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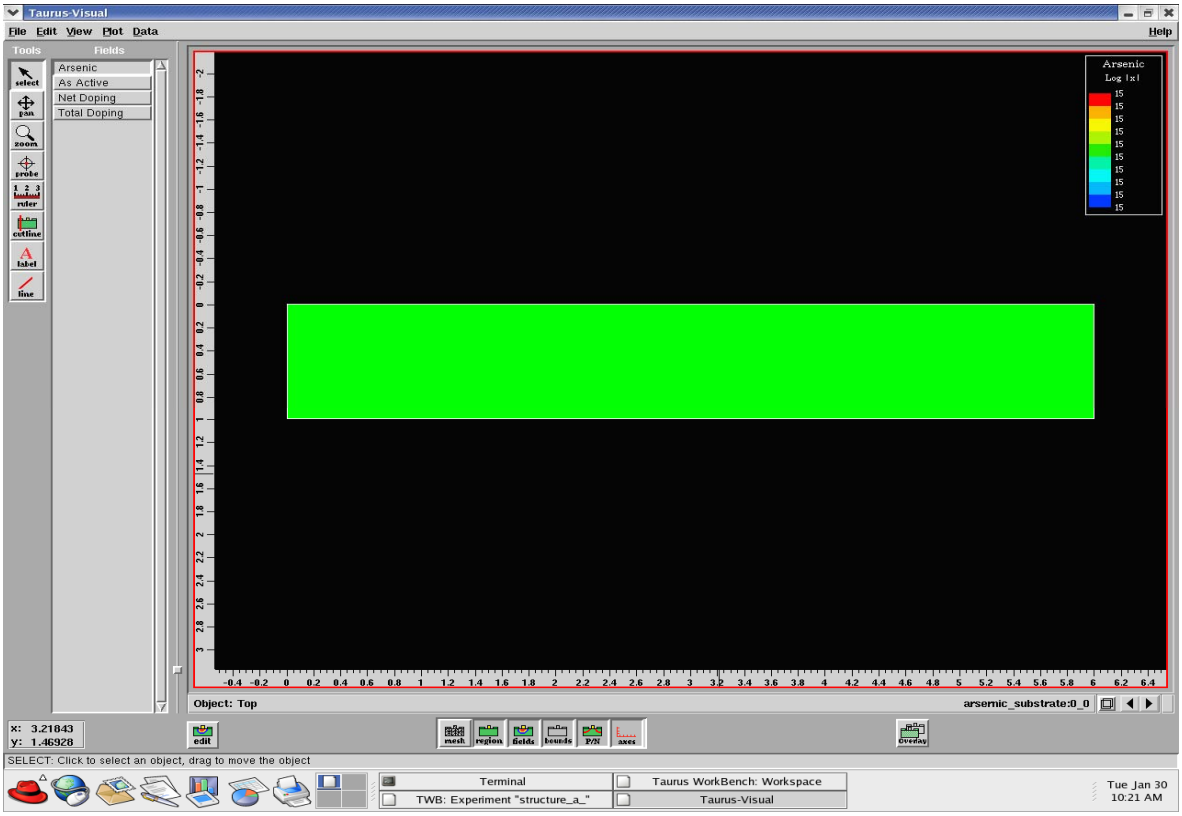
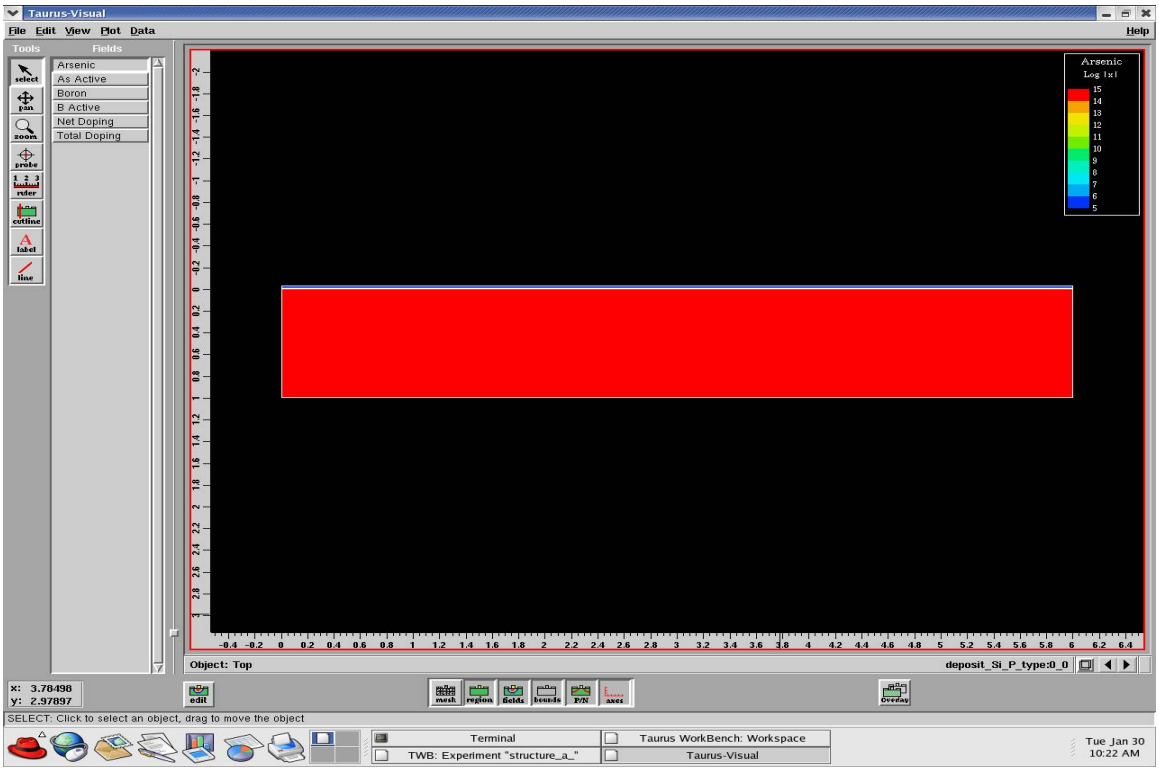
APPENDIX A

