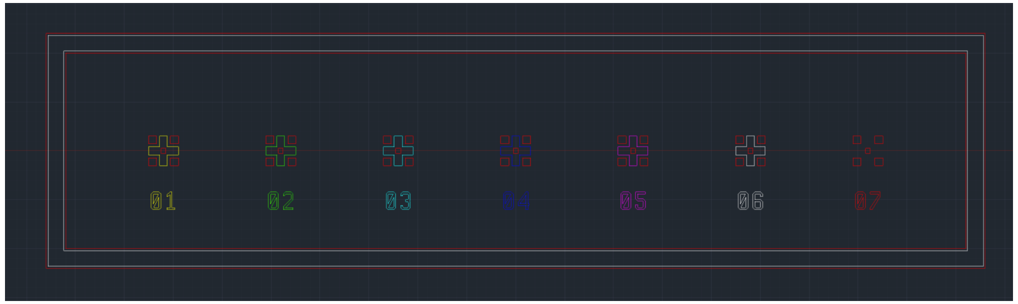


35-1. metal deposit [10000Å]
35-2. Alloy (420℃, 30min)

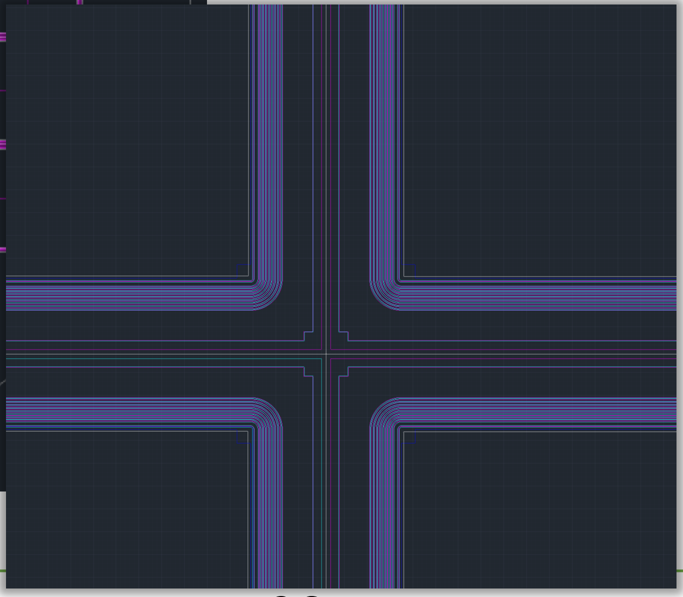
Photomask designed



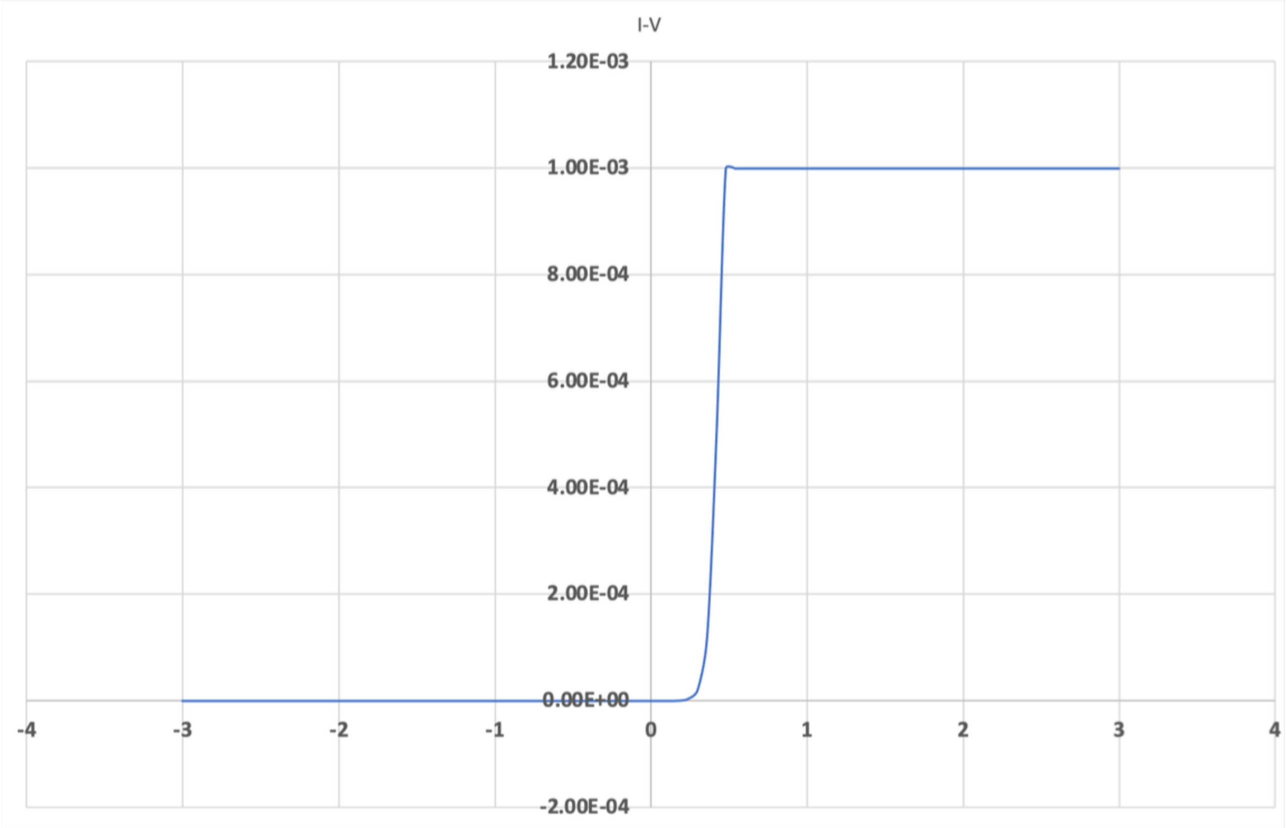
Photomask layout of 8″ wafer using AutoCAD tool

