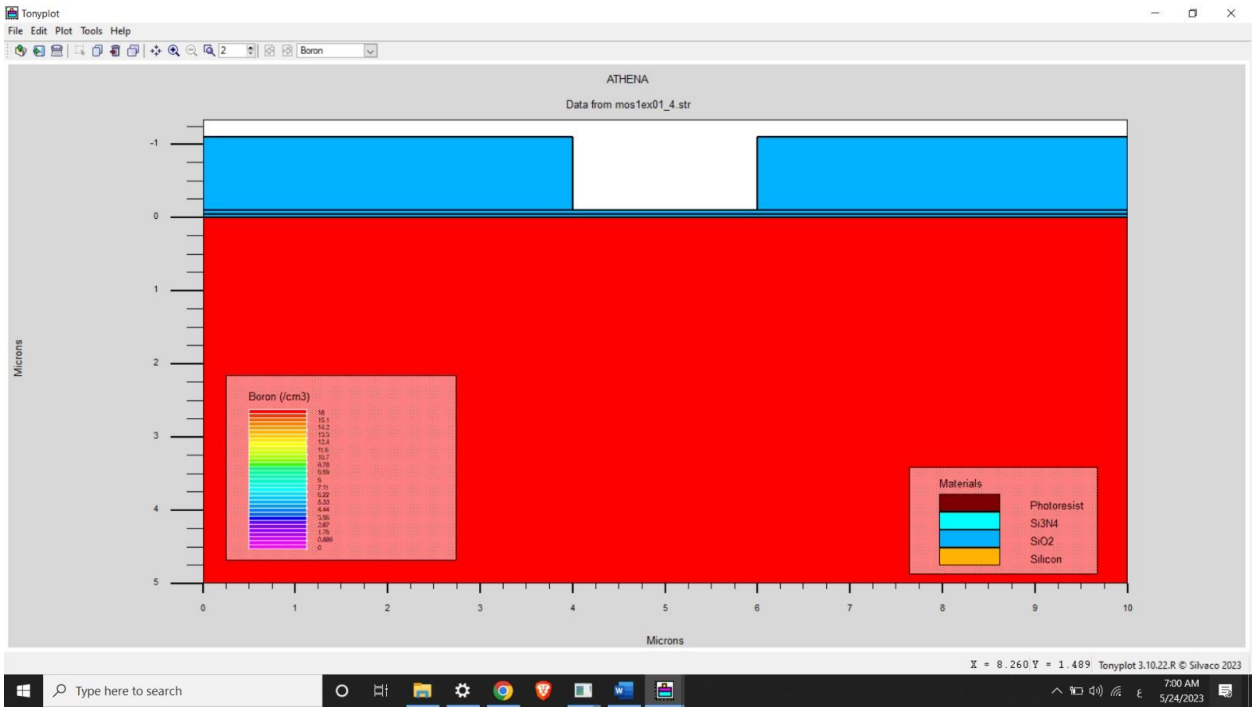
Section I: Mesh:

```
# Meshing lines
line x loc=0 spac =0.5
line x loc =2 spac =0.5
line x loc =4 spac =0.5
line x loc =6 spac =0.5
line x loc =8 spac =0.5
line x loc =10 spac =0.5

# Meshing lines
line y loc = 0 spac = 0.5
line y loc = 2 spac = 0.5
line y loc = 3 spac = 0.5
line y loc = 4 spac = 0.5
line y loc = 5 spac = 1
```

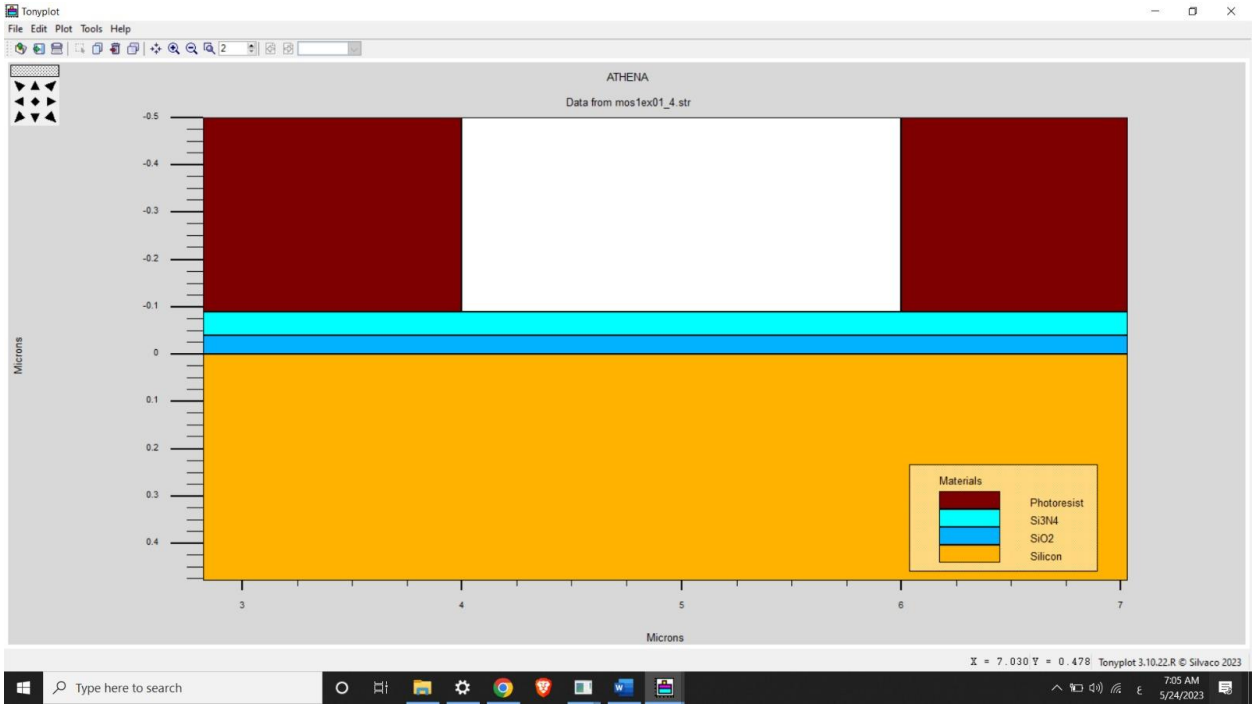
Section II: Choose substrate:

```
# Initialization
init orientation=100 c.boron=10e15 space.mul=2
structure outfile=mos1ex00_0.str
```



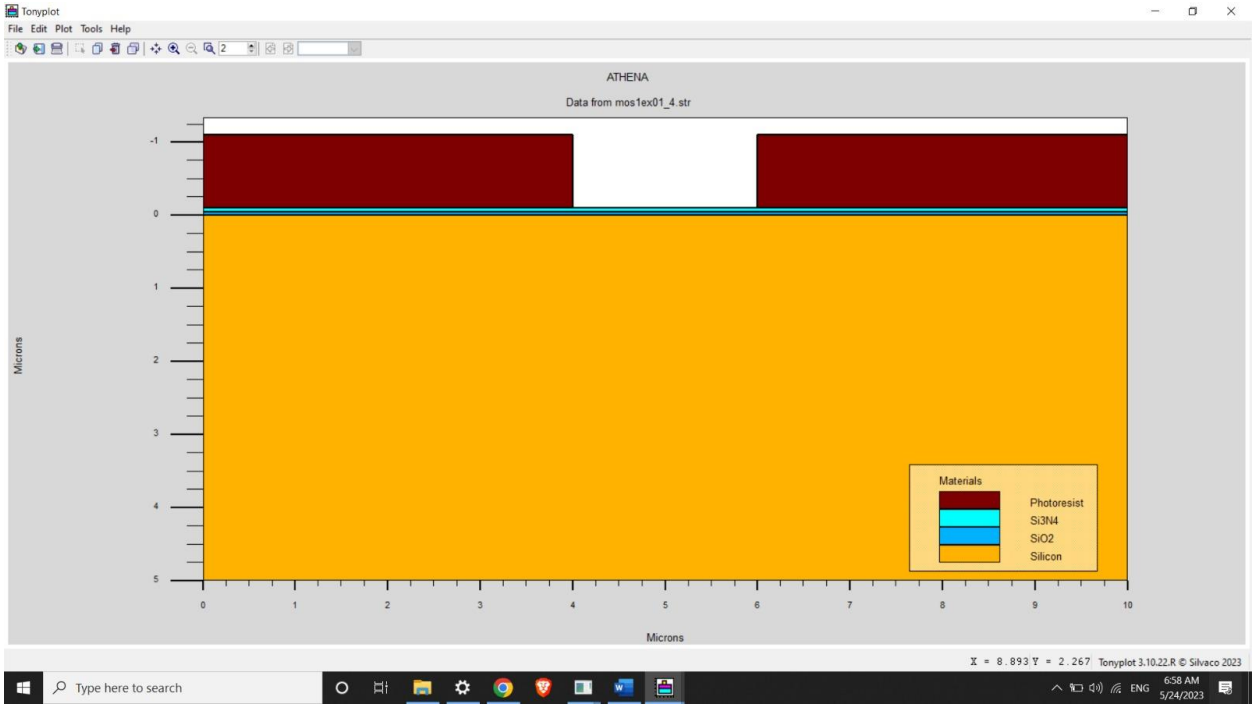
Section III: Oxide layer:

```
# Oxide layer
deposit oxide thickness=0.04
structure outfile=mos1ex01_0.str
```



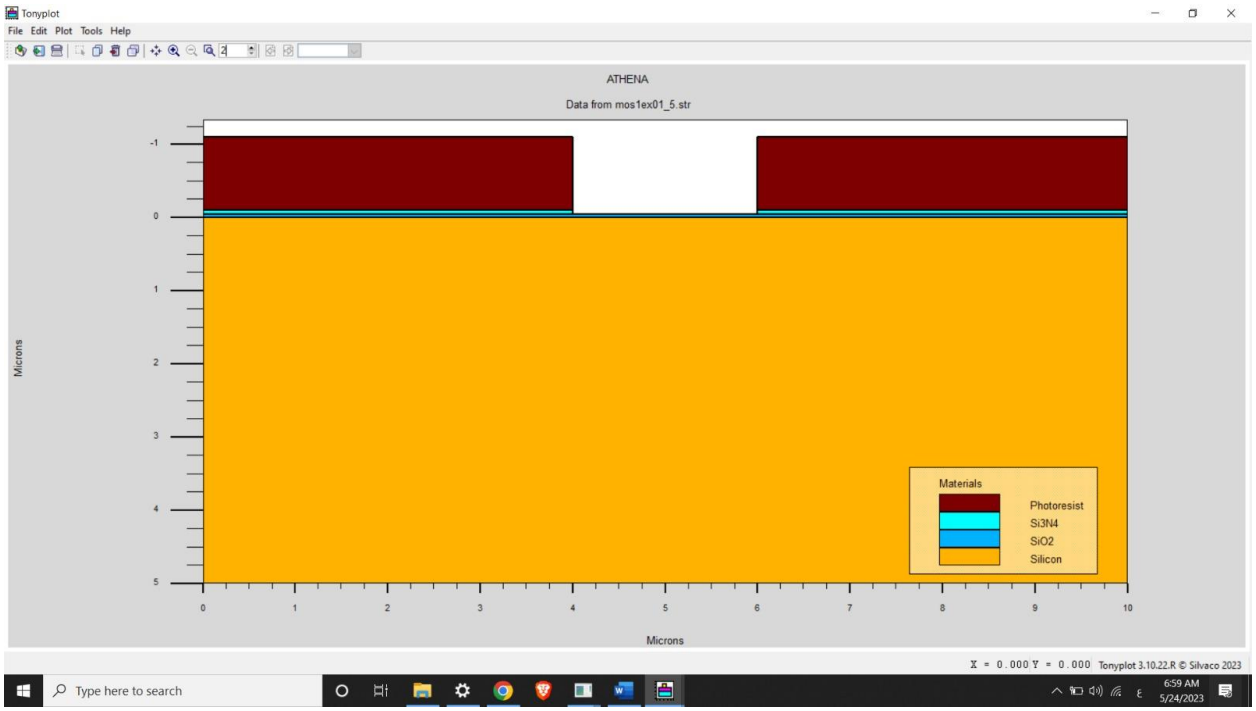
Section IV: LPCVD Silicon Nitride :

#nitride layer
deposit nitride thickness =0.05
structure outfile=mos1ex02_0.str
#photoresist layer
deposit photoresist thickness=1
structure outfile=mos1ex01_3.str
#etch layer in photoresist
etch photoresist start x=4 y = 0.09
etch continue x=6 y = 0.09
etch continue x=6 y = -1.09
etch done x=4 y = -1.09
structure outfile=mos1ex01_4.str