Structure Generation In The Process Simulation

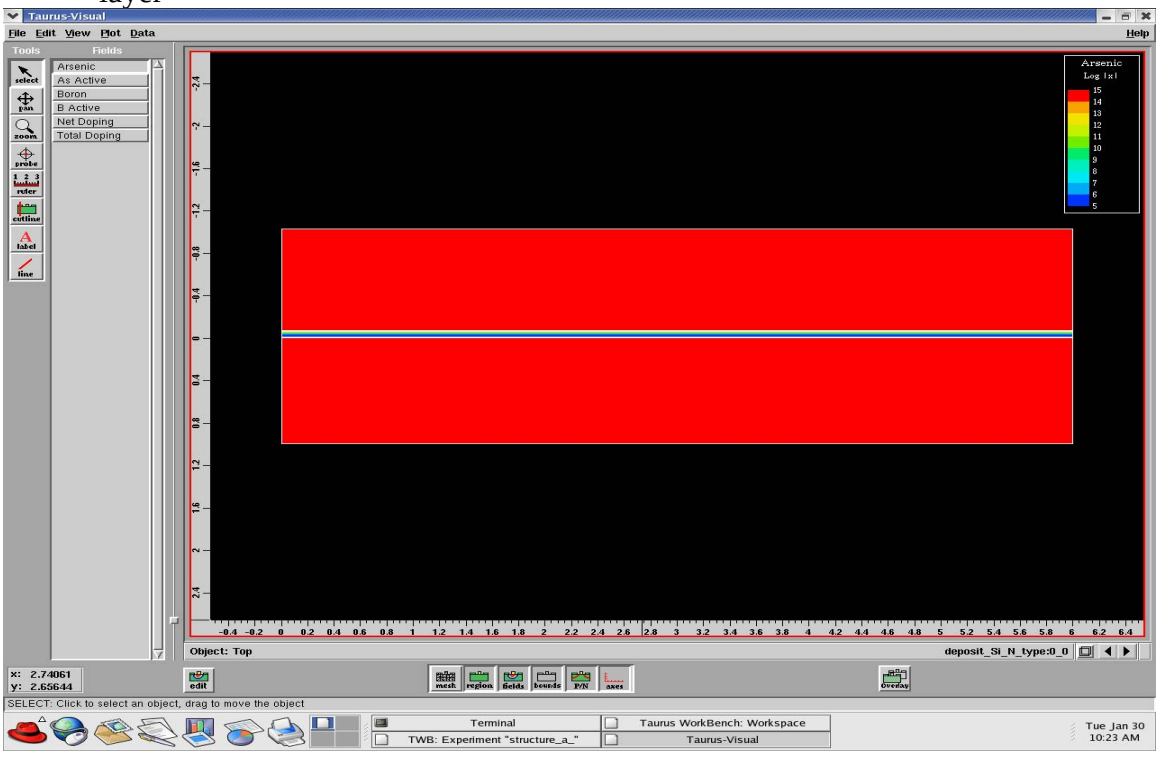
1. Silicon arsenic bare wafer.(Structure A)



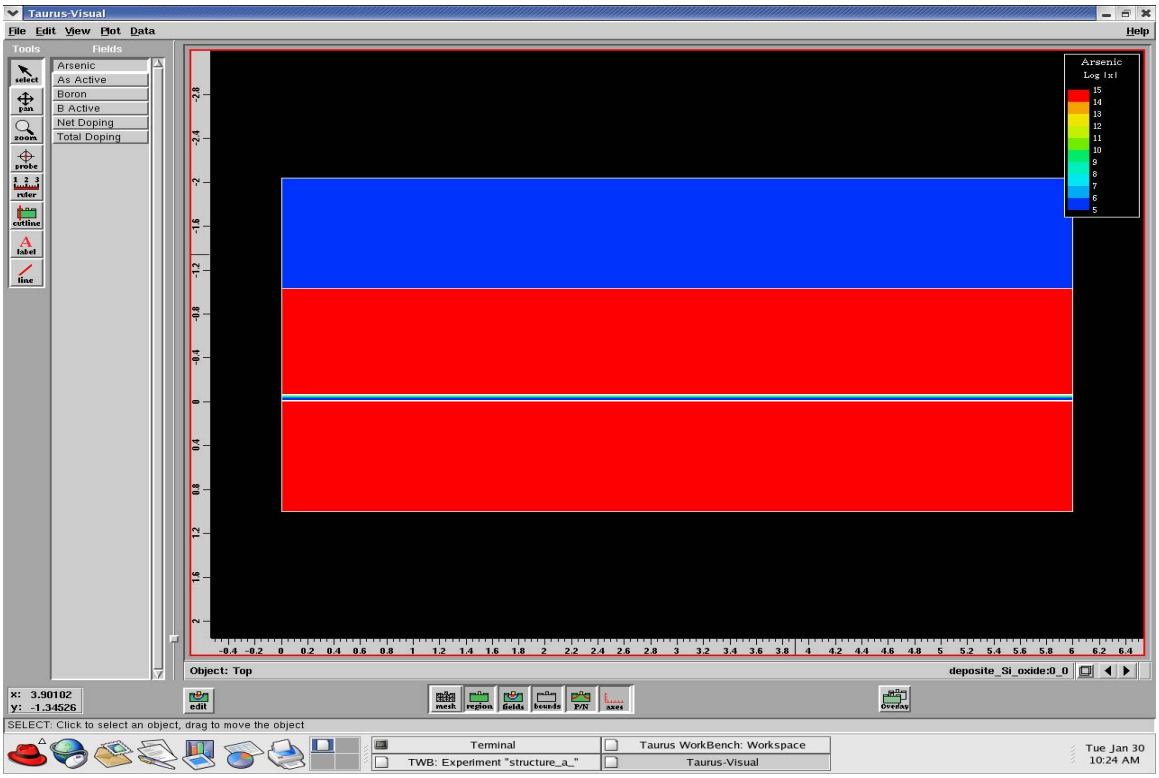
2. Silicon doped Boron layer is deposited on the top of the substrate.