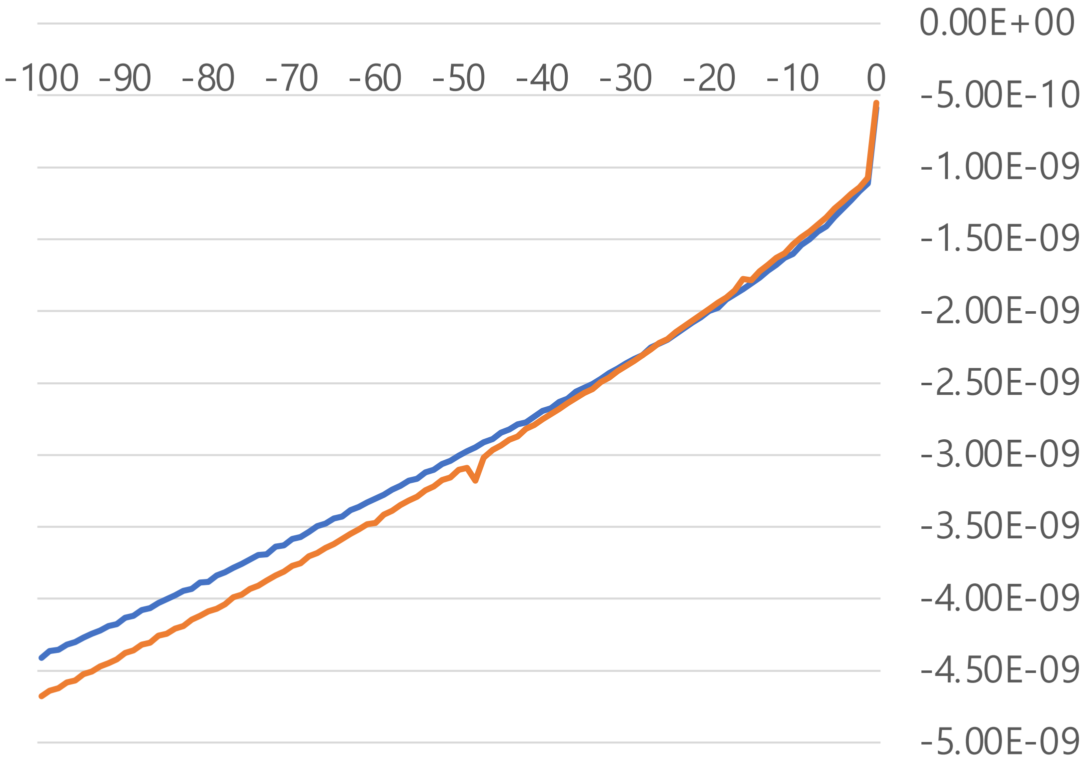


Align key for NNFC

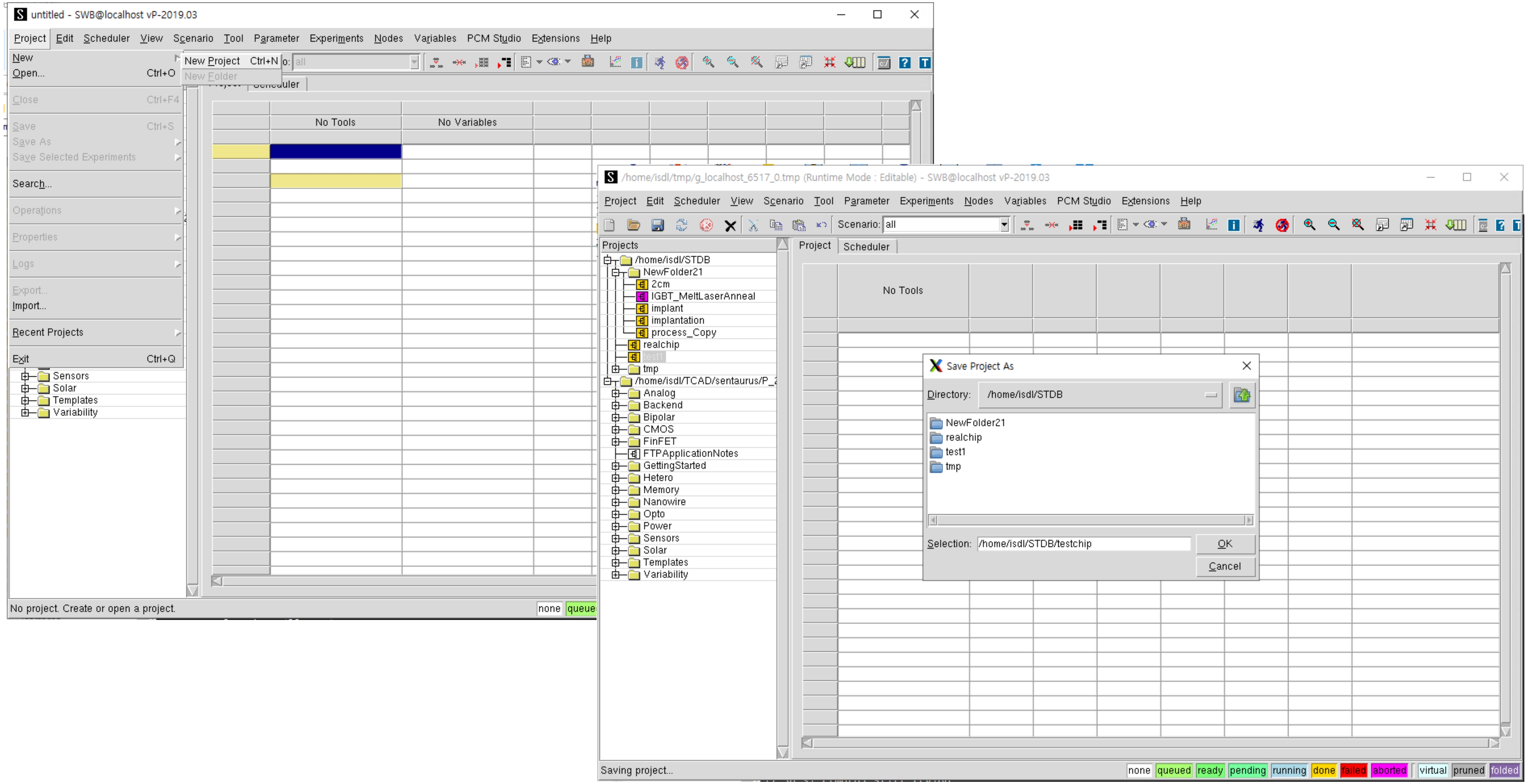