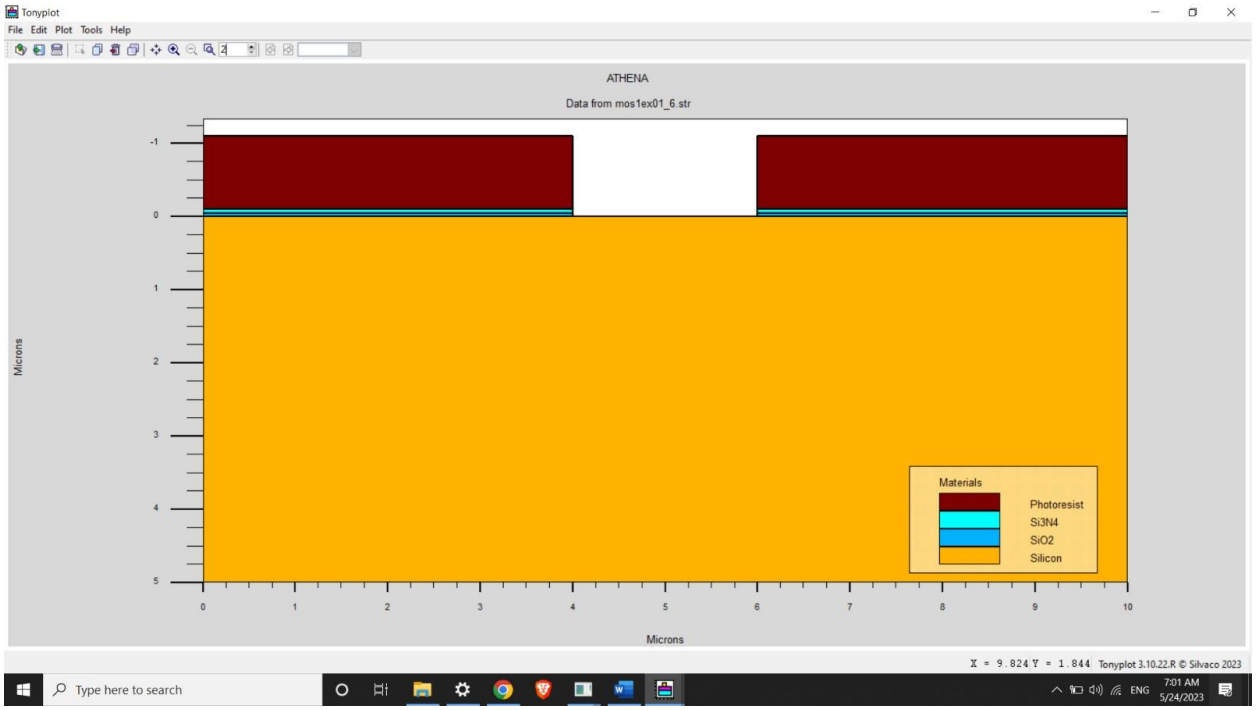


etch nitride

etch nitride start x=4 y=-0.04
etch continue x=6 y = -0.09
etch continue x=6 y = -0.04
etch done x=4 y = -0.09
structure outfile=mos1ex01_5.str

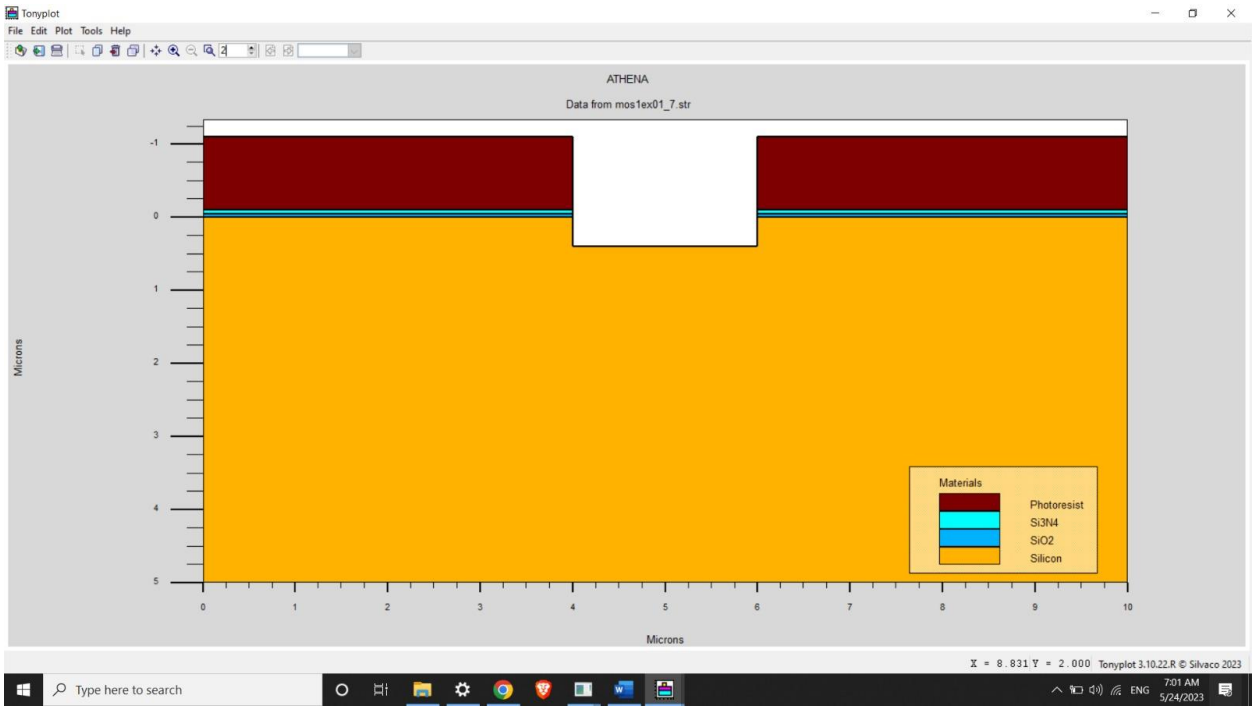


#etch oxide
etch oxide start x=4 y=0
etch continue x=6 y = 0
etch continue x=6 y = -0.04
etch done x=4 y = -0.04
structure outfile=mos1ex01_6.str



Section V: Shallow trench isolation formation (STI):

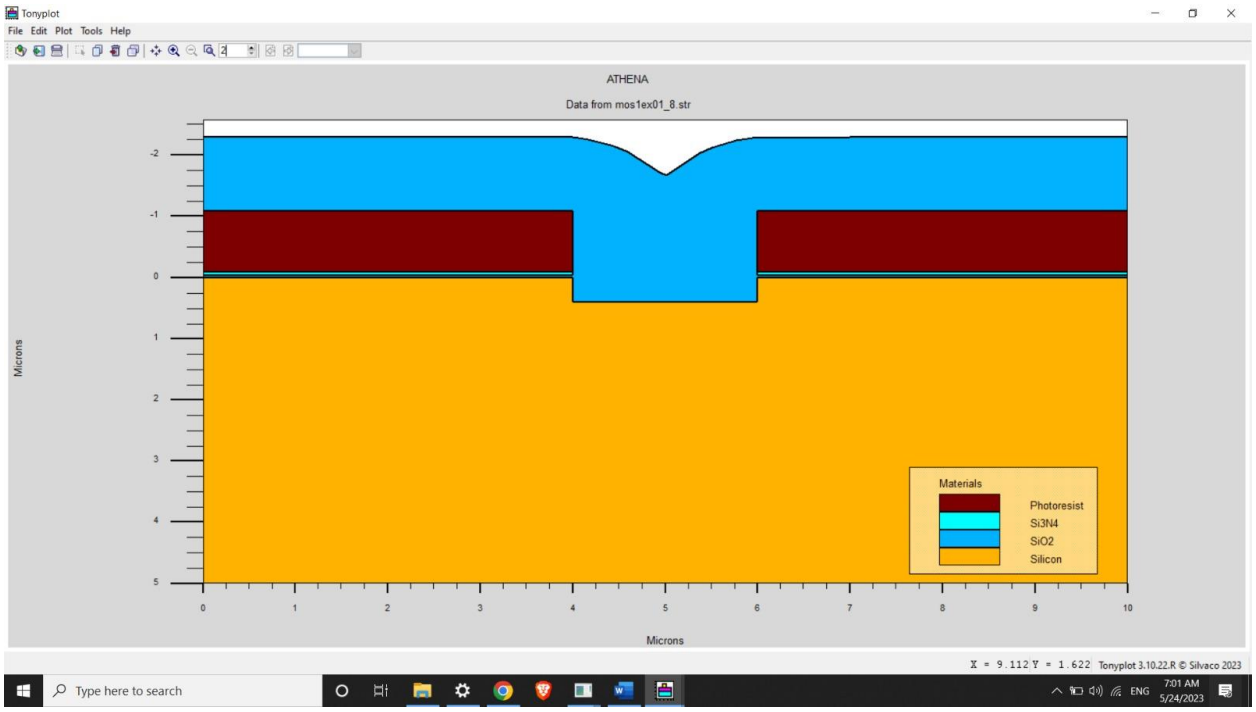
#form trench
etch silicon start x=4 y = 0
etch continue x=6 y = 0
etch continue x=6 y = 0.4
etch done x=4 y =0.4
structure outfile=mos1ex01_7.str



#oxide deposit

deposit oxide thickness=1.2

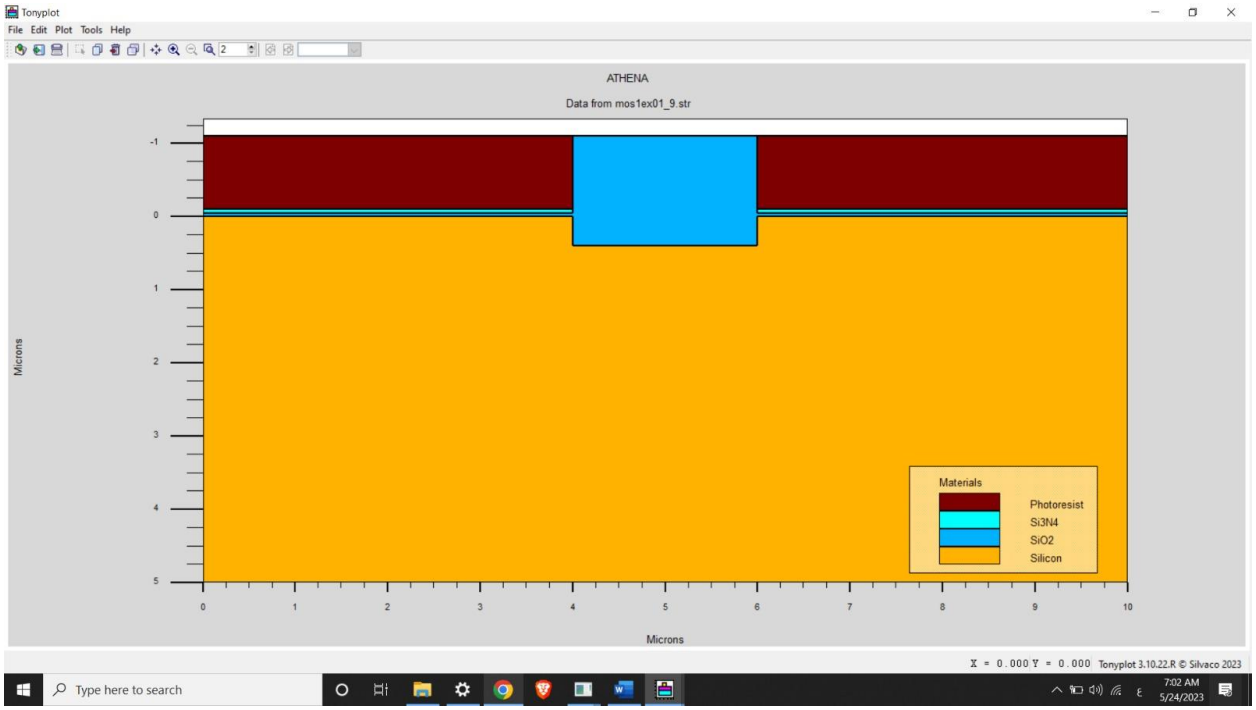
structure outfile=mos1ex01_8.str



#oxide polishing

etch oxide start x=0 y=-1.09

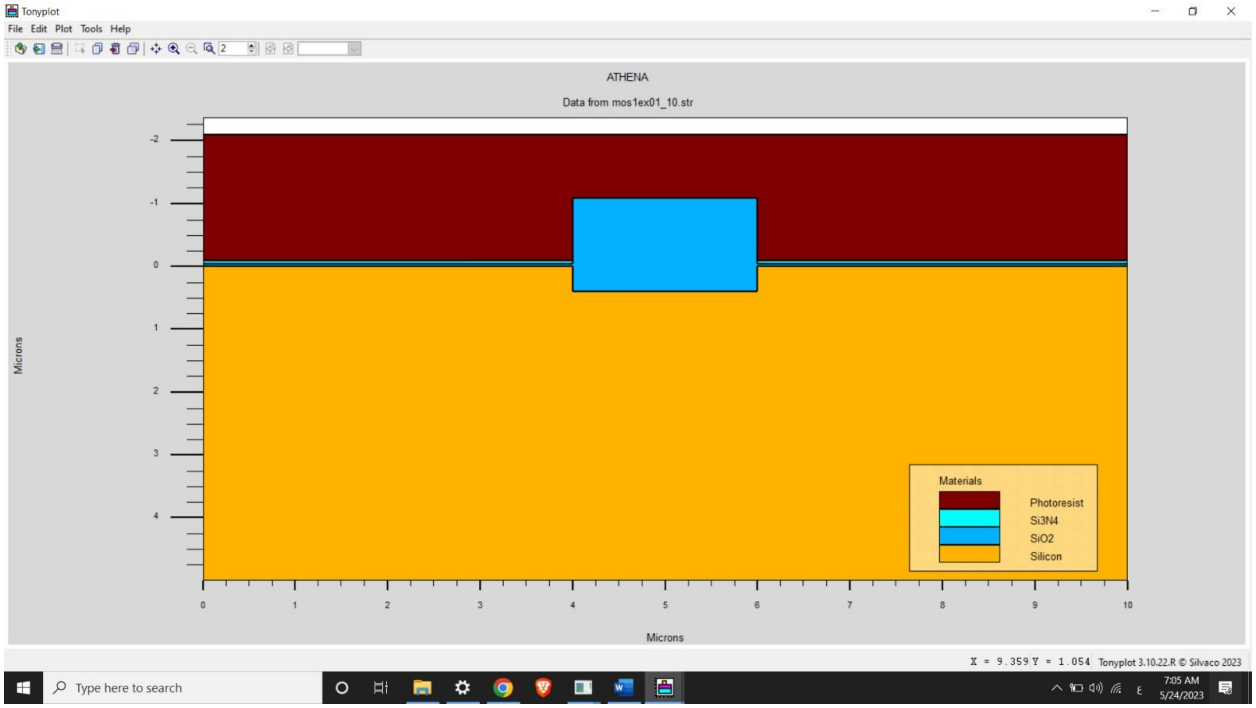
etch continue x=10 y =-1.09
etch continue x=10 y = -2.6
etch done x=4 y = -2.6
structure outfile=mos1ex01_9.str