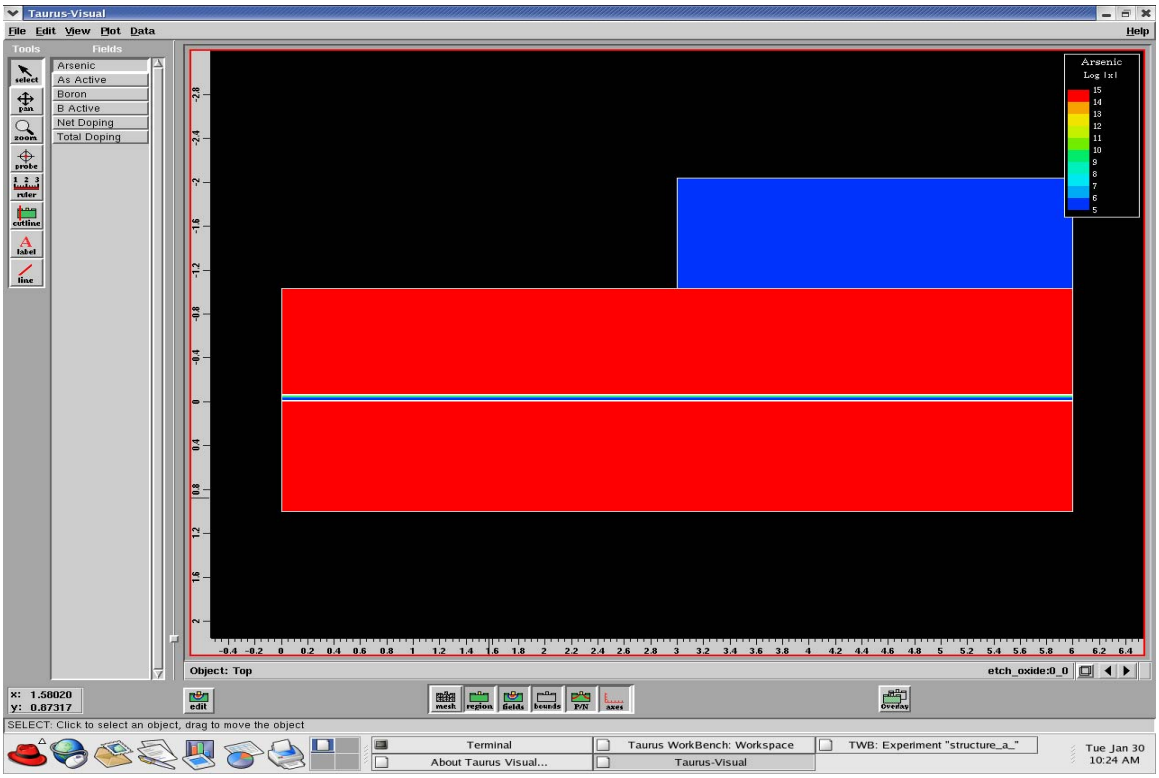
3. Silicon doped Arsenic is deposited on top of the silicon doped Boron underling layer