Performance of fabricated chip



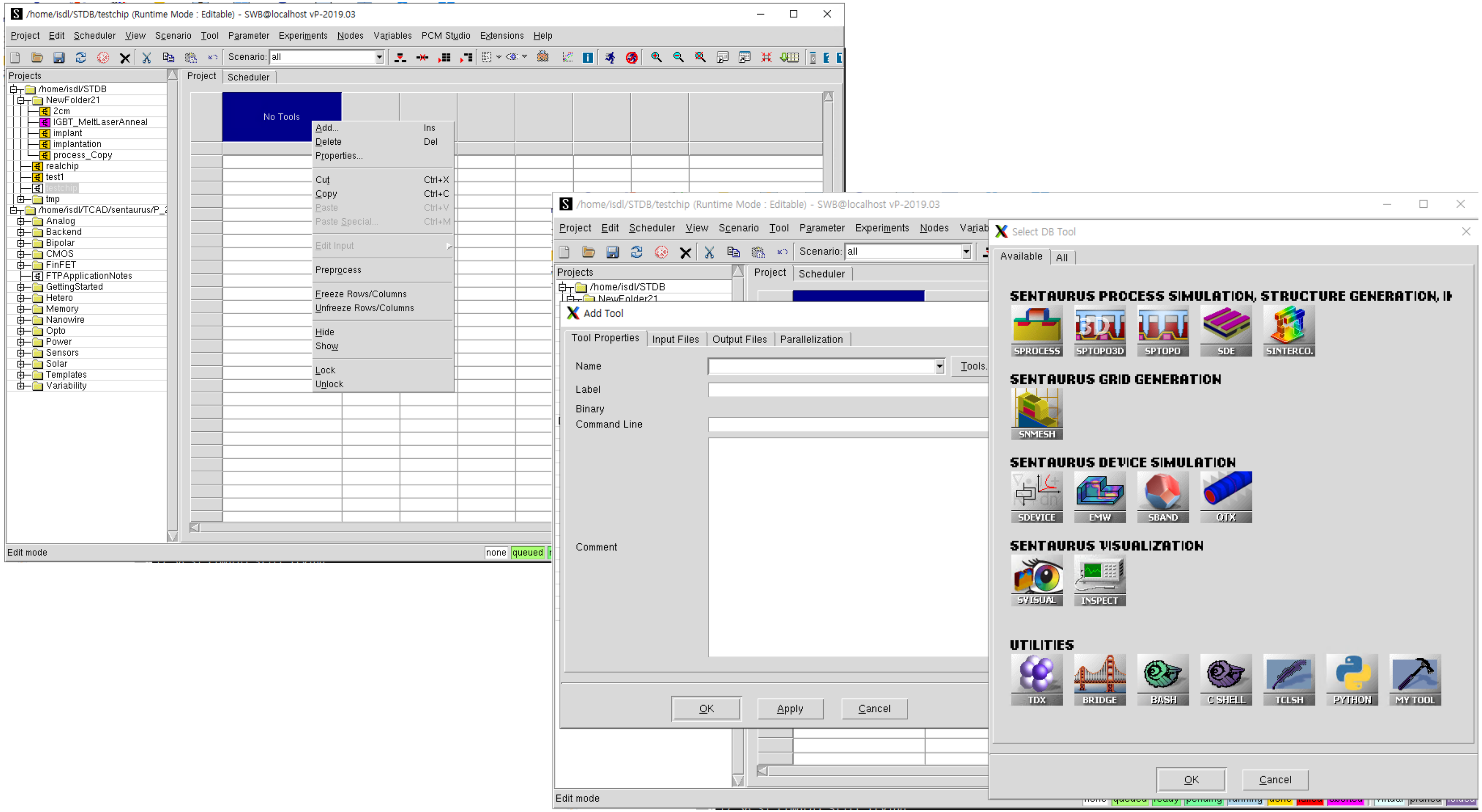


Hands on session

