ECE 445 Assignment 3

PEI-YU LIN

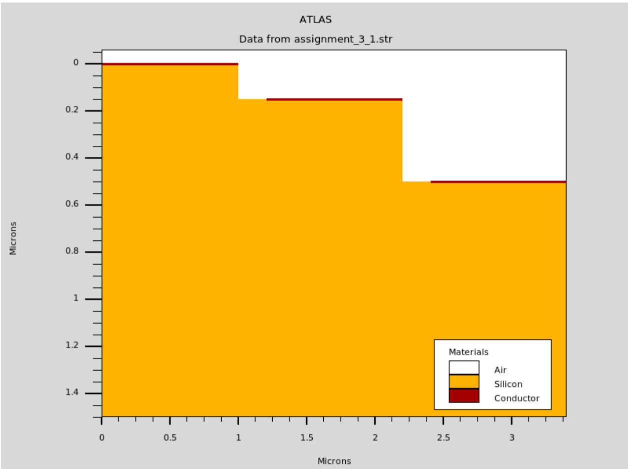
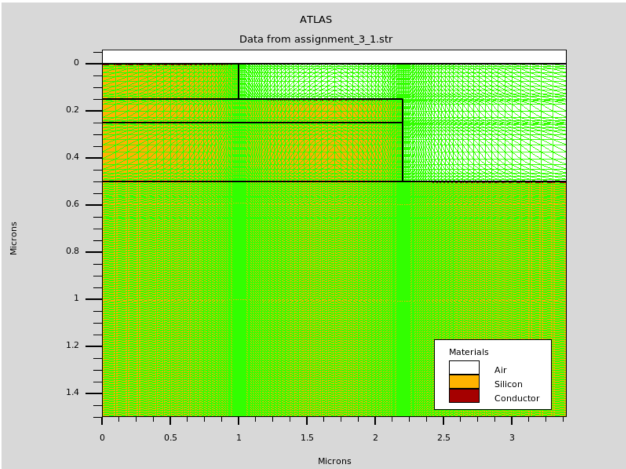
Code

```
go atlas
#Length and Thickness of the Emitter (um)
set Le = 1
set Te = 0.15
#Length and Thickness of the Base (um)
set Lb = 1
set Tb = 0.1  # 0.2
#Length and Thickness of the Collector (um)
set Lc = 1
set Tc =0.25
#Length of the basement (um)
set L = 3.4
set T = 1

#Device width in z-direction(um)
mesh width = 100

# X-mesh
x.mesh loc=0.0 spac=0.1
x.mesh loc=$Le/2 spac=0.05
x.mesh loc=$Le spac=0.01
x.mesh loc=$Le+0.2+$Lb/2 spac=0.05
x.mesh loc=$Le+0.2+$Lb spac=0.01
x.mesh loc=$Le+0.2+$Lb+0.2+$Lc/2 spac=0.05
x.mesh loc=$Le+0.2+$Lb+0.2+$Lc spac=0.1

# Y-mesh
y.mesh loc=0.0 spac=0.01
y.mesh loc=$Te/2 spac=0.02
y.mesh loc=$Te spac=0.01
y.mesh loc=$Te+$Tb/2 spac=0.03
y.mesh loc=$Te+$Tb spac=0.01
y.mesh loc=$Te+$Tb+$Tc/2 spac=0.03
y.mesh loc=$Te+$Tb+$Tc spac=0.01
y.mesh loc=$Te+$Tb+$Tc+$T spac=0.01
```