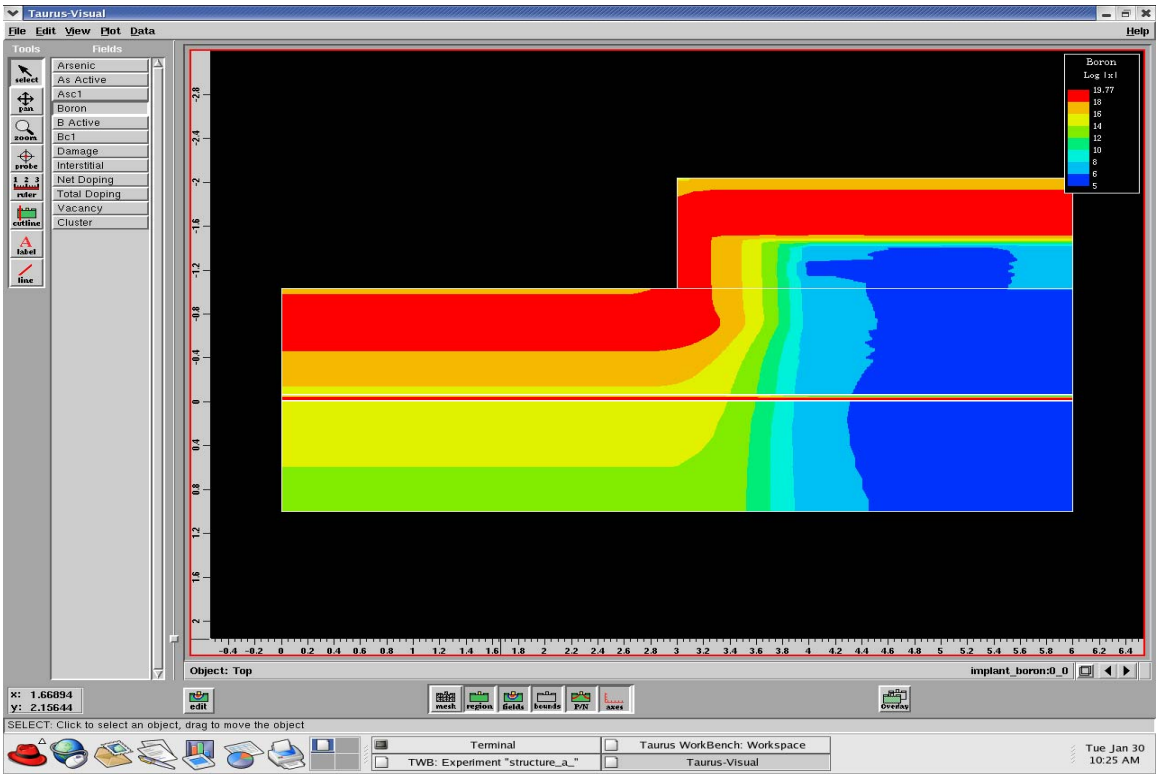
4. A silicon oxide layer is grow on top of the silicon doped Arsenic layer



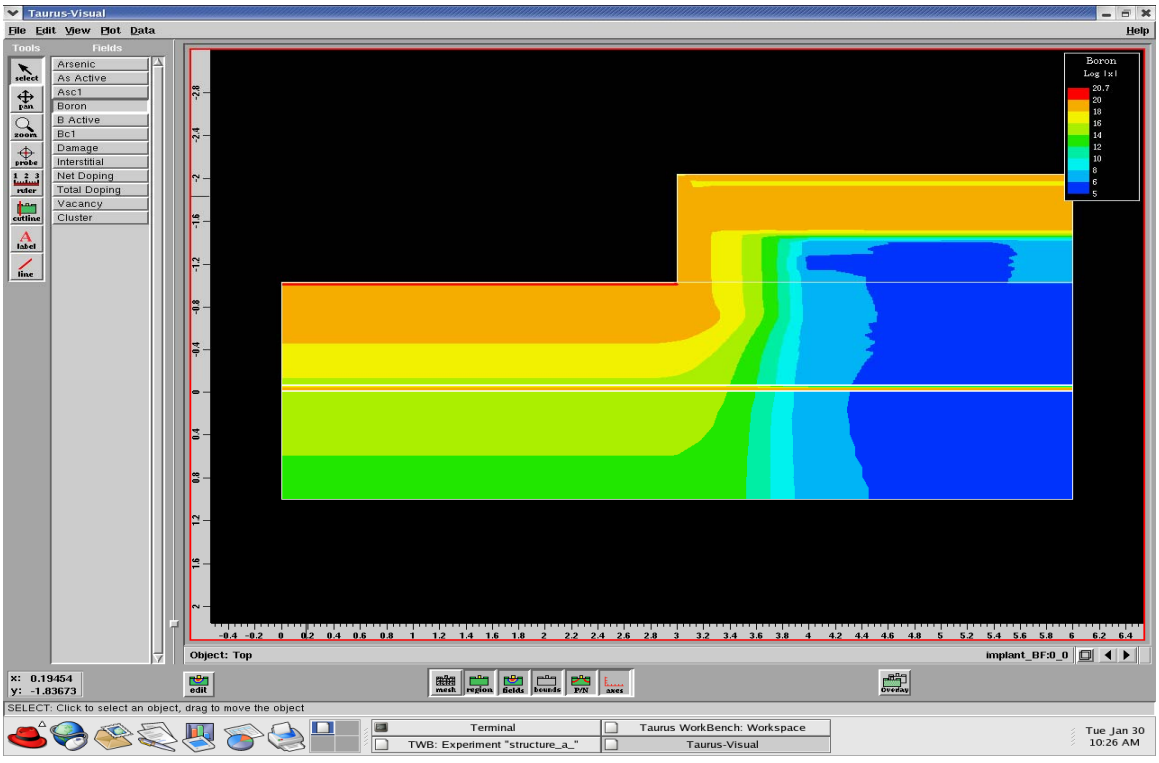
5. The silicon oxide then will be etch to the specific structure pattern.



