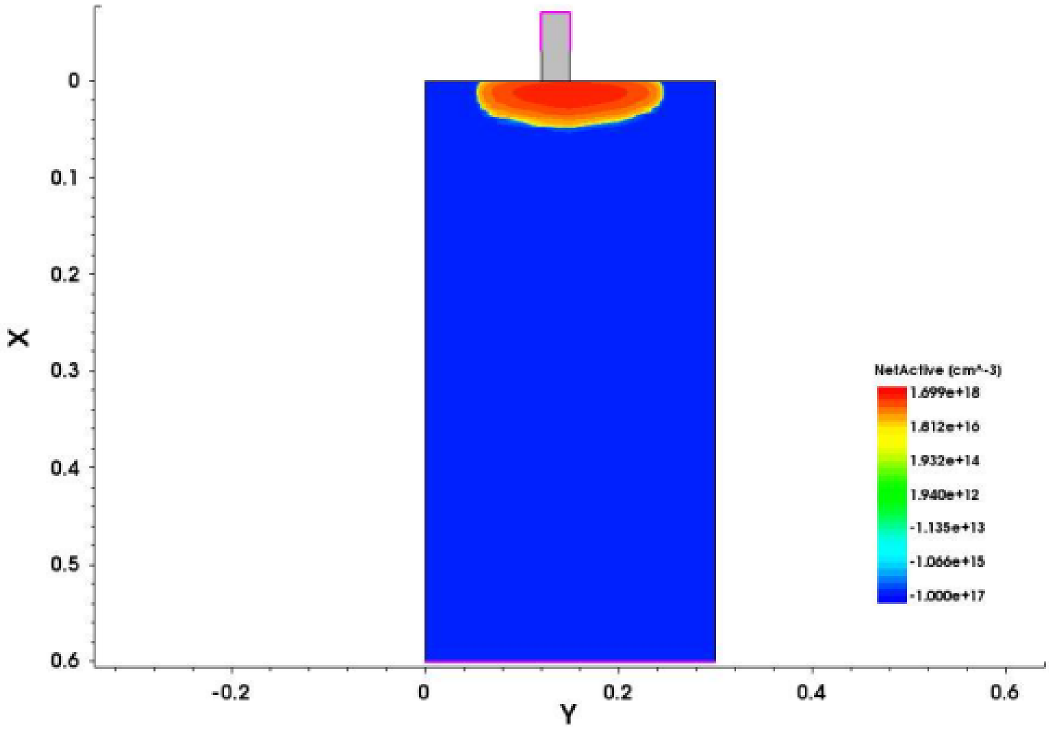
Q.1: You need to make a pn junction in sprocess with the structure roughly as shown below:



You need to use Boron for p type substrate and then implant P for getting n region. The dose and energy should be adjusted to get a peak concentration close to 1e18 cm-3 and a junction depth of 50 nm.

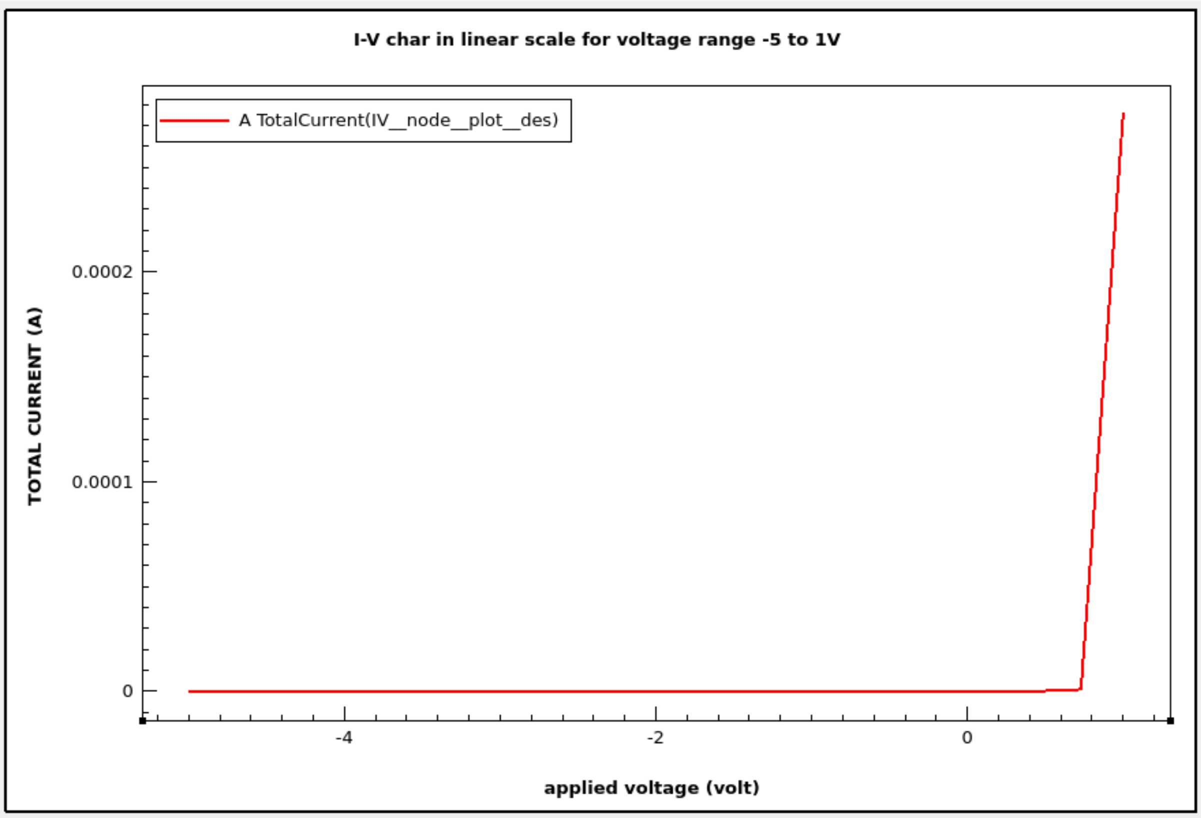
Plot the IV characteristics of the device for a voltage range of -5 V to 1 V in the linear as well as log scale. Plot the energy band diagrams, carrier concentrations and electron and hole components of the currents for different voltages, namely -1 V, 0 V, 0.2 V and 1 V.