Section VI: N well Formation:

#apply photoresist for n-well formation

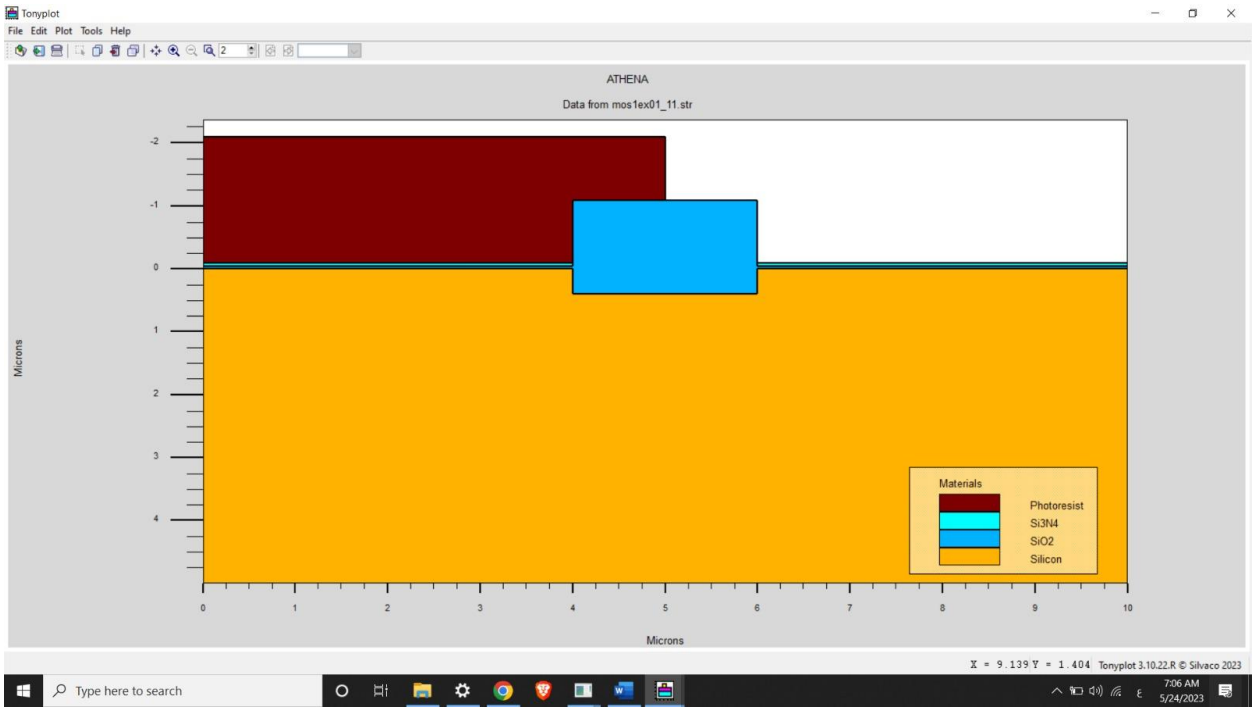
deposit photoresist thickness=1
structure outfile=mos1ex01_10.str



#etch part

etch photoresist right p1.x=5

structure outfile=mos1ex01_11.str



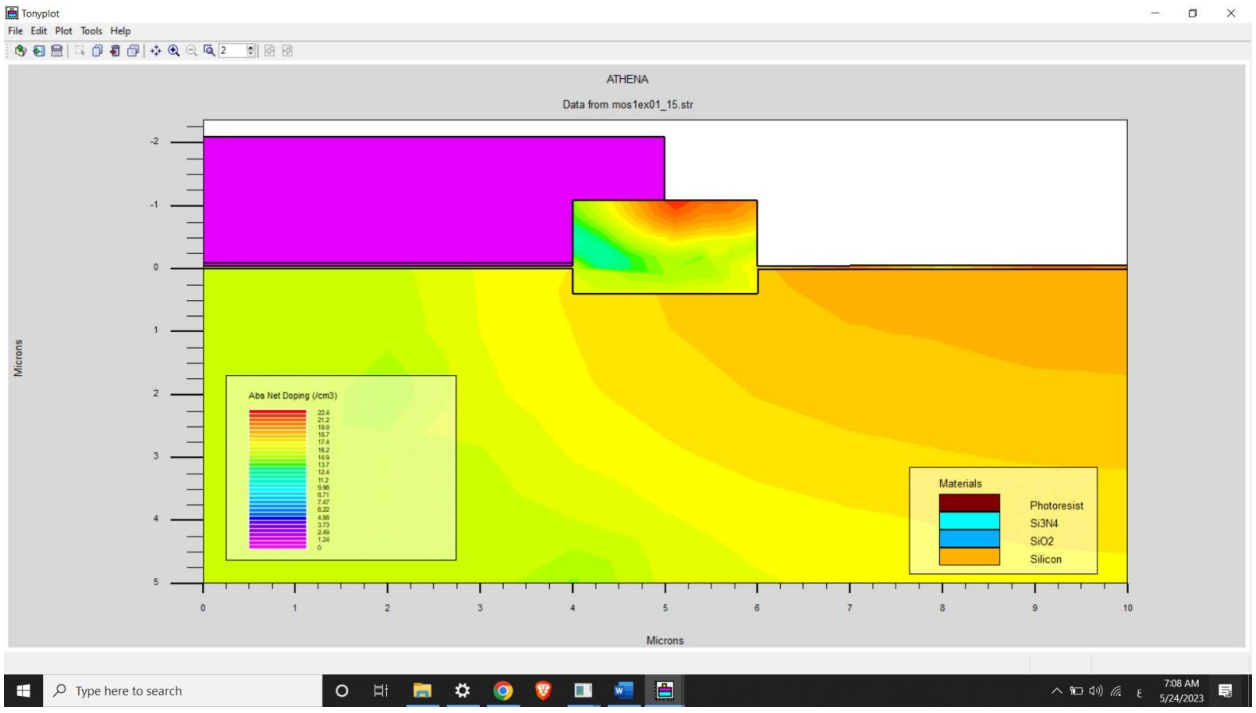
#etch nitride

etch nitride right p1.x=6

structure outfile=mos1ex01_12.str

#anneling
anneal

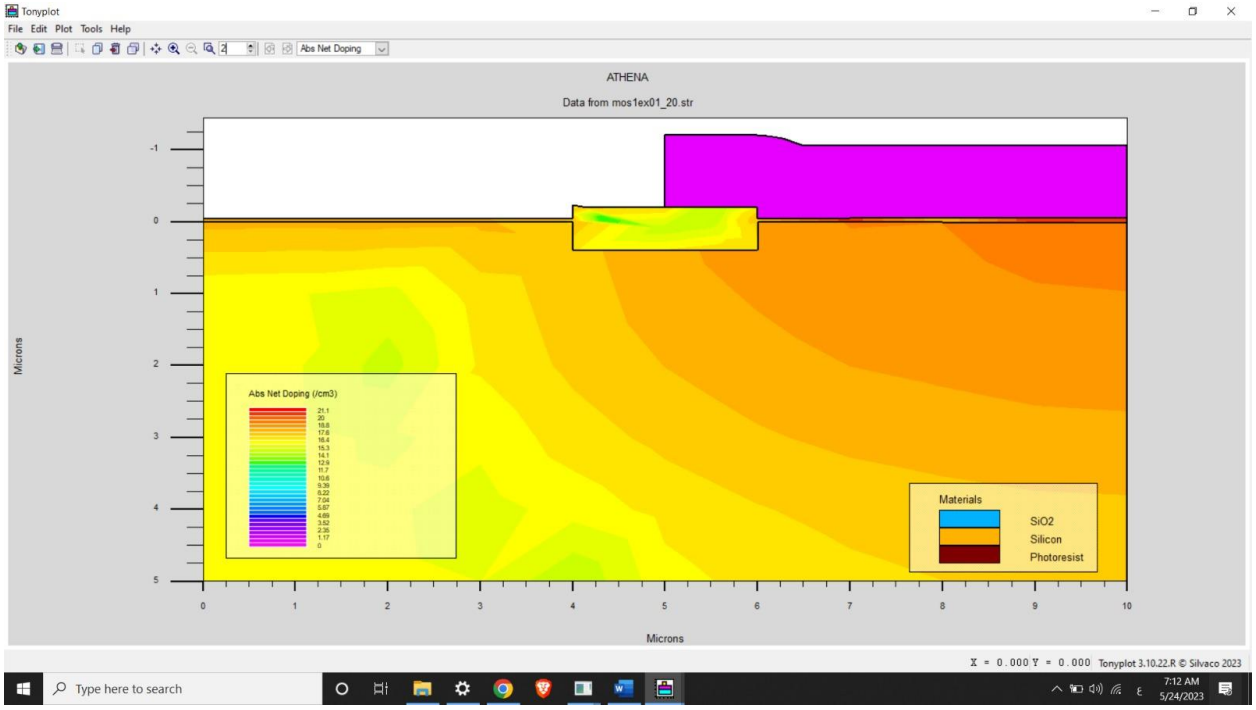
#n-well formation
IMPLANT phosph DOSE=1E16 ENERGY=350e3
ADAPT.PAR DIFF.LEN=0.1 SILICON I.BORON
DIFFUSE TEMP=1000 TIME=240 NITROGEN
structure outfile=mos1ex01_13.str
diffus time=50 temp=1000 t.rate=4.000 dryo2 press=0.10 hcl=3
diffus time=220 temp=1200 nitro press=1
diffus time=90 temp=1200 t.rate=-4.444 nitro press=1
structure outfile=mos1ex01_14.str



Section VII: Threshold (turning on) voltage:

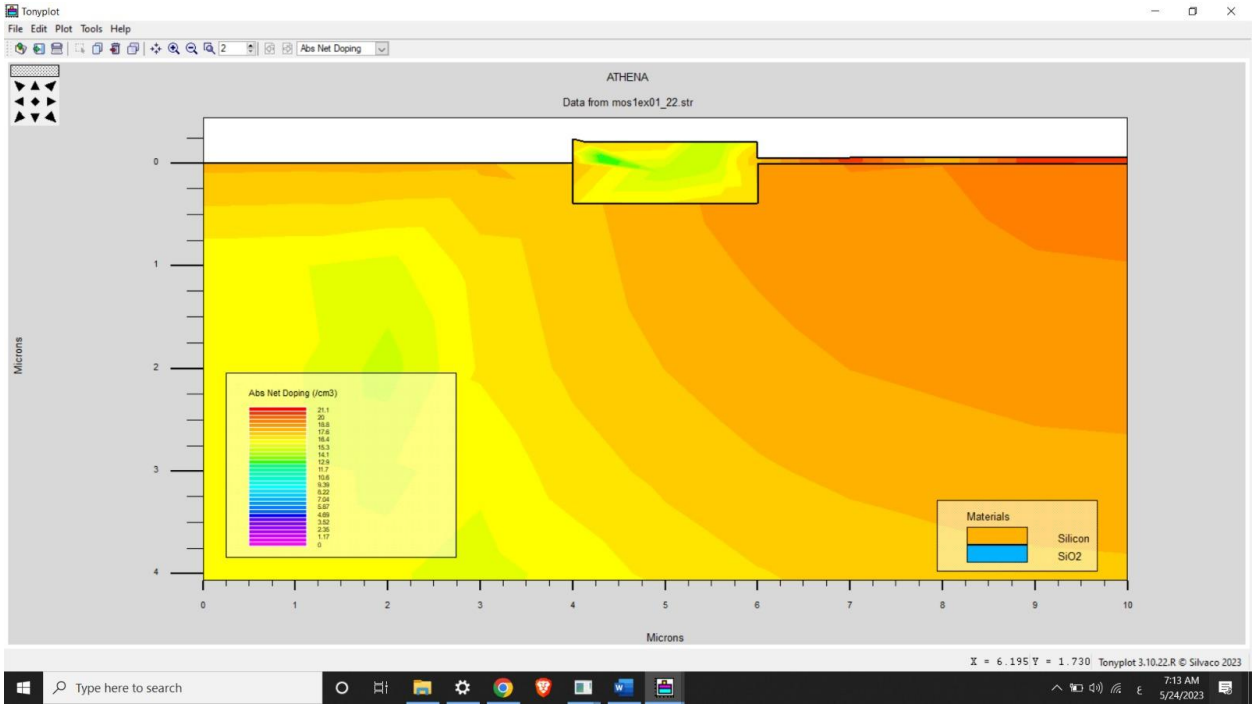
#vth adjustment nmos
implant boron energy =10 dose =5.0e12 pearson

structure outfile=mos1ex01_20.str



#etch
etch photoresist right p1.x=5
structure outfile=mos1ex01_21.str
#etch left oxide
etch oxide left p1.x=4
structure outfile=mos1ex01_22.str