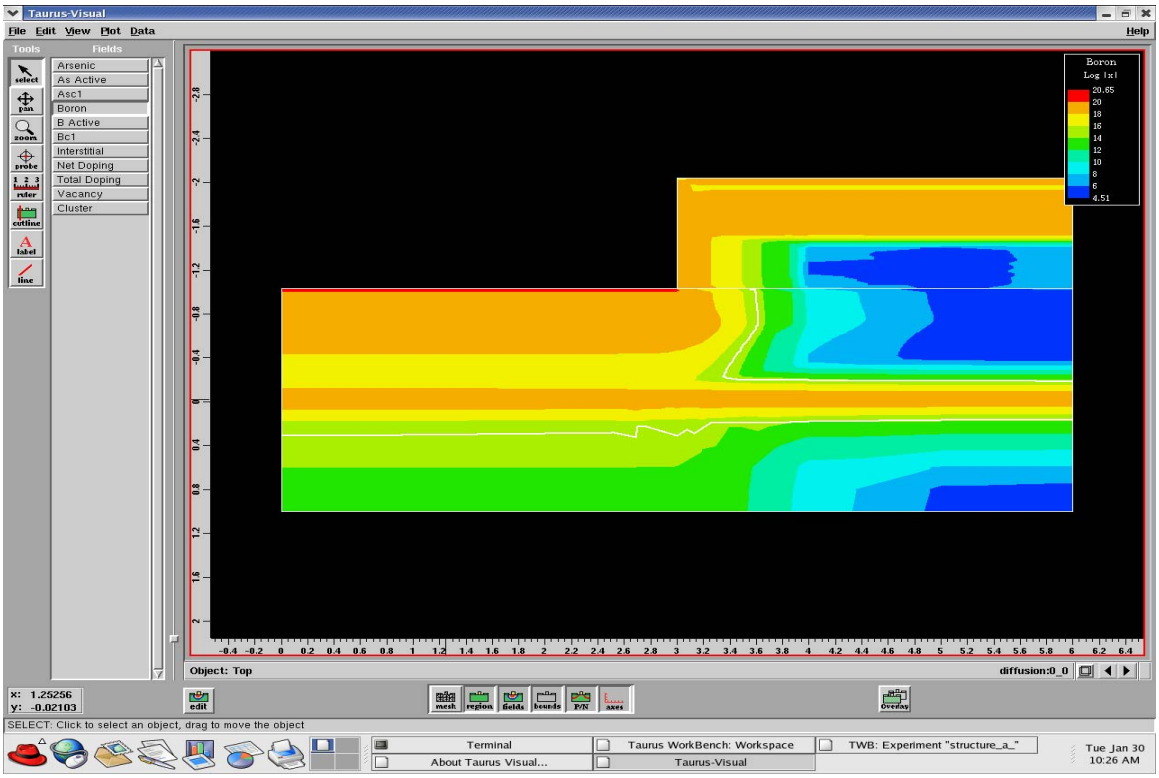
6. After that the Boron will implant into the structure



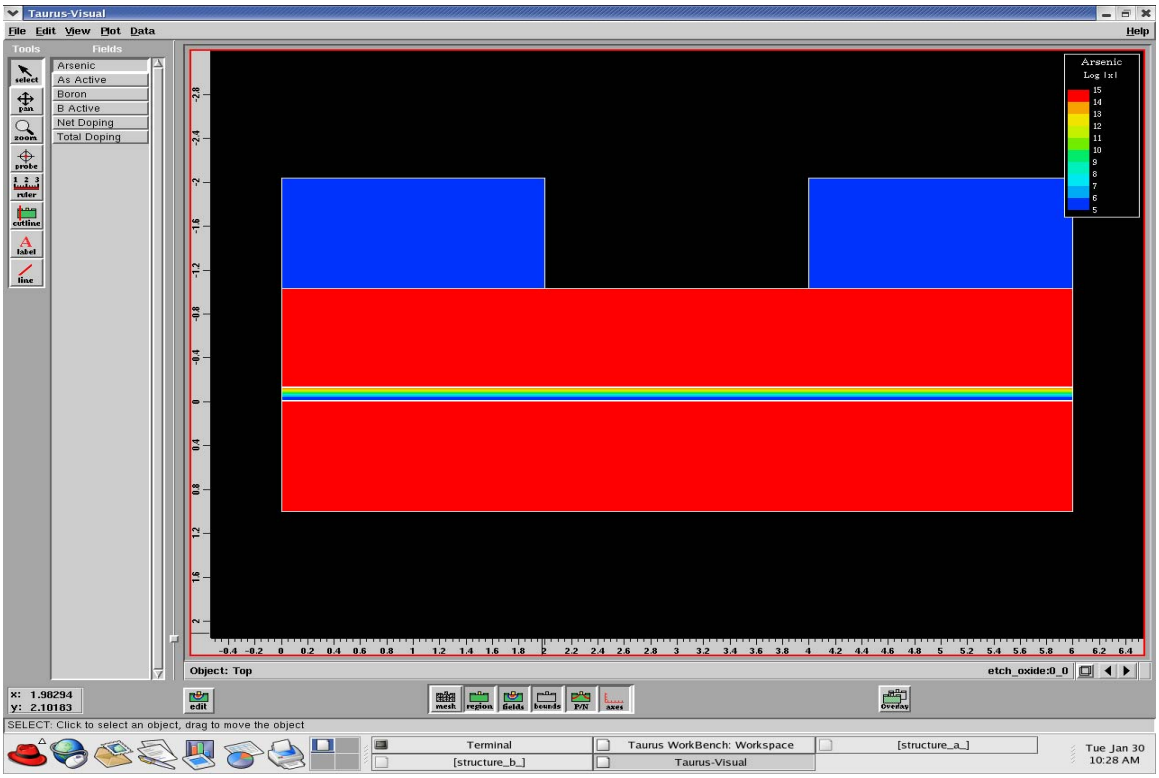
7. After the Boron implantation, this follow by Fluorine implantation into structure