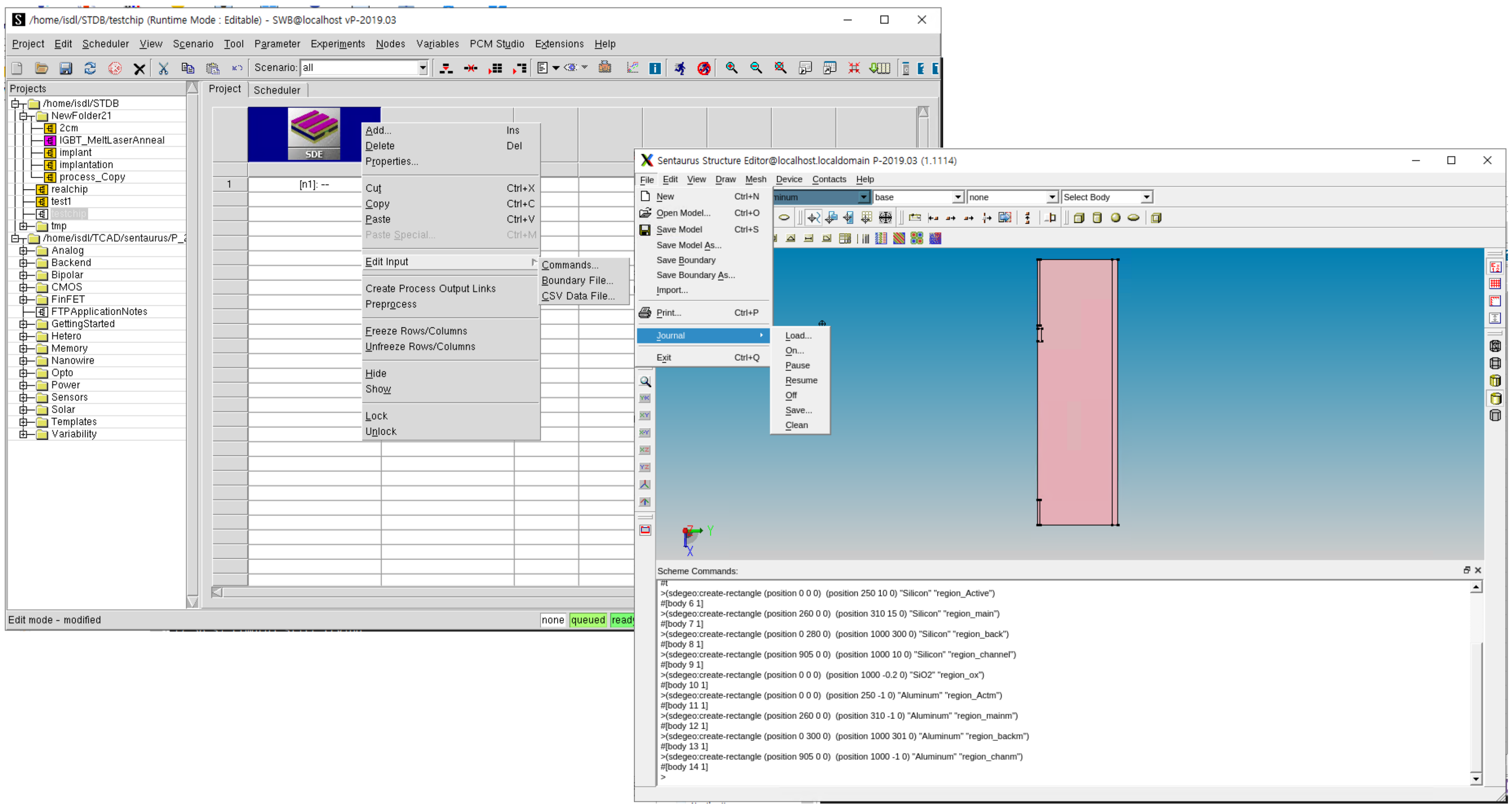


swb -> new project

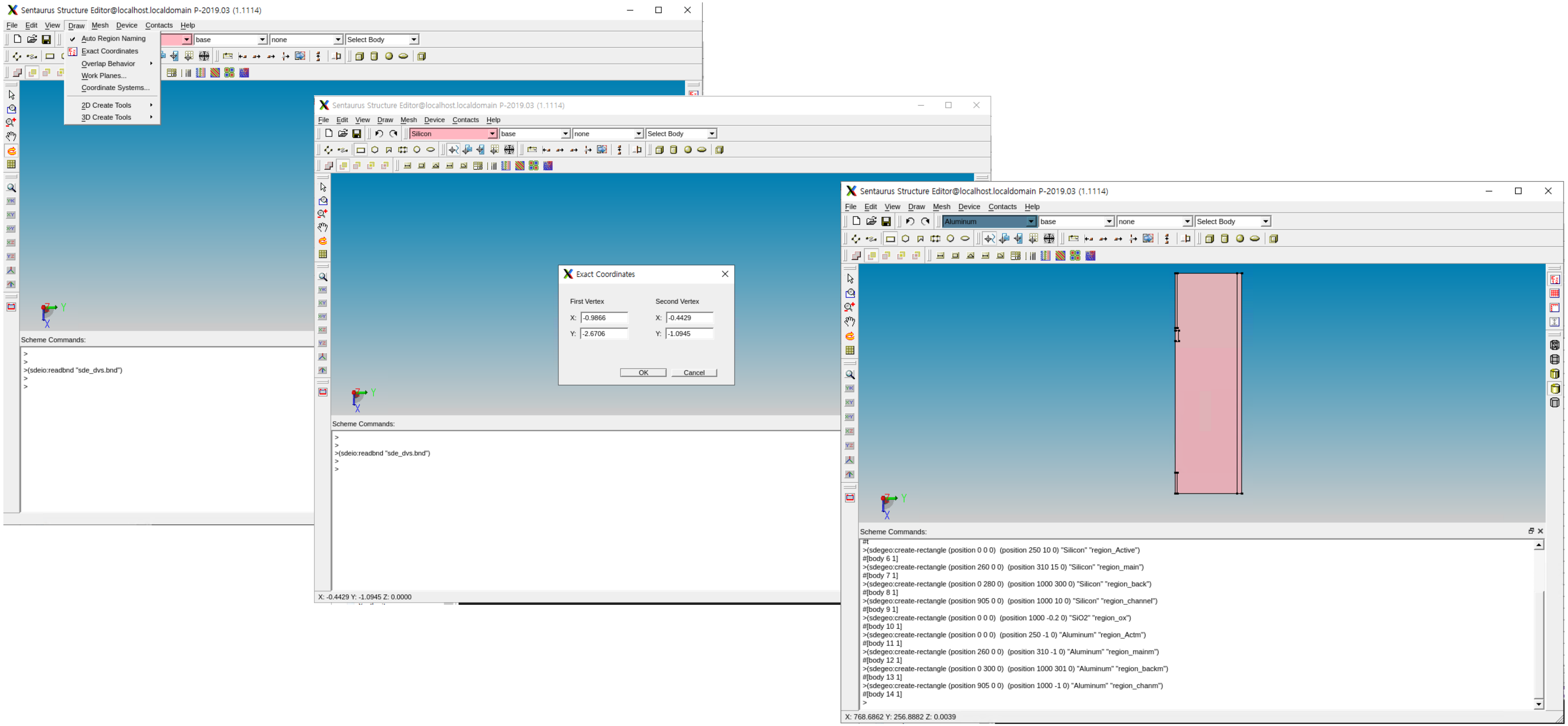
->Save (경로 STDB)