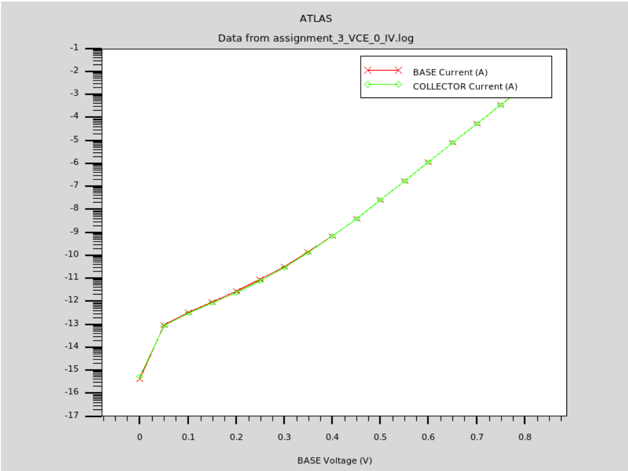
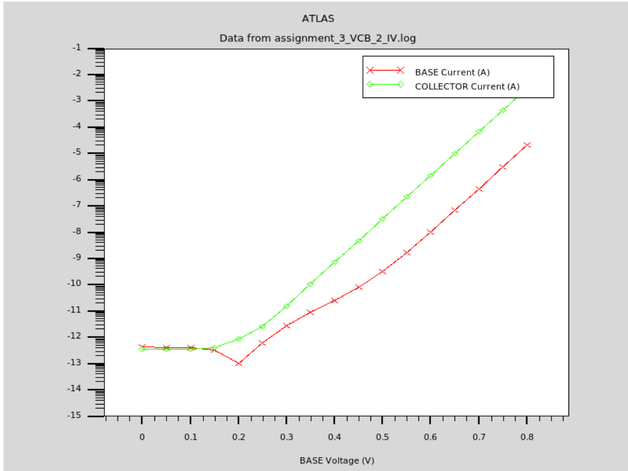
```
# Region
region num=1 material=air
region num=2 x.min=0.0 x.max=$Le y.min=0.0 y.max=$Te material=silicon
region num=3 x.min=0.0 x.max=$Le+0.2+$Lb y.min=$Te y.max=$Te+$Tb material=silicon
region num=4 x.min=0.0 x.max=$Le+0.2+$Lb y.min=$Te+$Tb y.max=$Te+$Tb+$Tc material=silicon
region num=5 x.min=0.0 x.max=$L y.min=$Te+$Tb+$Tc y.max=$Te+$Tb+$Tc+$T material=silicon

# Electrode
elec name=EMITTER x.max=$Le length=1.0 y.min=0 y.max=0
elec name=BASE x.max=$Le+0.2+$Lb length=1.0 y.min=$Te y.max=$Te
elec name=COLLECTOR x.max=$L  length=1.0 y.min=$Te+$Tb+$Tc y.max=$Te+$Tb+$Tc

# Doping
doping region=2 uniform n.type conc=5e19
doping region=3 uniform p.type conc=1e18
doping region=4 uniform n.type conc=2e16
doping region=5 uniform n.type conc=1e19

# Models
model srh drift.diff print

# Contact
contact name=EMITTER
contact name=BASE
contact name=COLLECTOR

# Method
method newton

# Output
output band.param con.band val.band flowline u.bbt

# Save the structure
save outf=assignment_3_1.str
#tonyplot assignment_3_1.str

# Initial solution
solve init
solve vCOLLECTOR=0
```

```
log outfile=assignment_3_VCE_0_IV.log
solve vBASE=0 vstep=0.05 vfinal=0.8 name=BASE
log off

solve init
solve vCOLLECTOR=1
log outfile=assignment_3_VCB_1_IV.log
solve vBASE=0 vstep=0.05 vfinal=0.8 name=BASE
log off

solve init
solve vCOLLECTOR=2
log outfile=assignment_3_VCB_2_IV.log
solve vBASE=0 vstep=0.05 vfinal=0.8 name=BASE
log off

solve init
solve vCOLLECTOR=5
log outfile=assignment_3_VCB_5_IV.log
solve vBASE=0 vstep=0.05 vfinal=0.8 name=BASE
log off

quit
```

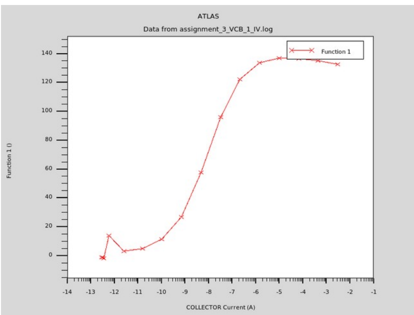
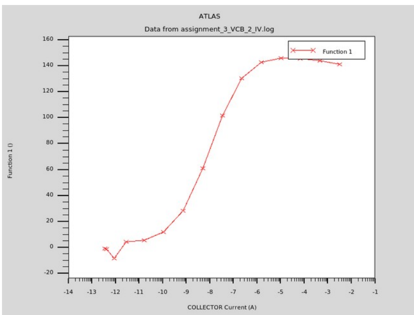
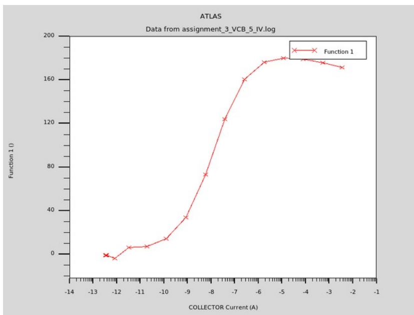
Structure and Meshing