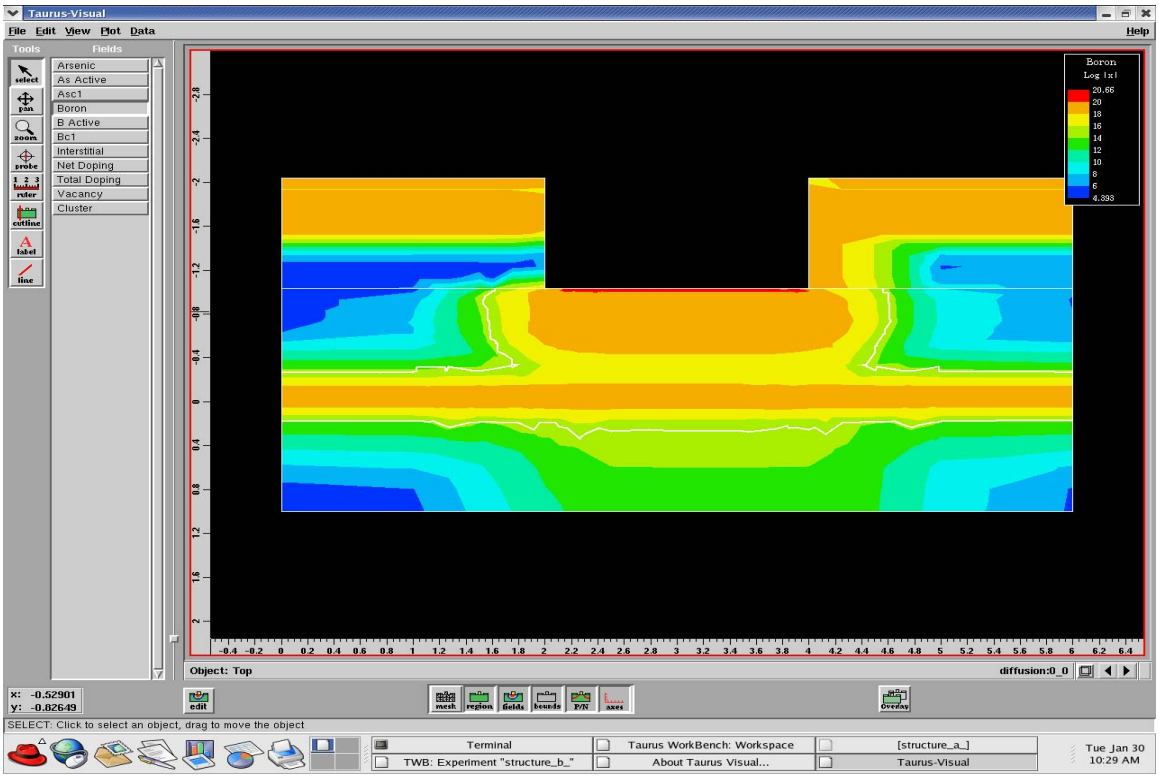
8. The last stage is diffusion process or annealing process



9. The silicon oxide then will be etch to the specific structure pattern. (structure B)



10 The last stage is diffusion process or annealing process (structure B)



APPENDIX B

Input File Of The Process Simulation

1. Silicon arsenic bare wafer (Structure A)

```
$driver ts4
$module arsernic_substrate:0
Line x location = 0 spacing = 40
Line x location = 1 spacing = 35
Line x location = 2 spacing = 30
Line x location = 3 spacing = 30
Line x location = 4 spacing = 30
Line x location = 5 spacing = 35
Line x location = 6 spacing = 40
Line y location = 0 spacing = 35
Line y location = 0.2 spacing = 30
Line y location = 0.4 spacing = 30
Line y location = 0.6 spacing = 30
Line y location = 0.8 spacing = 30
Line y location = 1 spacing = 35
initialize <100> impurity = arsenic I.CONC = 1e15
$step save
savefile out.file=arsernic_substrate:0_0 tif
```

2. Deposit silicon P-type doping underlying layer

```
$driver ts4
$module deposit_Si_P_type:0
$step load
initialize in.file=arsernic_substrate:0_0 tif
Deposition material = silicon impurity = boron I.conc = 2e19 thicknes =
0.025 +
spaces = 30
$step save
savefile out.file=deposit_Si_P_type:0_0 tif
```

3. Deposit silicon N-type doping layer

```
$driver ts4
$module deposit_Si_N_type:0
$step load
initialize in.file=deposit_Si_P_type:0_0 tif
deposition material = silicon impurity = arsenic I.CONC = 1e15 thicknes =
1 +
spaces = 30
$step save
savefile out.file=deposit_Si_N_type:0_0 tif
```

4. Deposit silicon oxide layer

```
$driver ts4
$module deposite_Si_oxide:0
$step load
initialize in.file=deposit_Si_N_type:0_0 tif
deposition material = oxide thicknes = 1 spaces = 30
$step save
savefile out.file=deposite_Si_oxide:0_0 tif
```

5. Etch the silicon oxide layer to the specific structure pattern

```
$driver ts4
$module etch_oxide:0
$step load
initialize in.file=deposite_Si_oxide:0_0 tif
etch material = oxide start x = 0 y = -3
etch material = oxide continue x = 0 y = -1
etch material = oxide continue x = 3 y = -1
etch material = oxide done x = 3 y = -3
$step save
savefile out.file=etch_oxide:0_0 tif
```