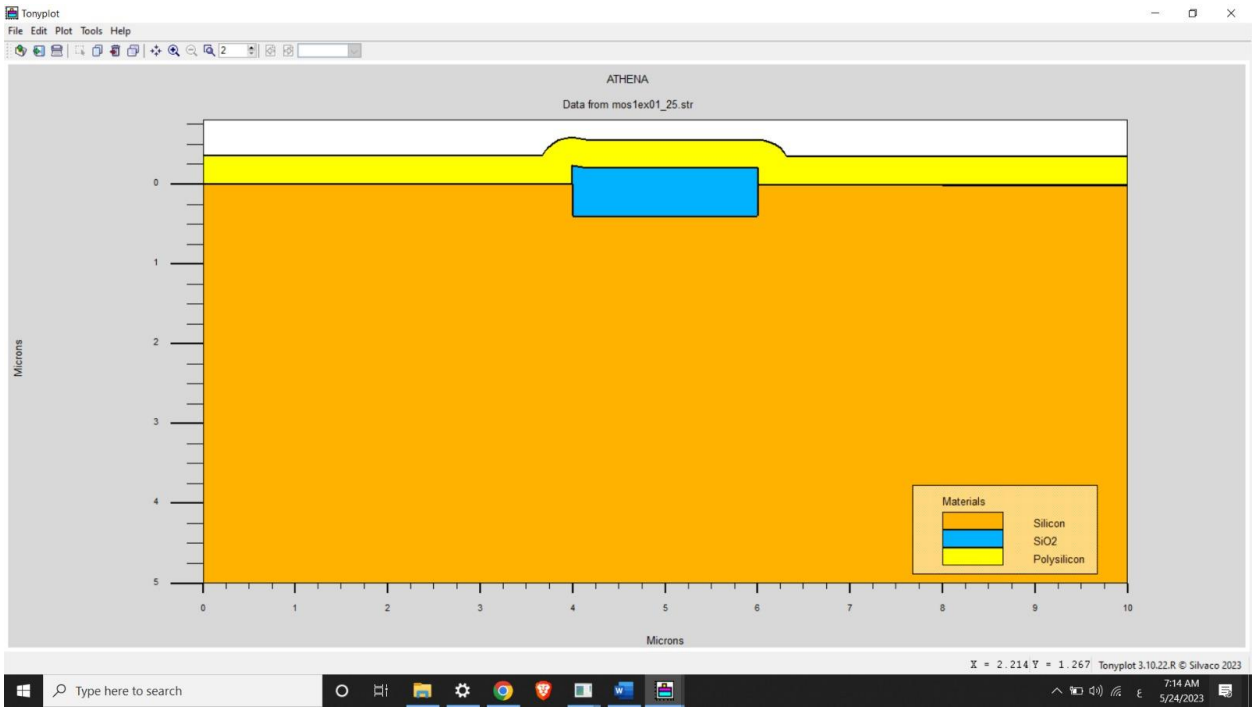
#etch right oxide
etch oxide right p1.x=6
structure outfile=mos1ex01_23.str



Section VII: Gate oxide forming:

```
# The growing of high-quality oxide in dry oxygen
deposit oxide thickness =5.7e-3
diffus time = 10 temp = 900 dryO2 press=1.00
structure outfile=mos1ex01_24.str
# Poly deposition
depo poly thick=350e-3 divi=10
```

structure outfile=mos1ex01_25.str



Gate patterning

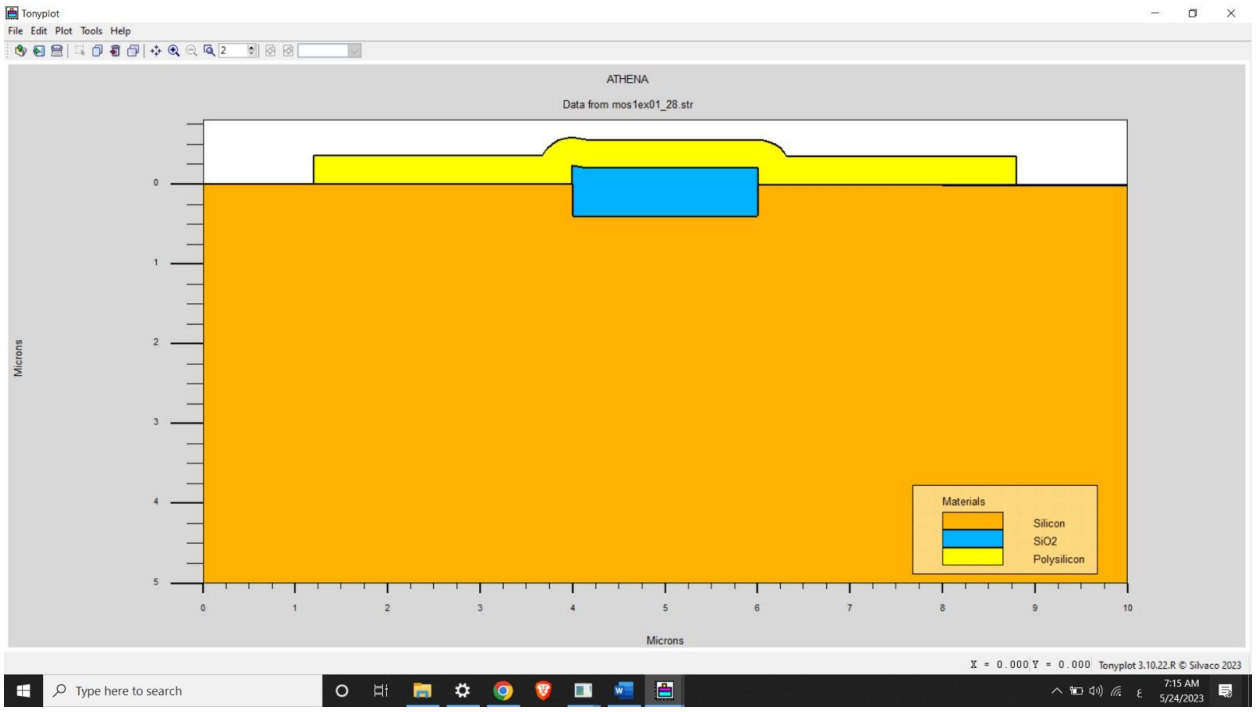
etch poly left p1.x=1.2

structure outfile=mos1ex01_27.str

#etch2

etch poly right p1.x=8.8

structure outfile=mos1ex01_28.str



#etch 3

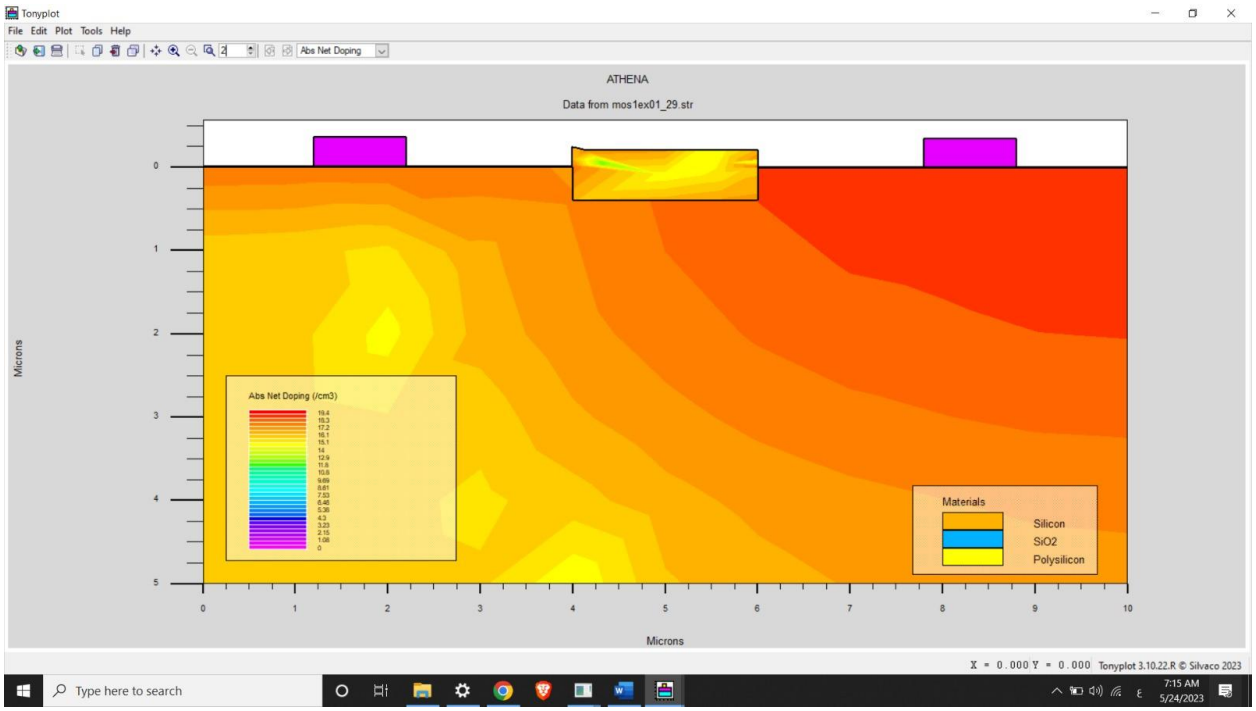
etch poly start x=2.2 y=0.2

etch continue x=7.8 y = 0.2

etch continue x=7.8 y = -2.4

etch done x=2.2 y = -2.4

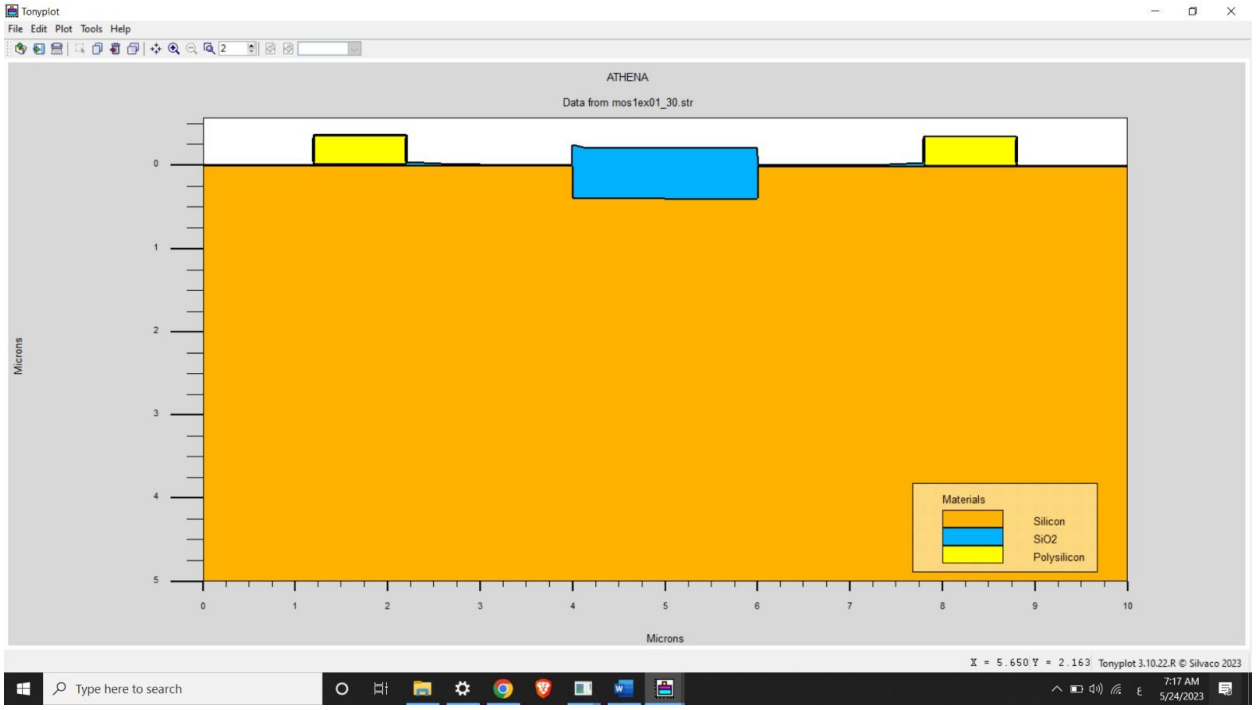
structure outfile=mos1ex01_29.str



Poly reoxidation

diffuse time=3 temp=900 weto2 press=1.0

structure outfile=mos1ex01_30.str



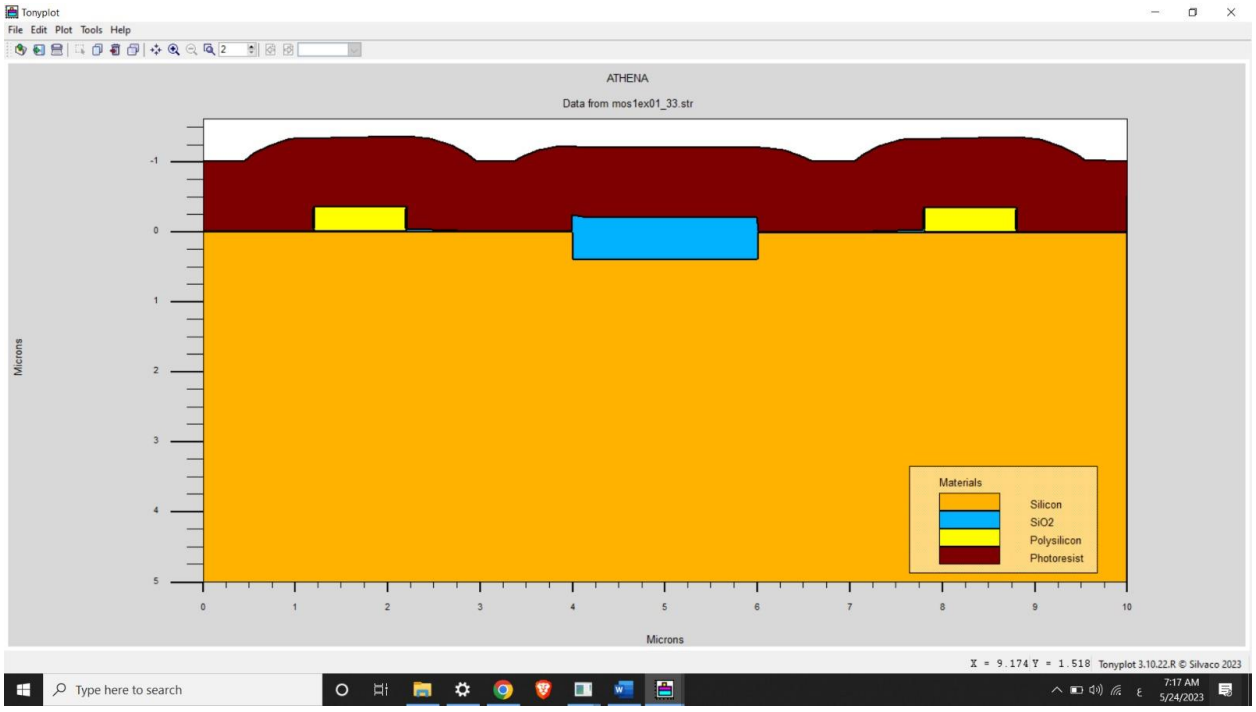
Section VIII: LDD formation (lightly doped drain) extensions:

#LDD formation

#deposit photoresist

deposit photoresist thickness=1

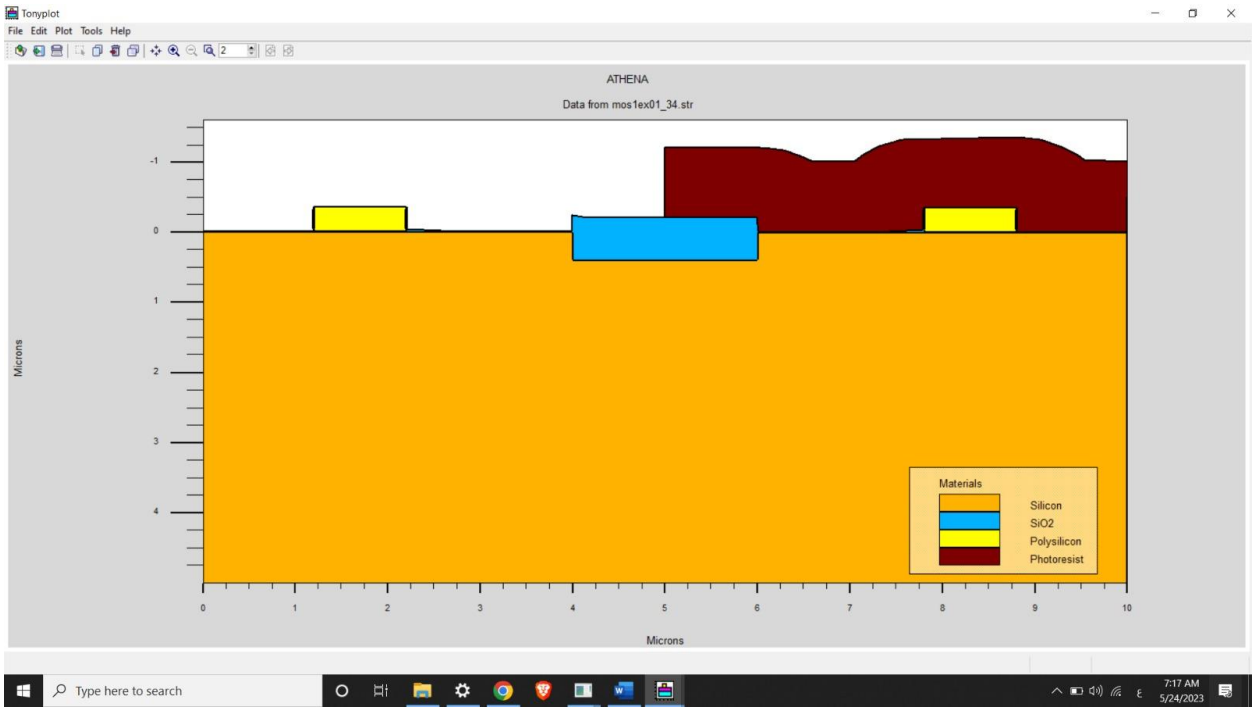
structure outfile=mos1ex01_33.str



#etch

etch photoresist left p1.x=5

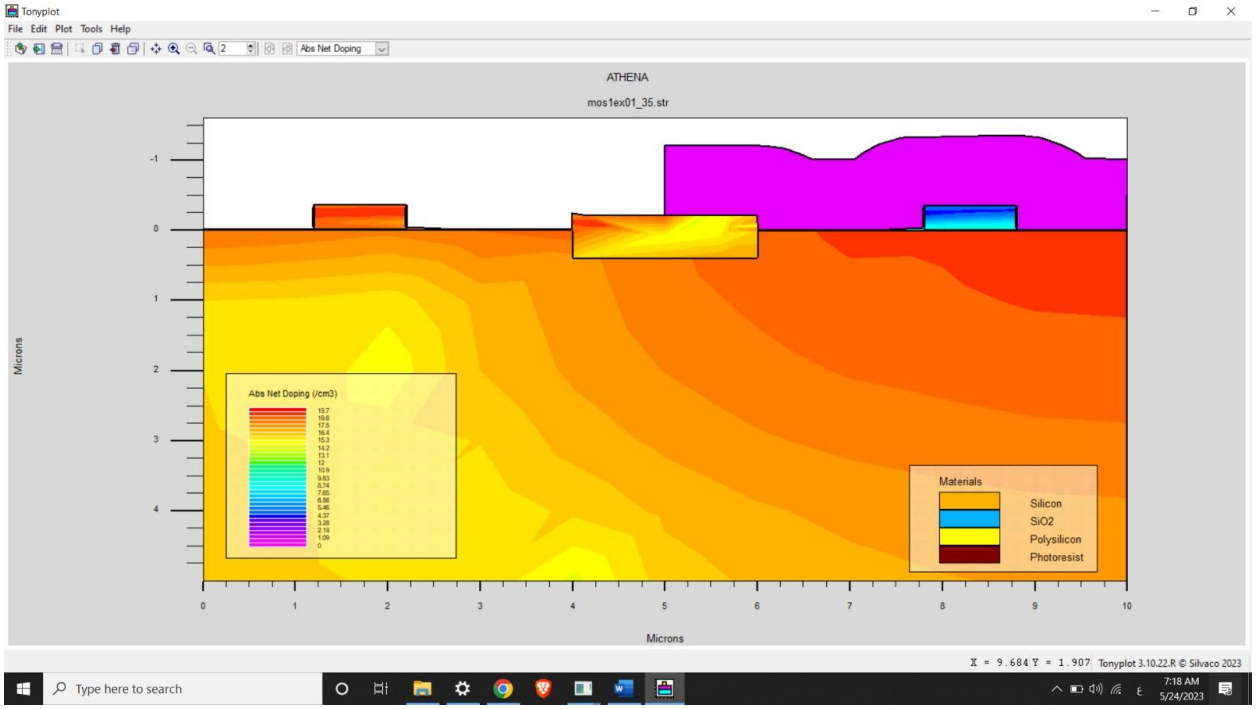
structure outfile=mos1ex01_34.str

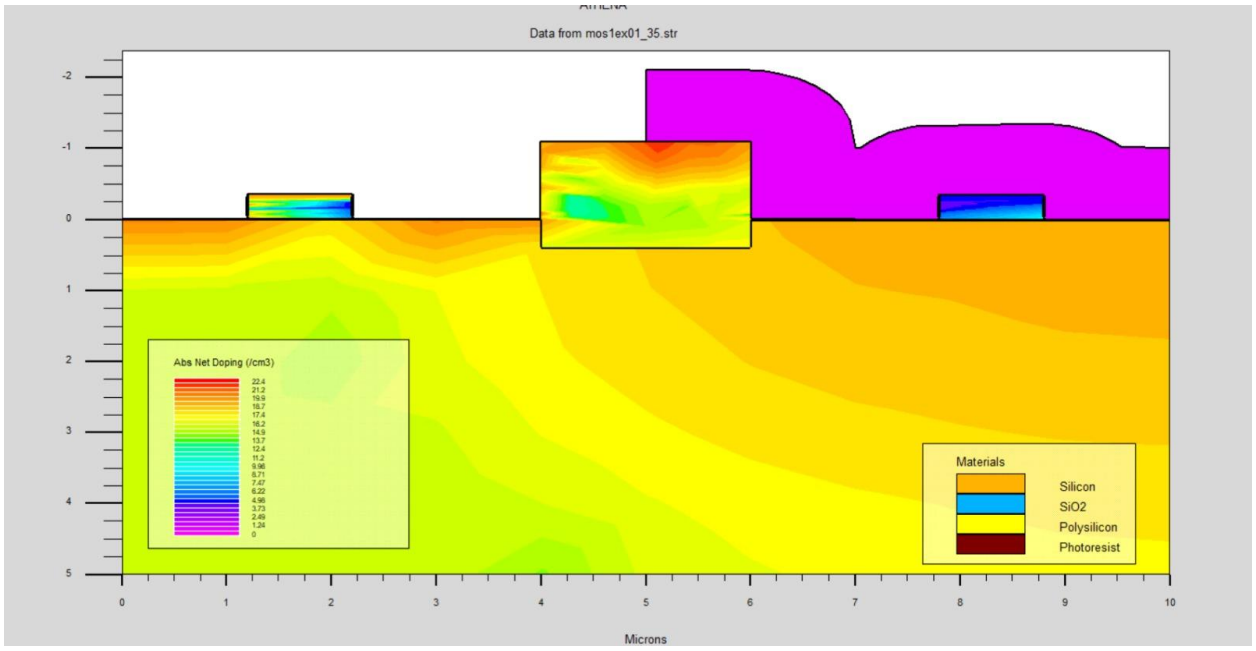


#implant phosphor

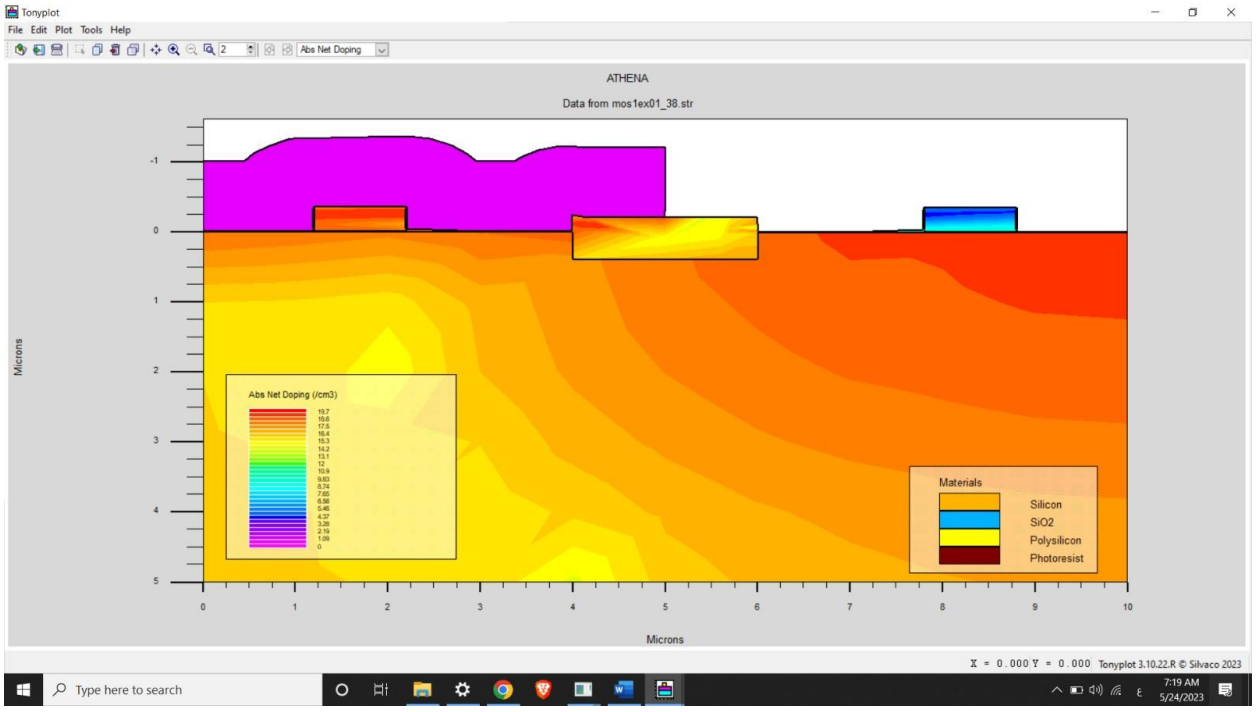
implant phospho energy =75 dose =5.0e14 pearson