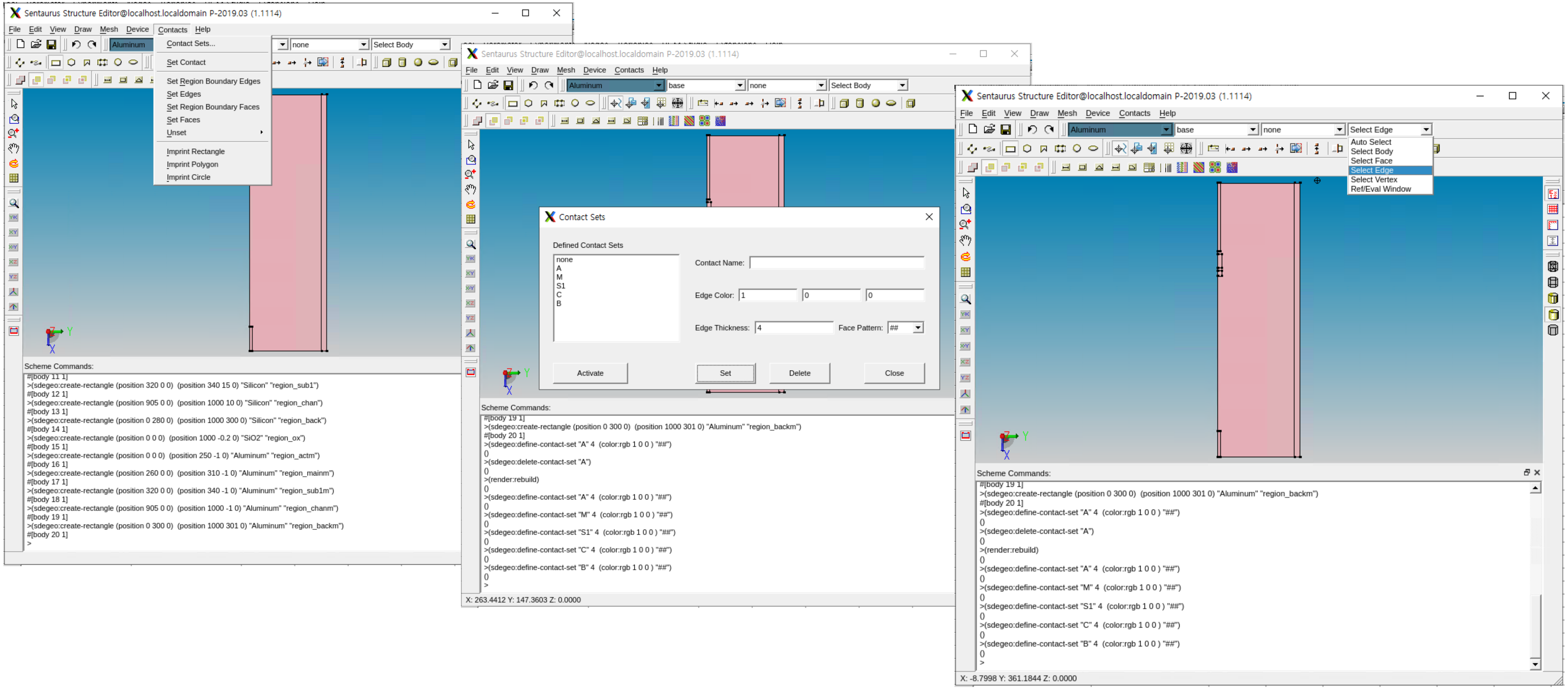
Tools -> Add -> SDE



Boundary File 클릭 -> SDE 창이 뜨면 file -> Journal -> on 클릭(기록용)