6. Implant the boron into the structure

```
$driver ts4
$module implant_boron:0
$step load
initialize in.file=vacancy_intertitial:0_0 tif
implant boron dose = 1e15 energy = 120 tilt = 7 D.RECOMB D.PLUS = 0.01 +
D.SCALE = 0.0
$step save
savefile out.file=implant_boron:0_0 tif
```

7. Implant the fluorine into the structure (20Kev)

```
$driver ts4
$module implant_BF:0
$step load
initialize in.file=implant_boron:0_0 tif
implant BF2 dose = 1e15 energy = 20 TILT = 7 D.RECOMB D.PLUS = 0.01 +
D.SCALE = 0.0
$step save
savefile out.file=implant_BF:0_0 tif
```

8. Implant the fluorine into the structure (35Kev)

```
$driver ts4
$module implant_BF:0
$step load
```

```
initialize in.file=implant_boron:0_0 tif
implant BF2 dose = 1e15 energy = 35 TILT = 7 D.RECOMB D.PLUS = 0.01 +
D.SCALE = 0.0
$step save
savefile out.file=implant_BF:0_0 tif
```

9. Implant the fluorine into the structure (50Kev)

```
$driver ts4
$module implant_BF:0
$step load
initialize in.file=implant_boron:0_0 tif
implant BF2 dose = 1e15 energy = 50 TILT = 7 D.RECOMB D.PLUS = 0.01 +
D.SCALE = 0.0
$step save
savefile out.file=implant_BF:0_0 tif
```

10. Vacancy and interstitial

```
$driver ts4
$module vacancy_intertitial:0
$step load
initialize in.file=etch_oxide:0_0 tif
method pd.full
method init.time = 1e16
method act.tran
interstitial silicon cm.sec D.0 = 1.55e6 D.E =3
boron cm.sec silicon  dipair.0 = 1e8*0.757 dipair.e = 3.46
interstitial silicon cm.sec Cequil.0 = 3.11e19 Cequil.E = 1.58
interstitial silicon /oxide cm.sec ksurf.0 = 1.0*7.33e3 ksurf.E = 1.88
interstitial silicon /ambient cm.sec ksurf.0 = 1.0*7.33e3 ksurf.E =1.88
vacancy  silicon cm.sec Cequil.0 = 1.0*4.77e18 Cequil.E = 0.71
vacancy  silicon cm.sec D.0 = 1.0*6.34e3 D.E = 3.29
boron  cm.sec silicon dvpair.0 = 1e8*0.747 dvpair.e = 3.46
vacancy  silicon /oxide cm.sec ksurf.0 = 1.0*1.12e4 ksurf.e = 2.48
vacancy  silicon /ambient cm.sec ksurf.0 = 1.0*1.12e4 ksurf.e = 2.48
interstitial silicon cm.sec Kb.0 = 1.0*1.4 kb.E =3.99
impurity  impurity = boron material = silicon  cm.sec t.act.0 = 4.1e-15 +
t.act.e = -3.7 act.min = 2.0
$step save
savefile out.file=vacancy_intertitial:0_0 tif
```

11. Process diffusion

```
$driver ts4
$module diffusion:0
$step load
initialize in.file=implant_BF:0_0 tif
diffusion temperature = 900 time = 30
$step save
savefile out.file=diffusion:0_0 tif
```

Structure B

1. silicon arsenic bare wafer.

```
$driver ts4
$module arsernic_substrate:0
Line x location = 0 spacing = 40
Line x location = 1 spacing = 35
Line x location = 2 spacing = 30
Line x location = 3 spacing = 30
Line x location = 4 spacing = 30
Line x location = 5 spacing = 35
Line x location = 6 spacing = 40
Line y location = 0 spacing = 35
Line y location = 0.2 spacing = 30
Line y location = 0.4 spacing = 30
Line y location = 0.6 spacing = 30
Line y  location = 0.8 spacing = 30
Line  y location = 1 spacing = 35
initialize <100> impurity = arsenic I.CONC = 1e15
$step save
savefile out.file=arsernic_substrate:0_0 tif
```

2. Deposit silicon P-type doping underlying layer

```
$driver ts4
$module deposit_Si_P_type:0
$step load
initialize in.file=arsernic_substrate:0_0 tif
Deposition material = silicon impurity = boron I.conc = 2e19 thicknes =
0.025 +
spaces = 30
$step save
savefile out.file=deposit_Si_P_type:0_0 tif
```

3. Deposit silicon N-type doping layer

```
$driver ts4
$module deposit_Si_N_type:0
$step load
initialize in.file=deposit_Si_P_type:0_0 tif
deposition material = silicon impurity = arsenic I.CONC = 1e15 thicknes =
1 +
spaces = 30
$step save
savefile out.file=deposit_Si_N_type:0_0 tif
```

4. Deposit silicon oxide layer

```
$driver ts4
$module deposite_Si_oxide:0
$step load
```

```
initialize in.file=deposit_Si_N_type:0_0 tif
deposition material = oxide thicknes = 1 spaces = 30
$step save
savefile out.file=deposite_Si_oxide:0_0 tif
```

5. Etch the silicon oxide layer to the specific structure pattern

```
$driver ts4
$module etch_oxide:0
$step load
initialize in.file=deposite_Si_oxide:0_0 tif
etch material = oxide start x = 2 y = -3
etch material = oxide continue x = 2 y = -1
etch material = oxide continue x = 4 y = -1
etch material = oxide done x = 4 y = -3
$step save
savefile out.file=etch_oxide:0_0 tif
```