structure outfile=mos1ex01_35.str





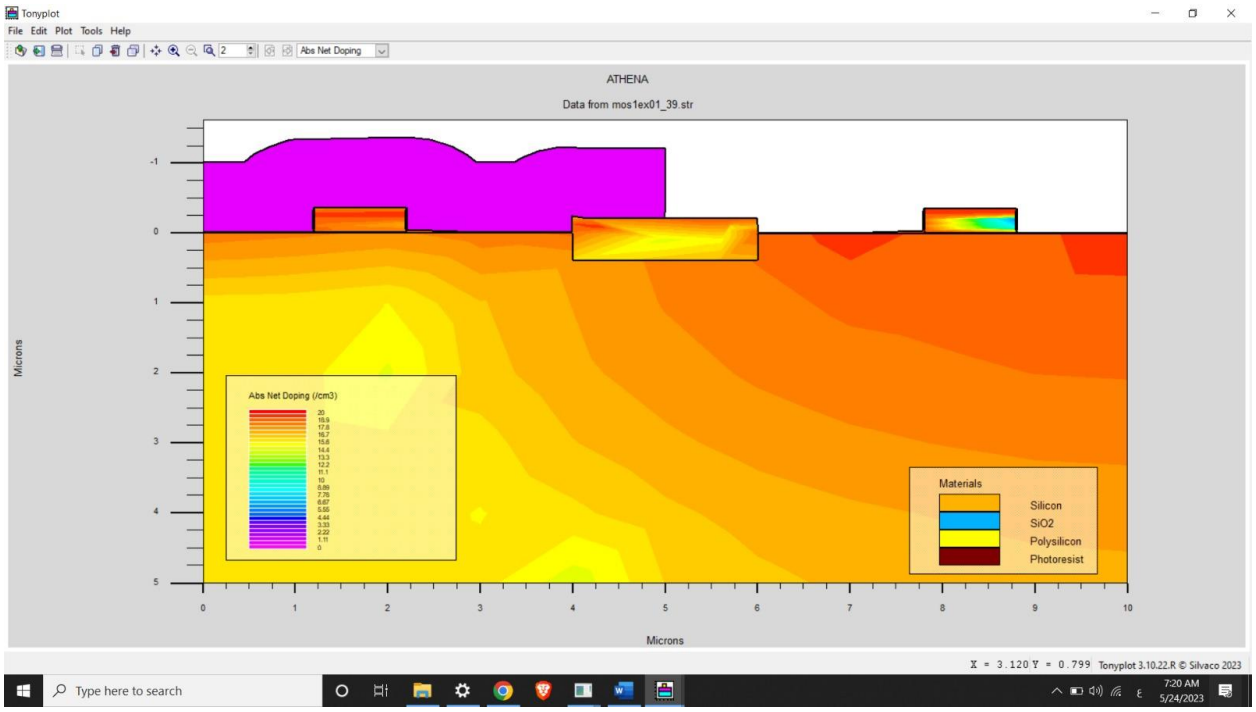

```
#etch
etch photoresist right p1.x=5
structure outfile=mos1ex01_36.str
#apply left resist
deposit photoresist thickness=1
structure outfile=mos1ex01_37.str
#etch
etch photoresist right p1.x=5
structure outfile=mos1ex01_38.str
```

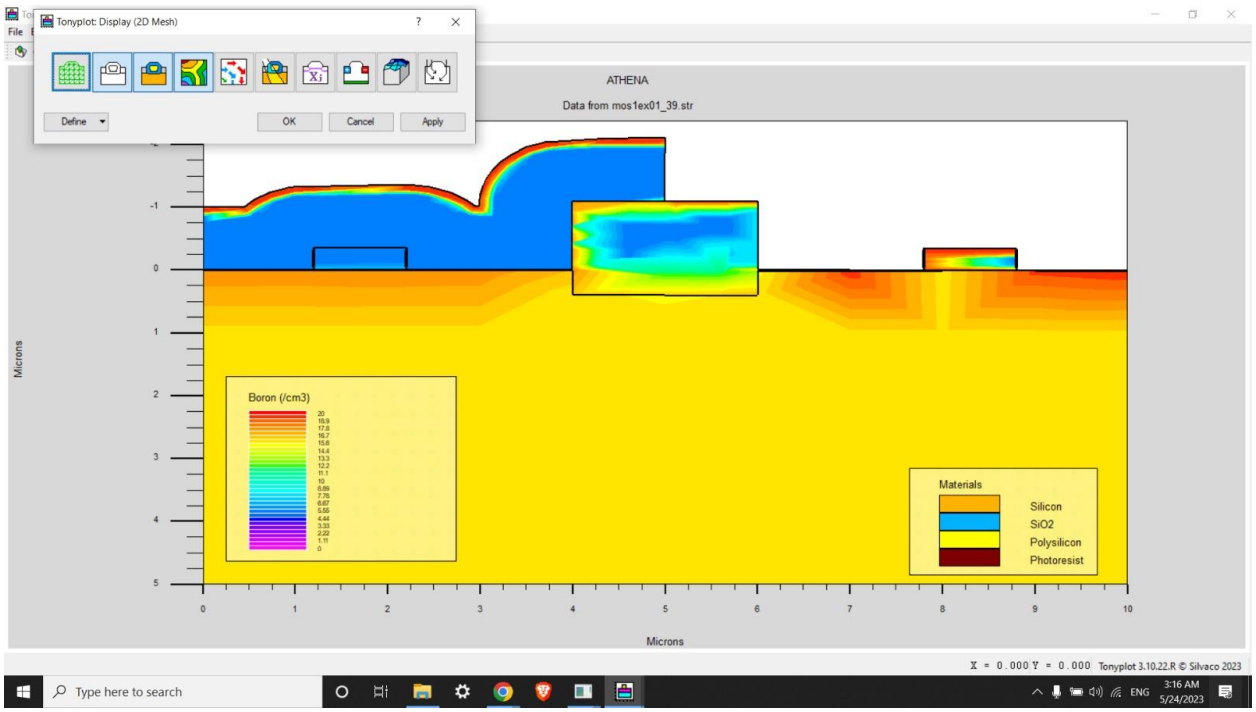


#implant boron

implant boron energy =10 dose =5.0e14 pearson

structure outfile=mos1ex01_39.str

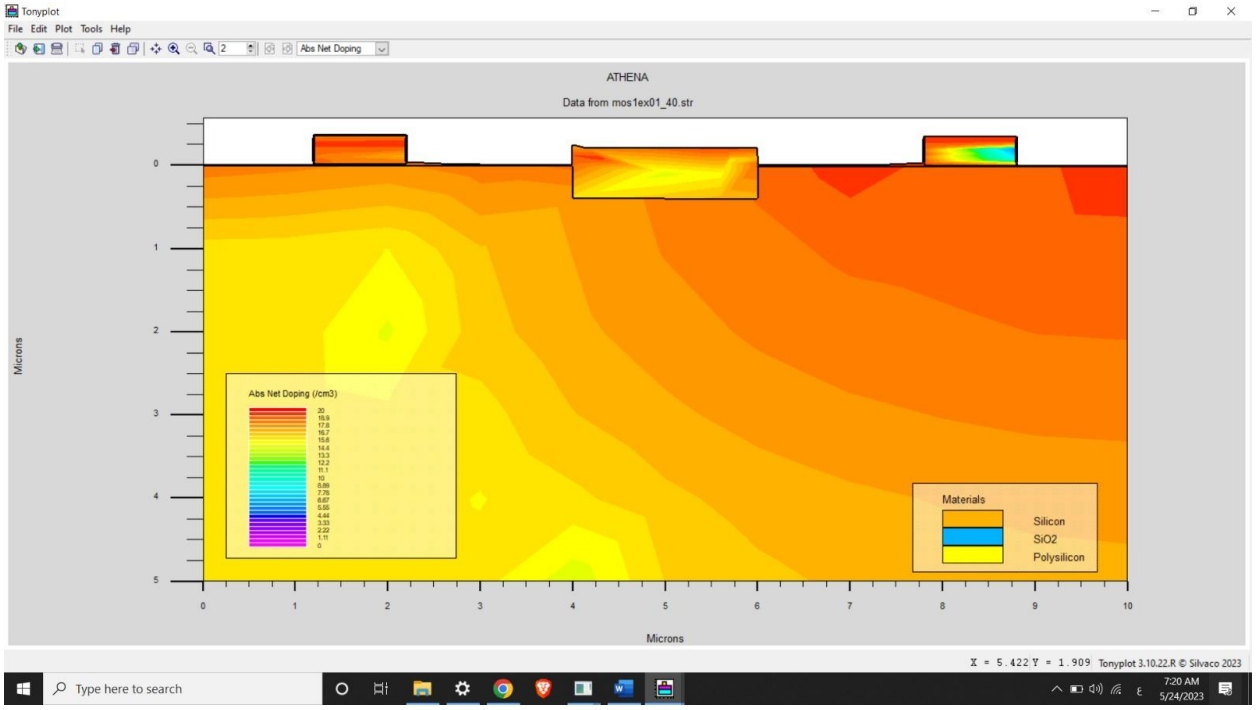




#etch photoresist

etch photoresist left p1.x=5

structure outfile=mos1ex01_40.str

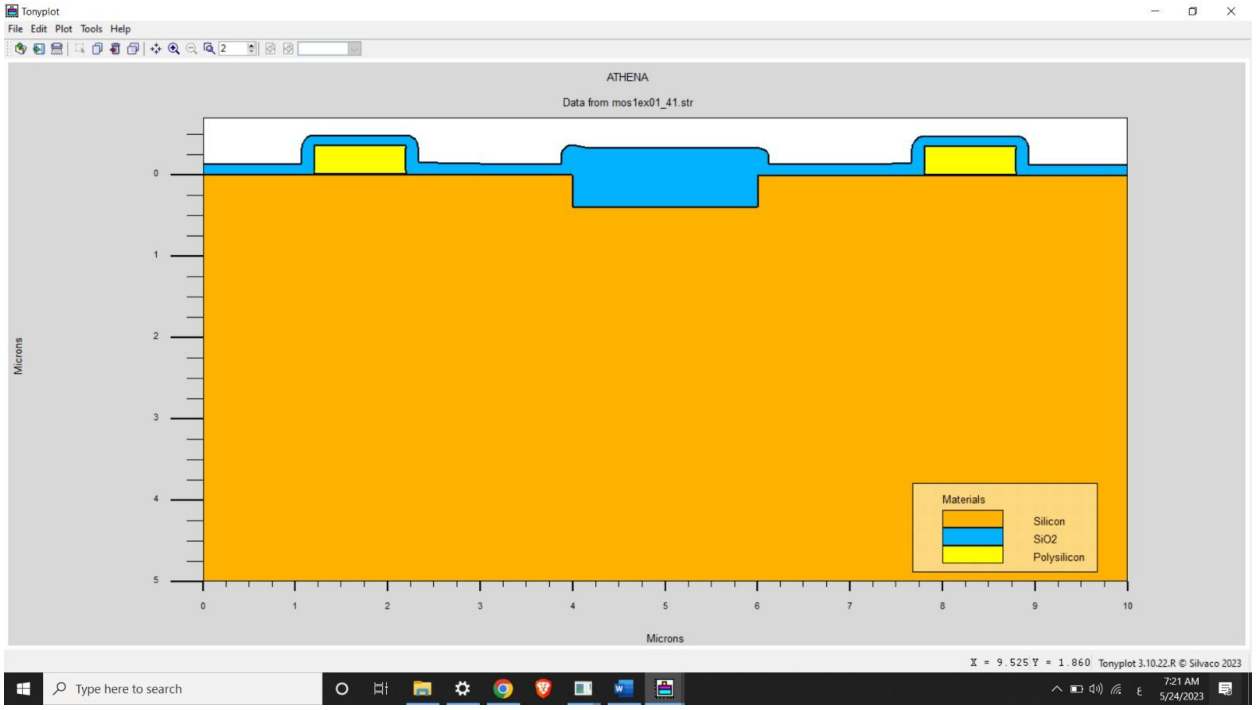


Section IX: Side wall Spacers:

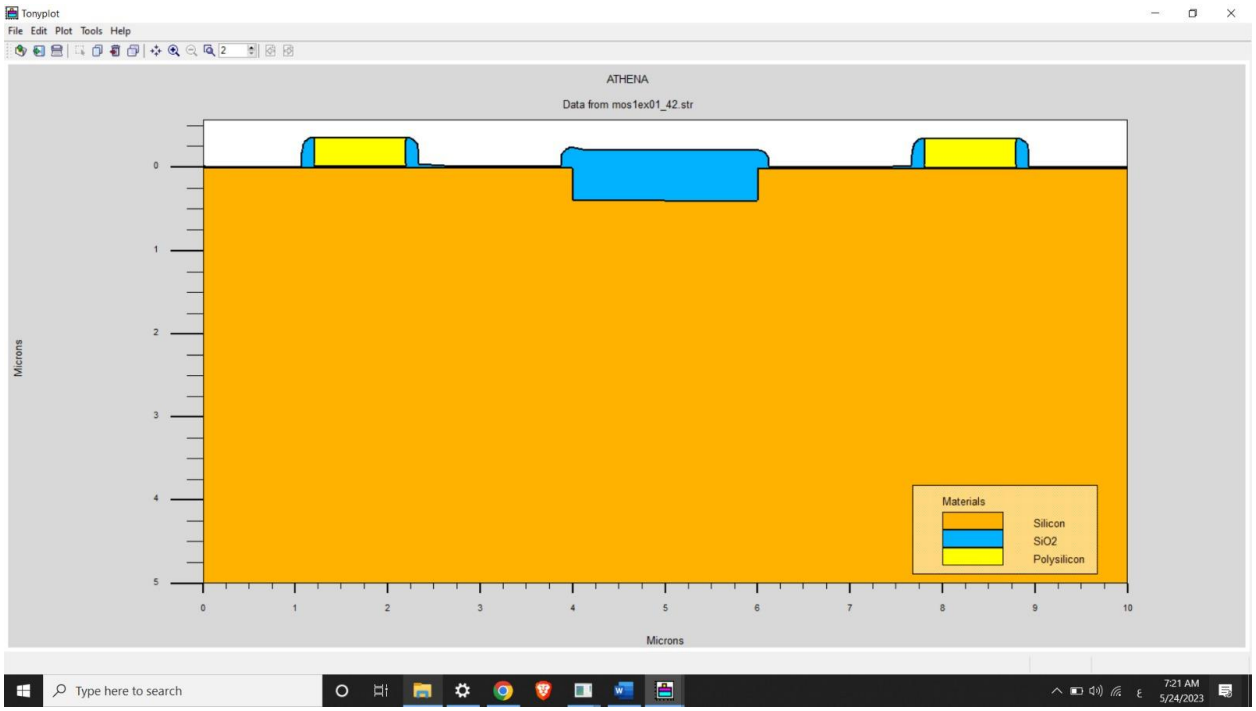
Gate oxide spacer deposition

depo oxide thick=0.120 divisions=10

structure outfile=mos1ex01_41.str

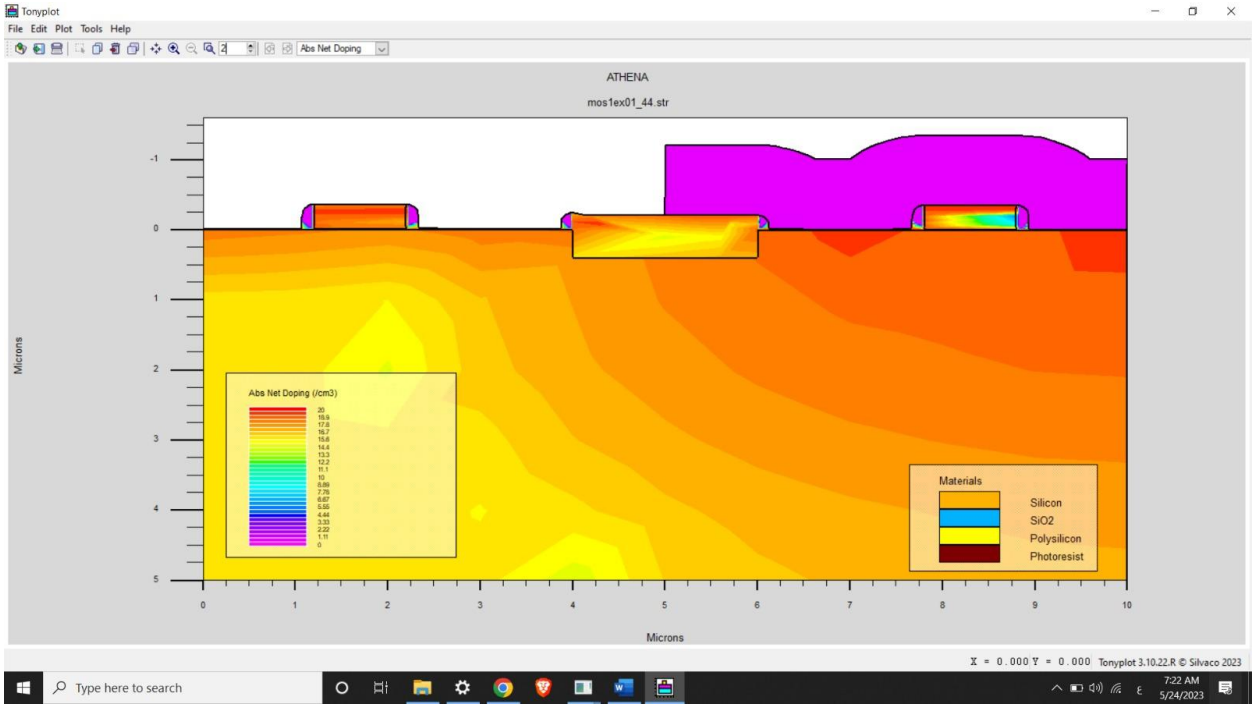


```
# Gate spacer formation
etch oxide dry thick=0.120
structure outfile=mos1ex01_42.str
```



Section X:Source and drain formation:

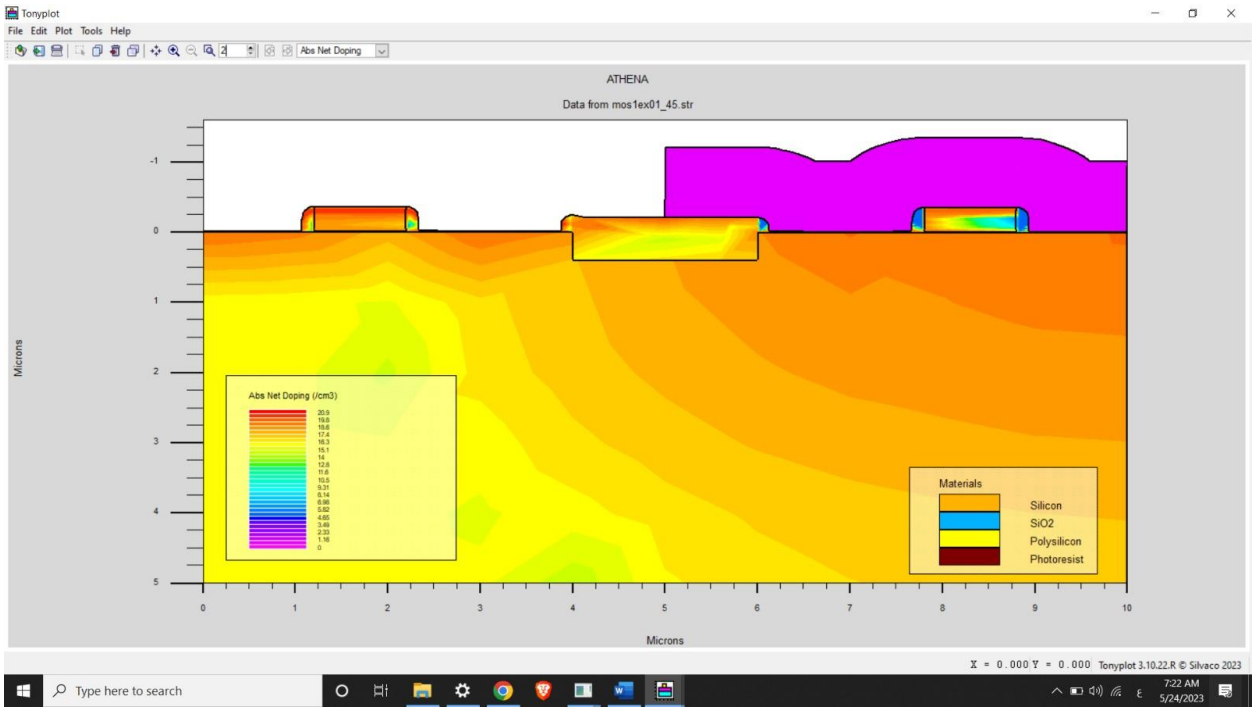
```
#source and drain
#apply photoresist
deposit photoresist thickness =1
structure outfile=mos1ex01_43.str
#etch
etch photoresist left p1.x=5
structure outfile=mos1ex01_44.str
```