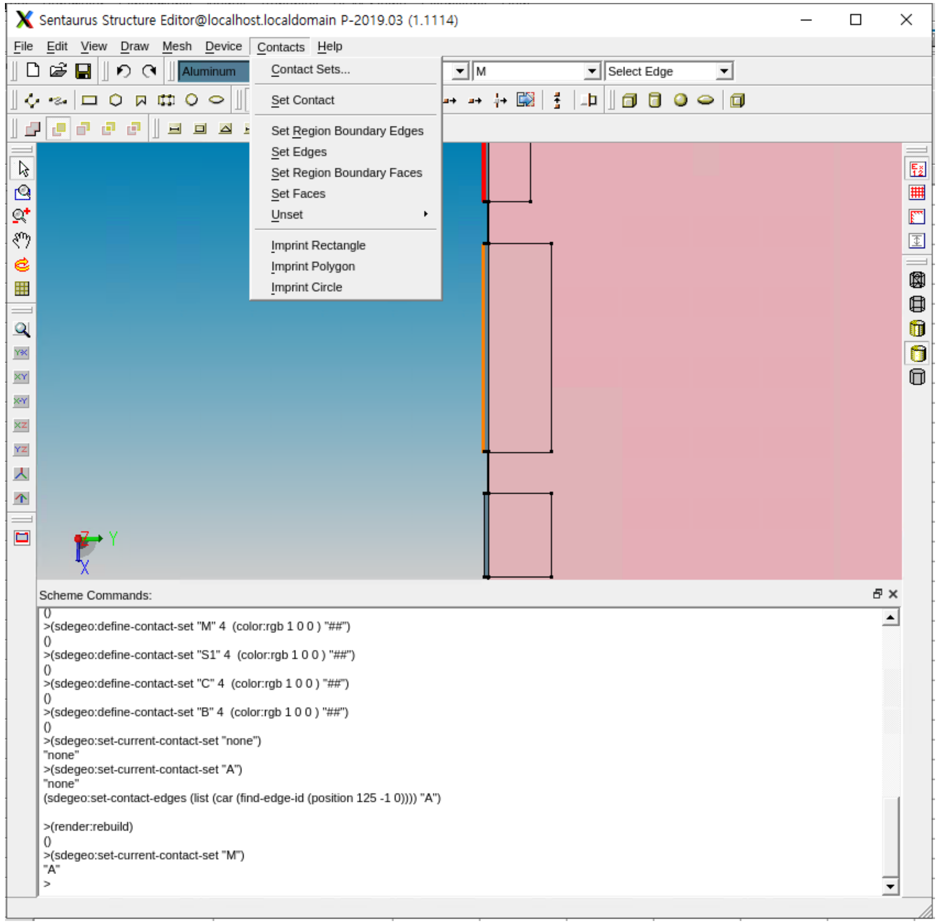


Draw -> exact coordinate -> 사각형 클릭, 단위는 um, silicon, aluminum등 선택

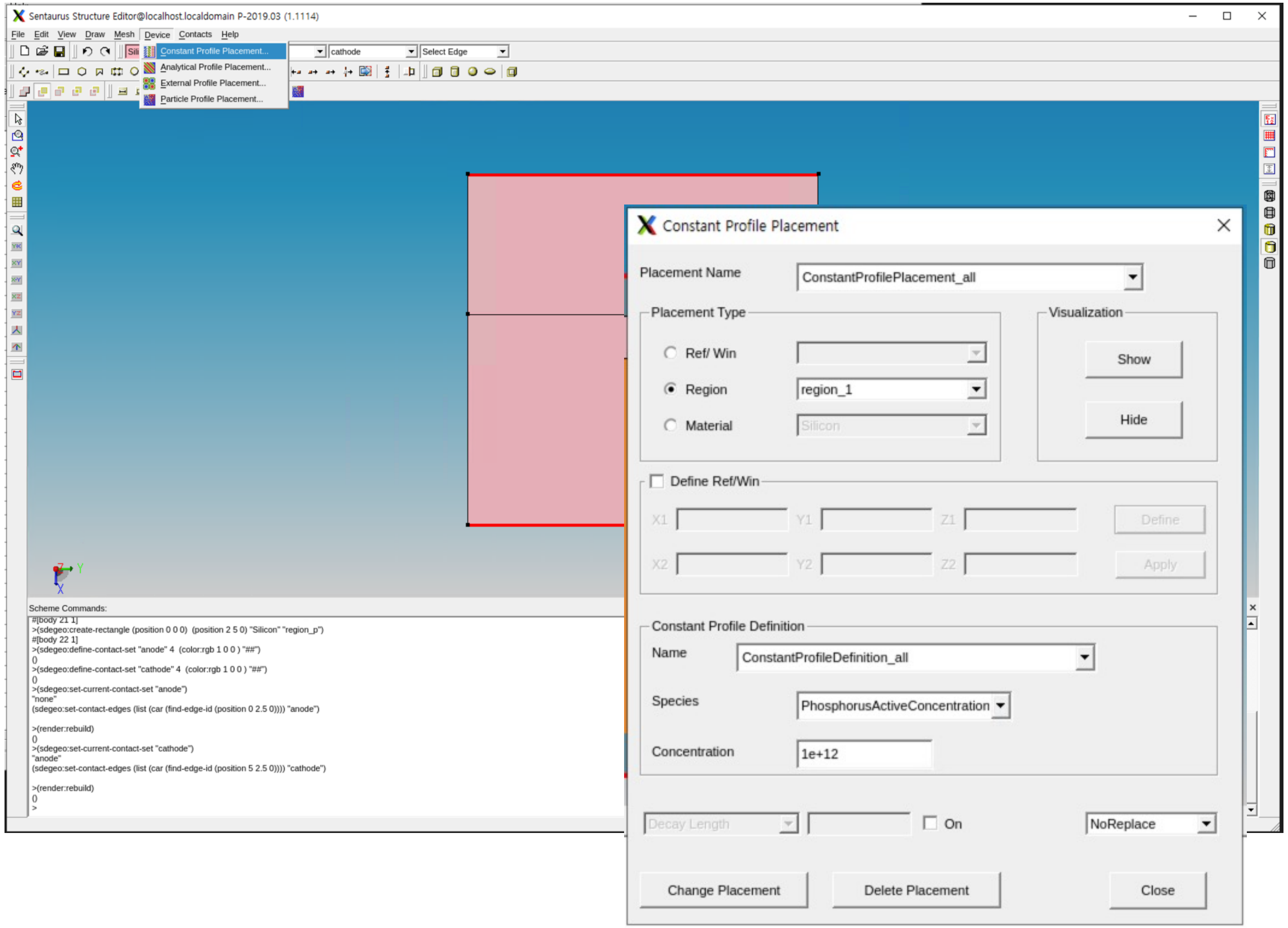