6. Implant the boron into the structure

```
$driver ts4
$module implant_boron:0
$step load
initialize in.file=vacancy_intertitial:0_0 tif
implant boron dose = 1e15 energy = 120 tilt = 7 D.RECOMB D.PLUS = 0.01 +
D.SCALE = 0.0
$step save
savefile out.file=implant_boron:0_0 tif
```

7. Implant the fluorine into the structure (20Kev)

```
$driver ts4
$module implant_BF:0
$step load
initialize in.file=implant_boron:0_0 tif
implant BF2 dose = 1e15 energy = 20 TILT = 7 D.RECOMB D.PLUS = 0.01 +
D.SCALE = 0.0
$step save
savefile out.file=implant_BF:0_0 tif
```

8. Implant the fluorine into the structure (35Kev)

```
$driver ts4
$module implant_BF:0
$step load
initialize in.file=implant_boron:0_0 tif
implant BF2 dose = 1e15 energy = 35 TILT = 7 D.RECOMB D.PLUS = 0.01 +
D.SCALE = 0.0
$step save
```

```
savefile out.file=implant_BF:0_0 tif
```

9. Implant the fluorine into the structure (50Kev)

```
$driver ts4
$module implant_BF:0
$step load
initialize in.file=implant_boron:0_0 tif
implant BF2 dose = 1e15 energy = 50 TILT = 7 D.RECOMB D.PLUS = 0.01 +
D.SCALE = 0.0
$step save
savefile out.file=implant_BF:0_0 tif
```

10. Vacancy and interstitial

```
$driver ts4
$module vacancy_intertitial:0
$step load
initialize in.file=etch_oxide:0_0 tif
method pd.full
method init.time = 1e16
method act.tran
interstitial silicon cm.sec D.0 = 1.55e6 D.E =3
boron cm.sec silicon  dipair.0 = 1e8*0.757 dipair.e = 3.46
interstitial silicon cm.sec Cequil.0 = 3.11e19 Cequil.E = 1.58
interstitial silicon /oxide cm.sec ksurf.0 = 1.0*7.33e3 ksurf.E = 1.88
interstitial silicon /ambient cm.sec ksurf.0 = 1.0*7.33e3 ksurf.E =1.88
vacancy  silicon cm.sec Cequil.0 = 1.0*4.77e18 Cequil.E = 0.71
vacancy  silicon cm.sec D.0 = 1.0*6.34e3 D.E = 3.29
boron  cm.sec silicon dvpair.0 = 1e8*0.747 dvpair.e = 3.46
vacancy  silicon /oxide cm.sec ksurf.0 = 1.0*1.12e4 ksurf.e = 2.48
vacancy  silicon /ambient cm.sec ksurf.0 = 1.0*1.12e4 ksurf.e = 2.48
interstitial silicon cm.sec Kb.0 = 1.0*1.4 kb.E =3.99
impurity  impurity = boron material = silicon  cm.sec t.act.0 = 4.1e-15 +
t.act.e = -3.7 act.min = 2.0
$step save
savefile out.file=vacancy_intertitial:0_0 tif
```

11. Process diffusion

```
$driver ts4
$module diffusion:0
$step load
initialize in.file=implant_BF:0_0 tif
diffusion temperature = 900 time = 30
$step save
savefile out.file=diffusion:0_0 tif
```

TSUPREM 4 TCAD program simulation for the timing result :

1. For diffuses 0.001 second

```
$driver ts4
$module diffusion:0
$step load
initialize in.file=implant_BF:0_0 tif
diffusion temperature = 900 time = 0.001/60
$step save
savefile out.file=diffusion:0_0 tif
```

2. For diffuses 0.01 second

```
$driver ts4
$module diffusion:0
$step load
initialize in.file=implant_BF:0_0 tif
diffusion temperature = 900 time = 0.01/60
$step save
savefile out.file=diffusion:0_0 tif
```

3. For diffuses 0.1 second

```
$driver ts4
$module diffusion:0
$step load
initialize in.file=implant_BF:0_0 tif
diffusion temperature = 900 time = 0.1/60
$step save
savefile out.file=diffusion:0_0 tif
```

4. For diffuses 0.5 second

```
$driver ts4
$module diffusion:0
$step load
initialize in.file=implant_BF:0_0 tif
diffusion temperature = 900 time = 0.5/60
$step save
savefile out.file=diffusion:0_0 tif
```

5. For diffuses 1 second

```
$driver ts4
$module diffusion:0
$step load
initialize in.file=implant_BF:0_0 tif
diffusion temperature = 900 time = 1
$step save
savefile out.file=diffusion:0_0 tif
```

6. For diffuses 10 second

```
$driver ts4
$module diffusion:0
$step load
initialize in.file=implant_BF:0_0 tif
diffusion temperature = 900 time = 10
$step save
savefile out.file=diffusion:0_0 tif
```

8. For diffuses 20 second

```
$driver ts4
$module diffusion:0
$step load
initialize in.file=implant_BF:0_0 tif
diffusion temperature = 900 time = 20
$step save
savefile out.file=diffusion:0_0 tif
```

9. For diffuses 30 second

```
$driver ts4
$module diffusion:0
$step load
initialize in.file=implant_BF:0_0 tif
diffusion temperature = 900 time = 30
$step save
savefile out.file=diffusion:0_0 tif
```