Structure	Meshing
	

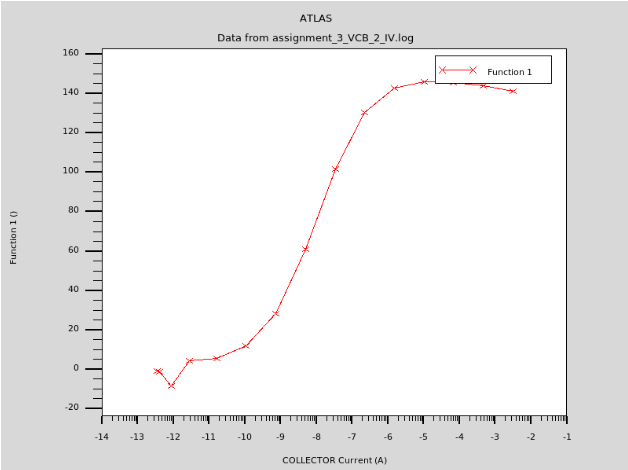
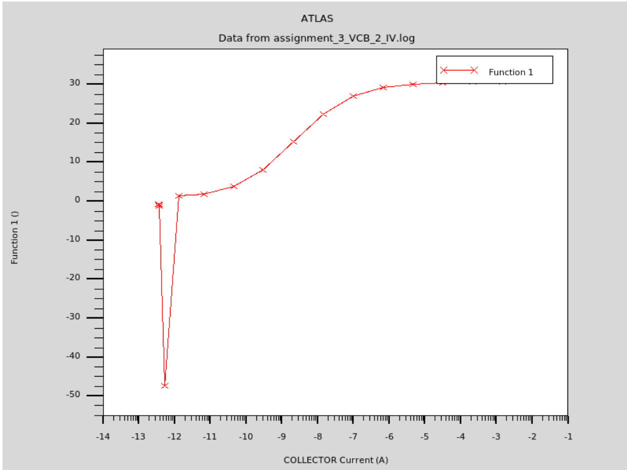
Q1

<table>
<tr><td colspan="2">Plot Gummel plot (log (I C) and log(I B) versus VBE (0- 0.8V))</td></tr>
<tr><td>under VCB = 0 V</td><td>under VCB = 2 V</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Explain the reasons for the differences between the two plots. (base width is 100 nm)</td></tr>
<tr><td colspan="2">The magnitude for base and collector currents increases when adding more voltage to collector is because the revise bias of the collector is increasing so that electrons can freely flow towards the collector. In addition, the dip of the base current is due to recombination.</td></tr>
</table>

Q2

<table>
<tr><td colspan="3">Plot beta versus log (IC) for V BE (0- 0.8V)</td></tr>
<tr><td>VCB = 1 V</td><td>VCB = 2 V</td><td>VCB = 5 V</td></tr>
<tr><td>
</td><td>
</td><td>
</td></tr>
<tr><td colspan="3">Explain the reason for the beta changes. (base width is 100 nm)</td></tr>
<tr><td colspan="3">1. Current gain = ic/ib
- As the voltage at the collector side increases from 0 to 5 V, beta increases drastically.
2. At Vcb=1V
- We have a low current gain when collector voltage is small because we have a low reverse bias.
- Most electrons that passes through the base are recombined before reaching the collector.
3. At Vcb=2V -> 5V
- Current gain increases as reverse bias is increased and the barrier would be even lower.</td></tr>
</table>

Q3

<table>
<tr><td colspan="2">Plot beta versus log (IC) for VBE (0- 0.8V) under VCB = 2 V</td></tr>
<tr><td>base width 100 nm</td><td>base width 200 nm</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Explain the reason for the beta changes</td></tr>
<tr><td colspan="2">Base width increase, current gain decreases.
- As base width increases, the electrons have to travel a great distance before reaching collector.
- Chances of being recombined before reaching the collector increases.
  - Small amount of electrons are able to reach the collector region.
  - If the base width is increased even further like double, no electrons can reach the collector.</td></tr>
</table>