Contacts -> contact Sets -> electrode 만들기

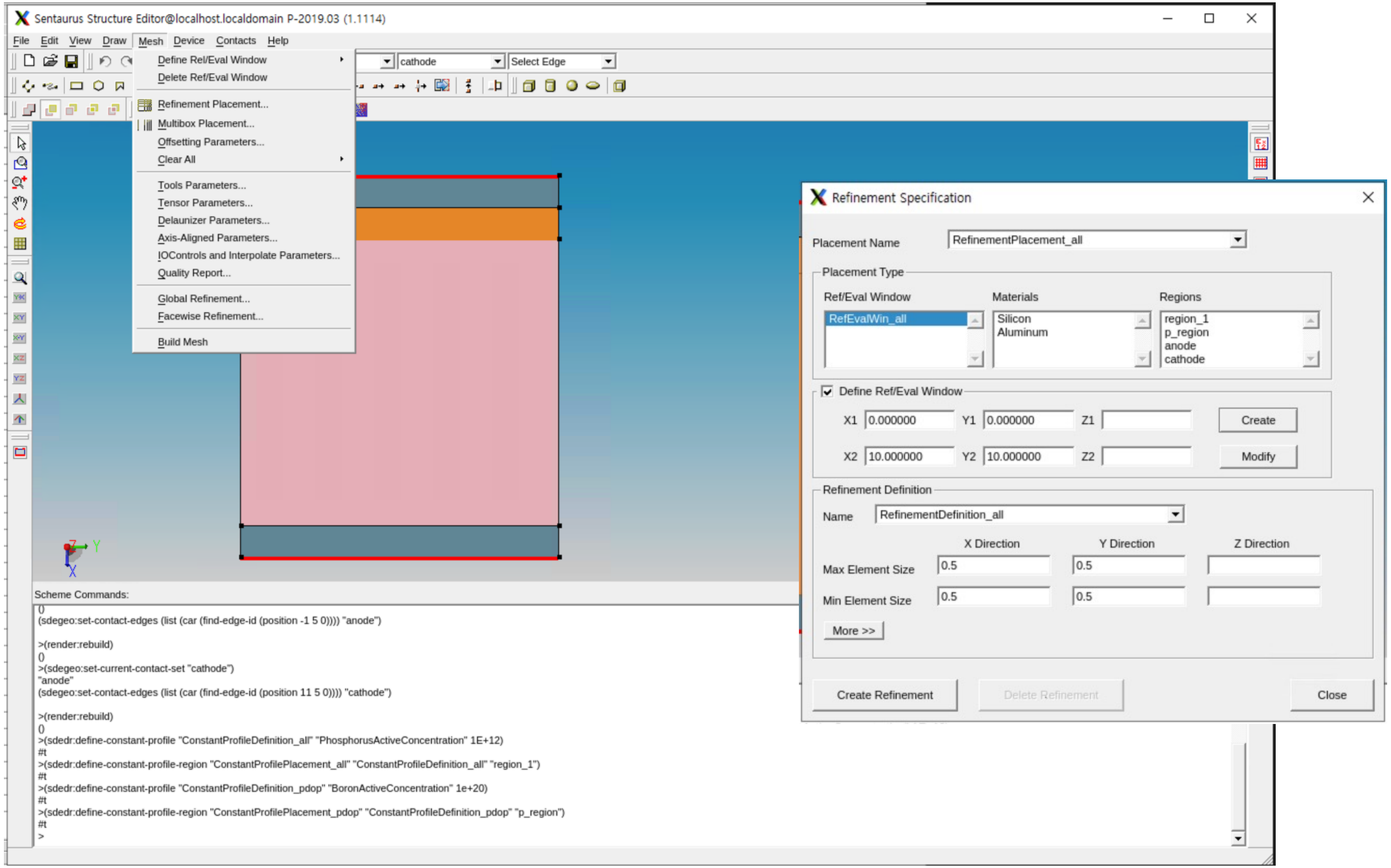
-> select body에서 select edge로 바꾸고 none부분을 지정하고자 하는 이름으로 변경