#arsenic doping

implant arsenic energy = 75 dose = 4.0e15 pearson

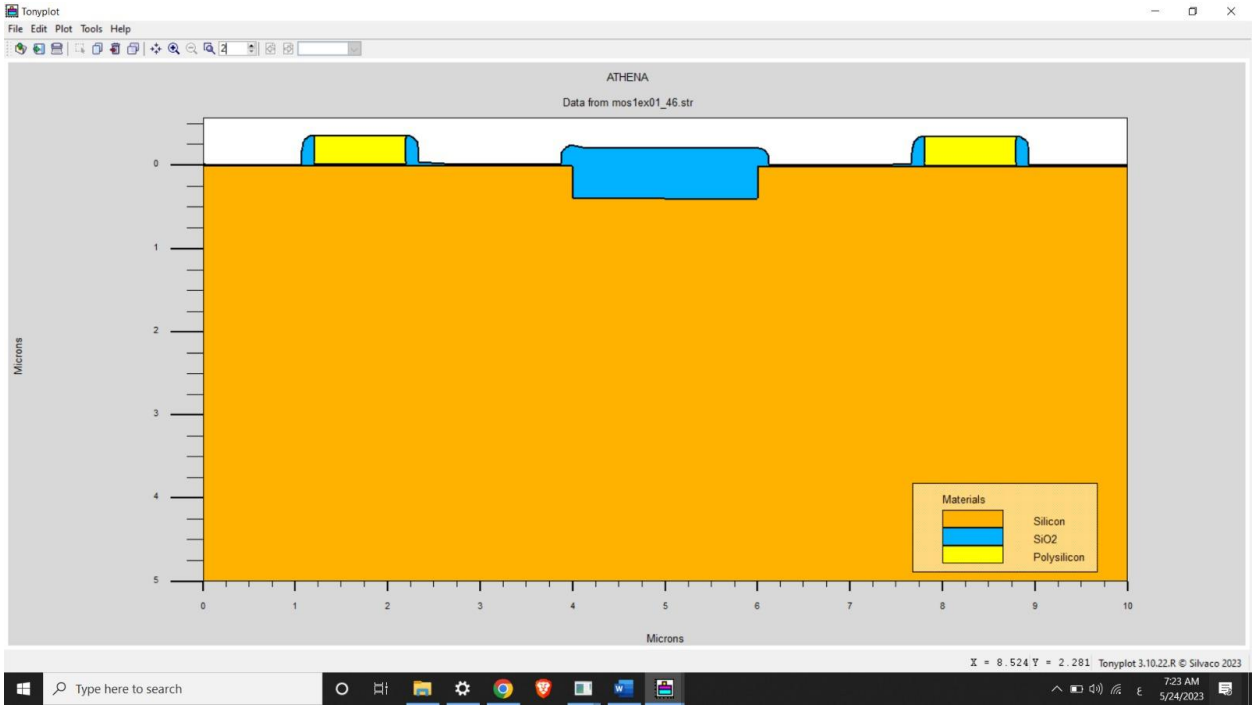
structure outfile=mos1ex01_45.str



#etch photoresist

etch photoresist right p1.x=5

structure outfile=mos1ex01_46.str



#apply photoresist

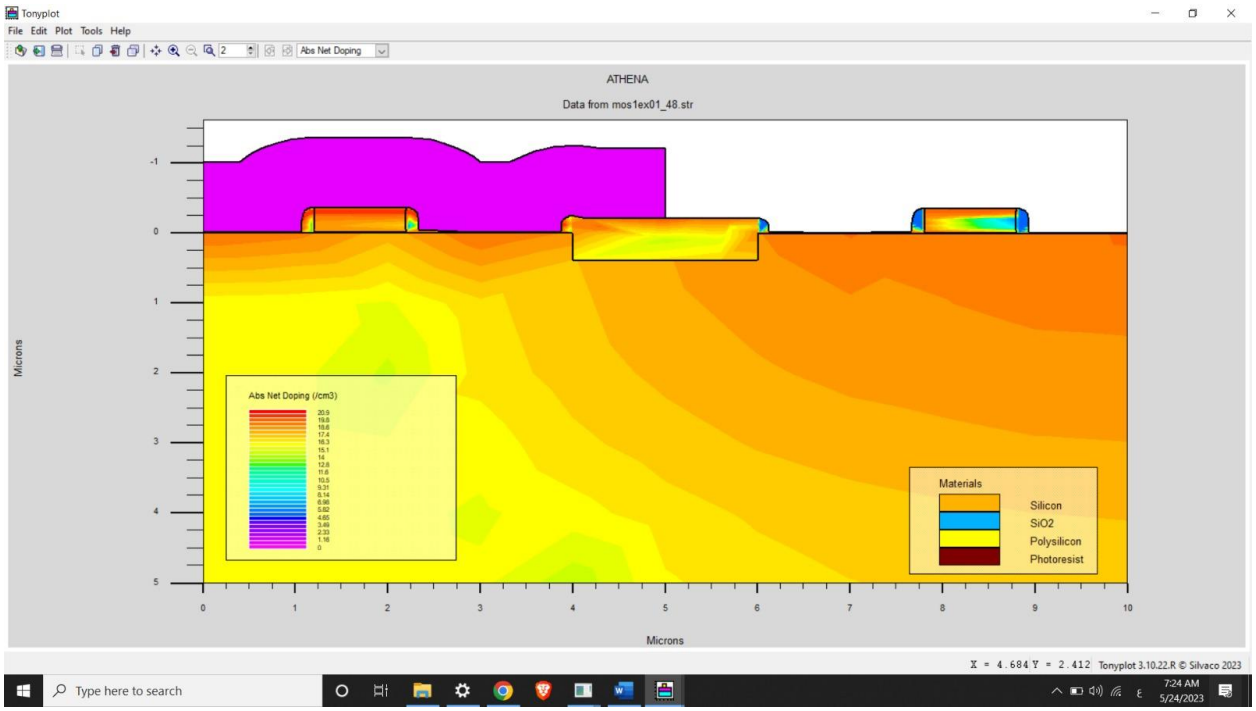
deposit photoresist thickness =1

structure outfile=mos1ex01_47.str

#etch photoresist

etch photoresist right p1.x=5

structure outfile=mos1ex01_48.str

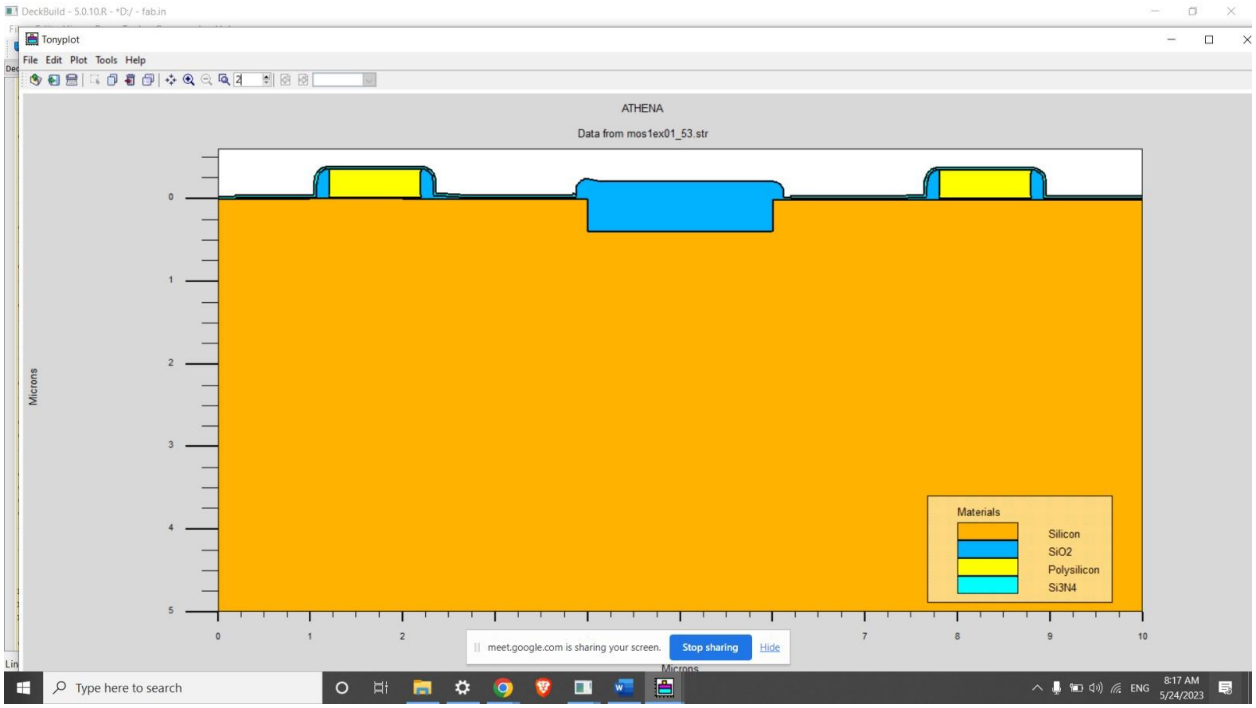


#dope
implant boron energy =10 dose = 3.0e15 pearson
structure outfile=mos1ex01_49.str
#etch
etch photoresist left p1.x=5
structure outfile=mos1ex01_50.str

Section XI: Silicide layer:

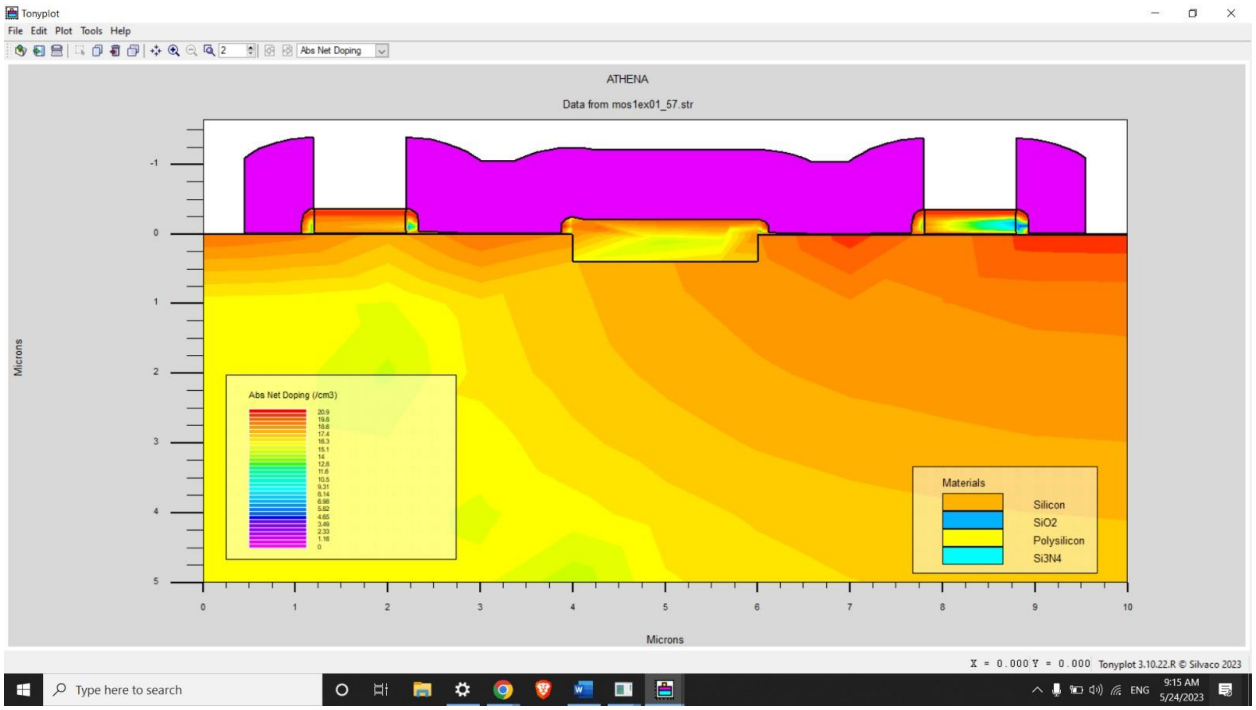
pattern S/D ohmic contact
etch oxide left p1.x=0.2
deposit Ni thick=0.03 divi=10
structure outfile=mos1ex01_52.str

#etch
etch Ni start x=3 y = -1
etch continue x=6.2 y = -1
etch continue x=6.2 y = 0.1
etch done x=4 y =0.1
structure outfile=mos1ex01_53.str



Section XII: First metal level formation:

```
# pattern S/D contact metal
etch oxide left p1.x=0.2
deposit Ni thick=1 divi=10
structure outfile=mos1ex01_54.str
etch Ni left p1.x=0.45
etch Ni right p1.x=9.55
structure outfile=mos1ex01_55.str
#etch
etch Ni start x=1.2 y = -1.4
etch continue x=2.2 y = -1.4
etch continue x=2.2 y = 0.2
etch done x=1.2 y =0.2
structure outfile=mos1ex01_56.str
#etch
etch Ni start x=7.8 y = -1.4
etch continue x=8.8 y = -1.4
etch continue x=8.8 y = 0.2
etch done x=7.8 y =0.2
structure outfile=mos1ex01_57.str
```



#etch

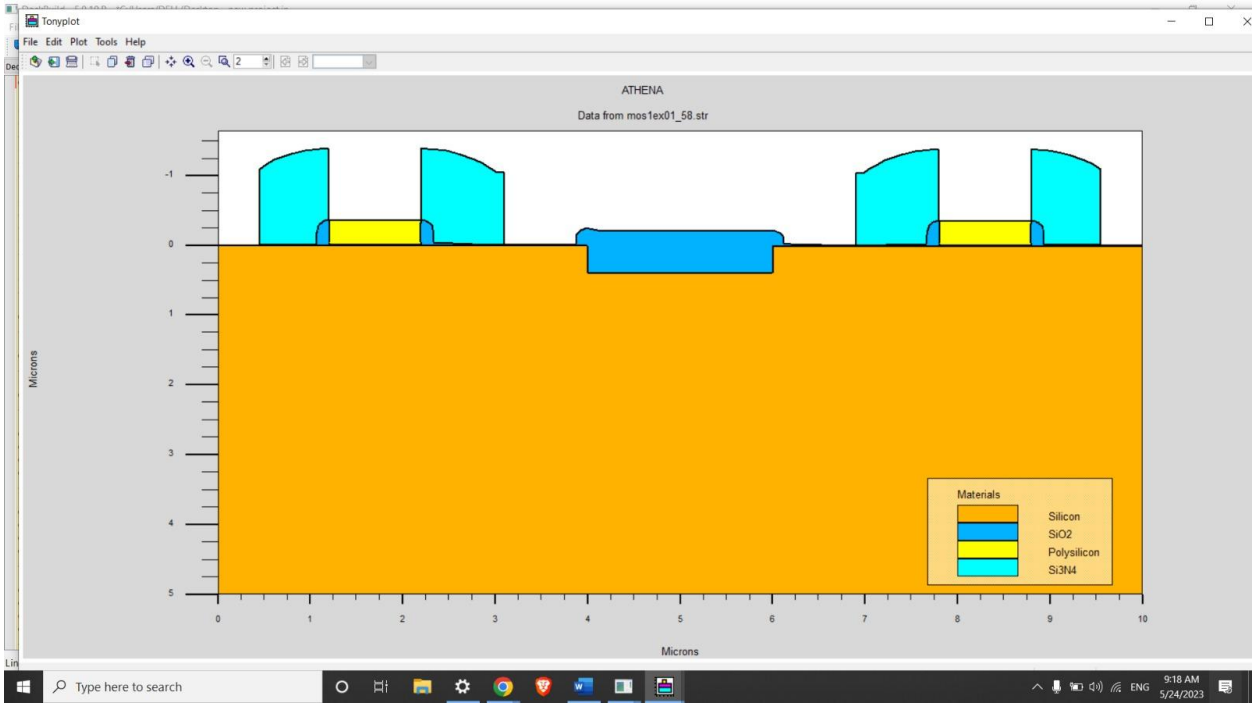
etch Ni start x=3.1 y = -1.4

etch continue x=6.9 y = -1.4

etch continue x=6.9 y = 0.2

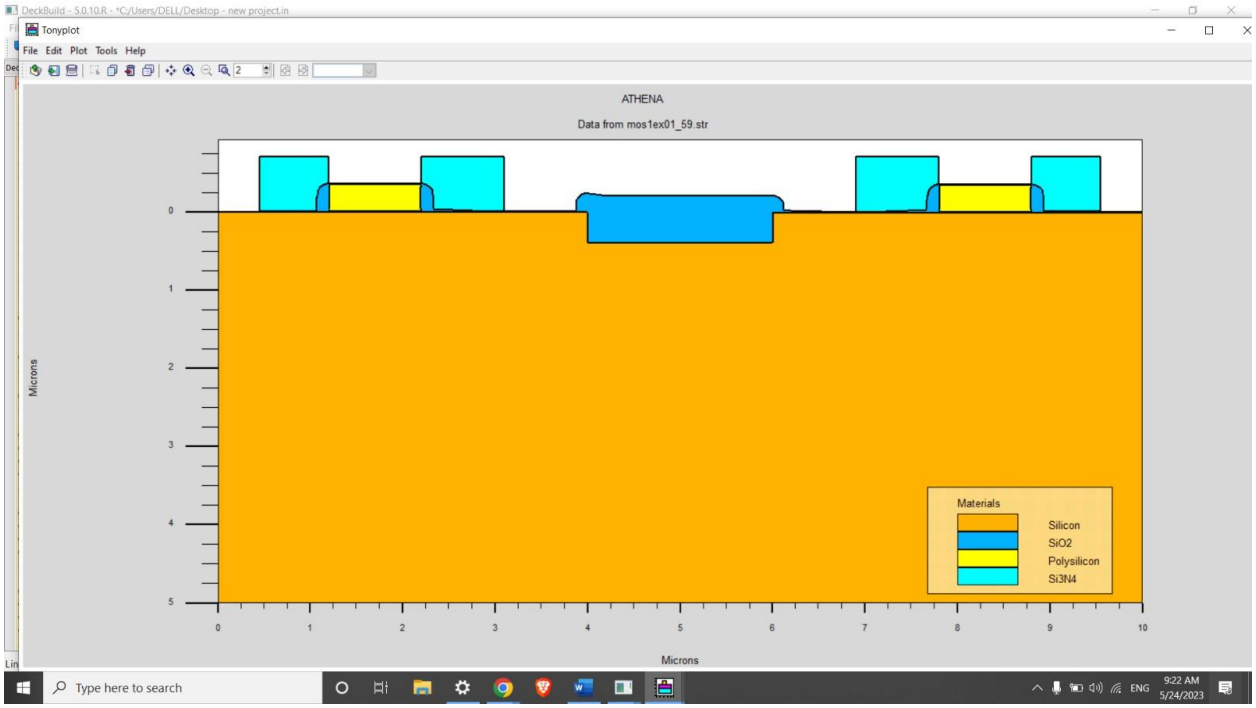
etch done x=3.1 y =0.2

structure outfile=mos1ex01_58.str



#etch

etch Ni start x=0 y = -1.4
etch continue x=10 y = -1.4
etch continue x=10 y = -0.7
etch done x=0 y =-0.7
structure outfile=mos1ex01_59.str



Section XII: References:

Barzdenas, V., Grazulevicius, G., & Vasjanov, A. (2019). TCAD tools in Undergraduate Studies: A laboratory work for learning deep submicron CMOS processes. *The International Journal of Electrical Engineering & Education*, *57*(2), 133–163. https://doi.org/10.1177/0020720919846811