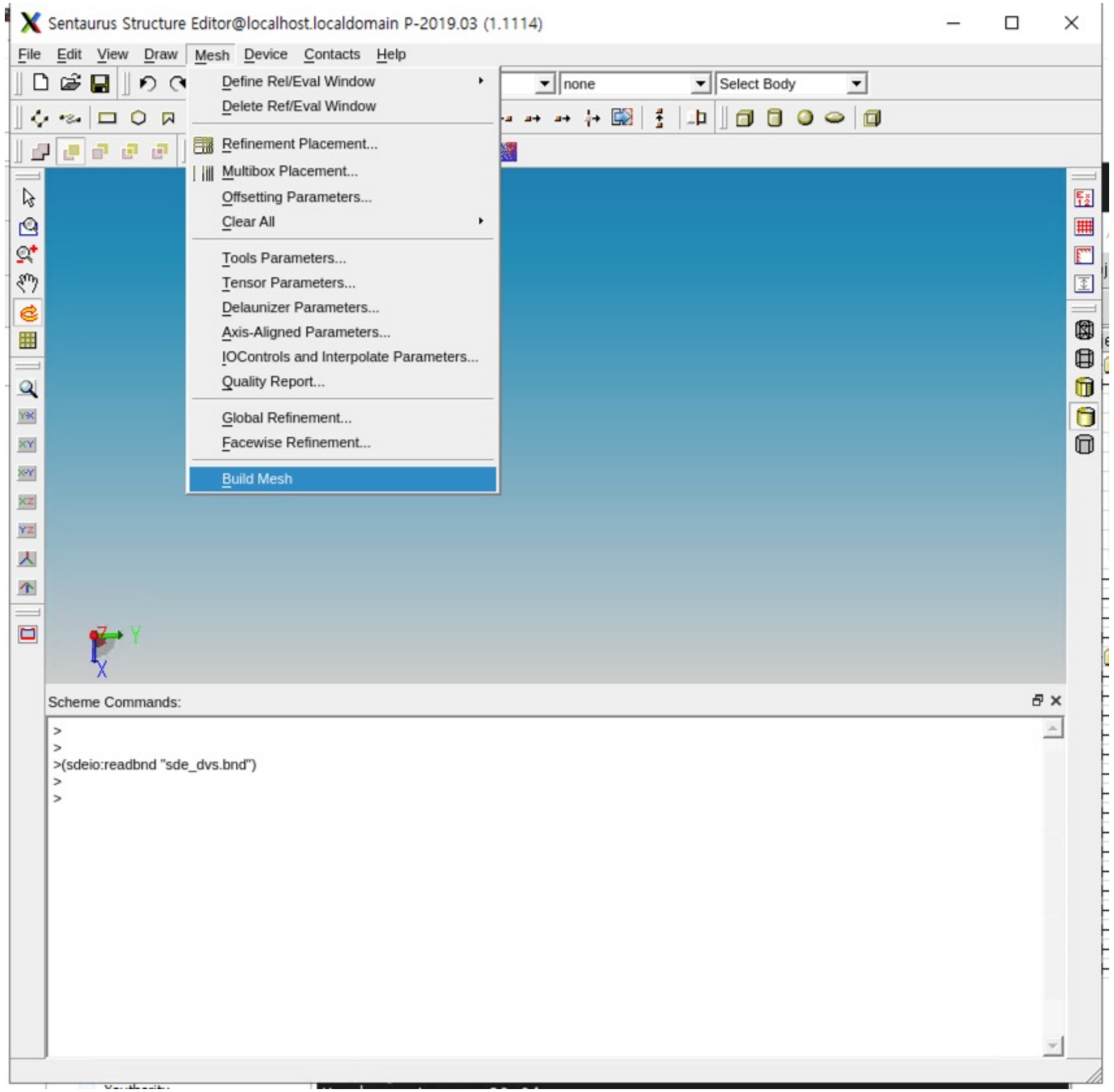
Electrode 라인 클릭 후 Set contact 클릭

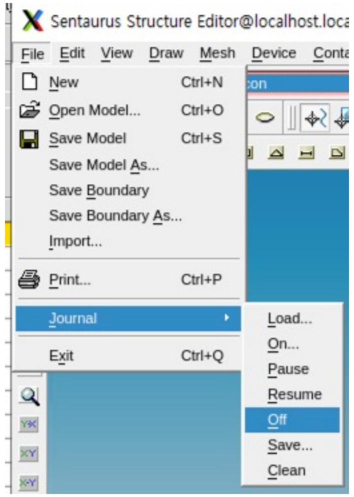


Doping concentration 정하기


Sentaurus Structure Editor@localhost.localdomain P-2019.03 (1.1114)
File Edit View Draw Mesh Device Contacts Help
Define Ref/Eval Window
Delete Ref/Eval Window
Refinement Placement...
Multibox Placement...
Offsetting Parameters...
Clear All
Tools Parameters...
Tensor Parameters...
Delaunizer Parameters...
Axis-Aligned Parameters...
IOControls and Interpolate Parameters...
Quality Report...
Global Refinement...
Facewise Refinement...
Build Mesh
cathode
Select Edge
Refinement Specification
Placement Name
RefinementPlacement_all
Placement Type
Ref/Eval Window
Materials
Regions
RefEvalWin_all
Silicon
Aluminum
region_1
p_region
anode
cathode
Define Ref/Eval Window
X1 0.000000 Y1 0.000000 Z1
X2 10.000000 Y2 10.000000 Z2
Create
Modify
Refinement Definition
Name RefinementDefinition_all
X Direction Y Direction Z Direction
Max Element Size 0.5 0.5
Min Element Size 0.5 0.5
More >>
Create Refinement
Delete Refinement
Close
Scheme Commands:
(sdegeo:set-contact-edges (list (car (find-edge-id (position -1 5 0)))) "anode")
>(render:rebuild)
>(sdegeo:set-current-contact-set "cathode")
"anode"
(sdegeo:set-contact-edges (list (car (find-edge-id (position 11 5 0)))) "cathode")
>(render:rebuild)
>(sdedr:define-constant-profile "ConstantProfileDefinition_all" "PhosphorusActiveConcentration" 1E+12)
>(sdedr:define-constant-profile-region "ConstantProfilePlacement_all" "ConstantProfileDefinition_all" "region_1")
>(sdedr:define-constant-profile "ConstantProfileDefinition_pdop" "BoronActiveConcentration" 1e+20)
>(sdedr:define-constant-profile-region "ConstantProfilePlacement_pdop" "ConstantProfileDefinition_pdop" "p_region")

Mesh 설정





완성된 구조 저장하기

Mesh -> Build Mesh

File -> Journal -> off

sdevice

jEdit - sdevice_des.cmd (변경함), detector_dvs.cmd, sdevice_des.cmd@localhost.localdomain

파일(F) 편집(E) 검색(S) 마커(M) 접기(o) 보기(V) 도구(U) 매크로(c) 플러그인(P) 도움말(H)

sdevice_des.cmd ($STDB/NewFolder21/test/)

```
#setdep @previous@

File {
 Grid     = "n@node|-1@_msh.tdr"
 Parameter = "@parameter@"
 Plot     = "@tdrdat@"
 Current  = "@plot@"
 Output   = "@log@"
}



Electrode {

 { Name="anode"   Voltage=0 }
 { Name="cathode"    Voltage=0 }

}

Physics{
 Temperature= 300
 EffectiveIntrinsicDensity( OldSlotboom )
}


Physics{
 Fermi
 Mobility(
 PhuMob
 HighFieldSaturation
  )
 Recombination(
  SRH(Tempdepencence ElectricField)
  Avalanche
 )
}


Plot{
 eDensity hDensity
 TotalCurrent/Vector eCurrent/Vector hCurrent/Vector
 eMobility hMobility
 eVelocity hVelocity
 eQuasiFermi hQuasiFermi
 eTemperature Temperature * hTemperature
 ElectricField/Vector ElectricField
 Potential SpaceCharge
 Doping DonorConcentration AcceptorConcentration
 SRH Band2Band * Auger
 AvalancheGeneration eAvalancheGeneration hAvalancheGeneration
 eGradQuasiFermi/Vector hGradQuasiFermi/Vector
 eEparallel hEparallel eENormal hENormal
 BandGap
 eSRHrecombination
 hSRHrecombination
 tSRHrecombination
 BandGapNarrowing
 eQuasiFermiEnergy hQuasiFermiEnergy
 Affinity
 ConductionBand ValenceBand
 eBarrierTunneling hBarrierTunneling * BarrierTunneling
 eTrappedCharge  hTrappedCharge
 eGapStatesRecombination hGapStatesRecombination
 eDirectTunnel hDirectTunnel
 Band2BandGeneration
 eBand2BandGeneration
```

1,19 (18/2287)