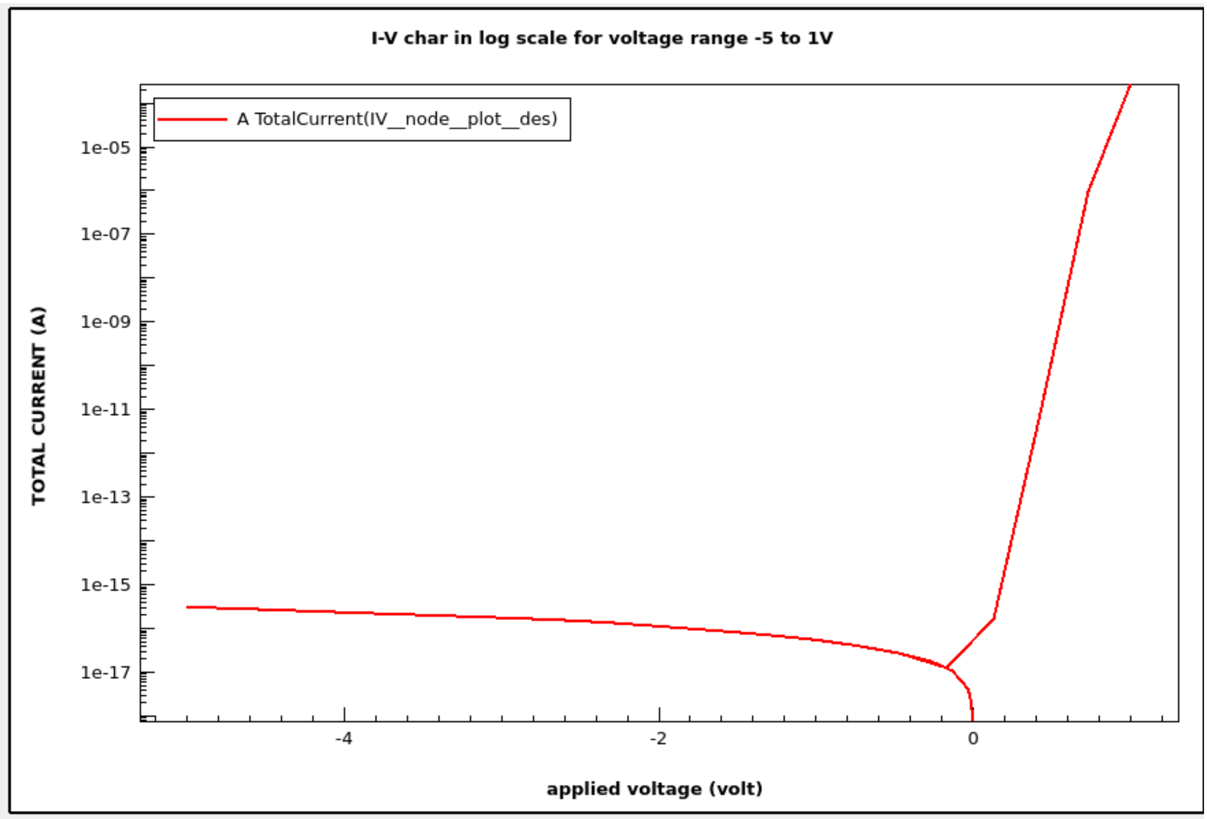
Note the reverse saturation current, compare it with what you expect theoretically? Note the slope of log(I) vs V in different regions in forward bias and compare it with what you expect theoretically. Plot the CV characteristics in reverse bias for 0 to -10 V, use a low frequency of 1 KHz. Also plot 1/C2

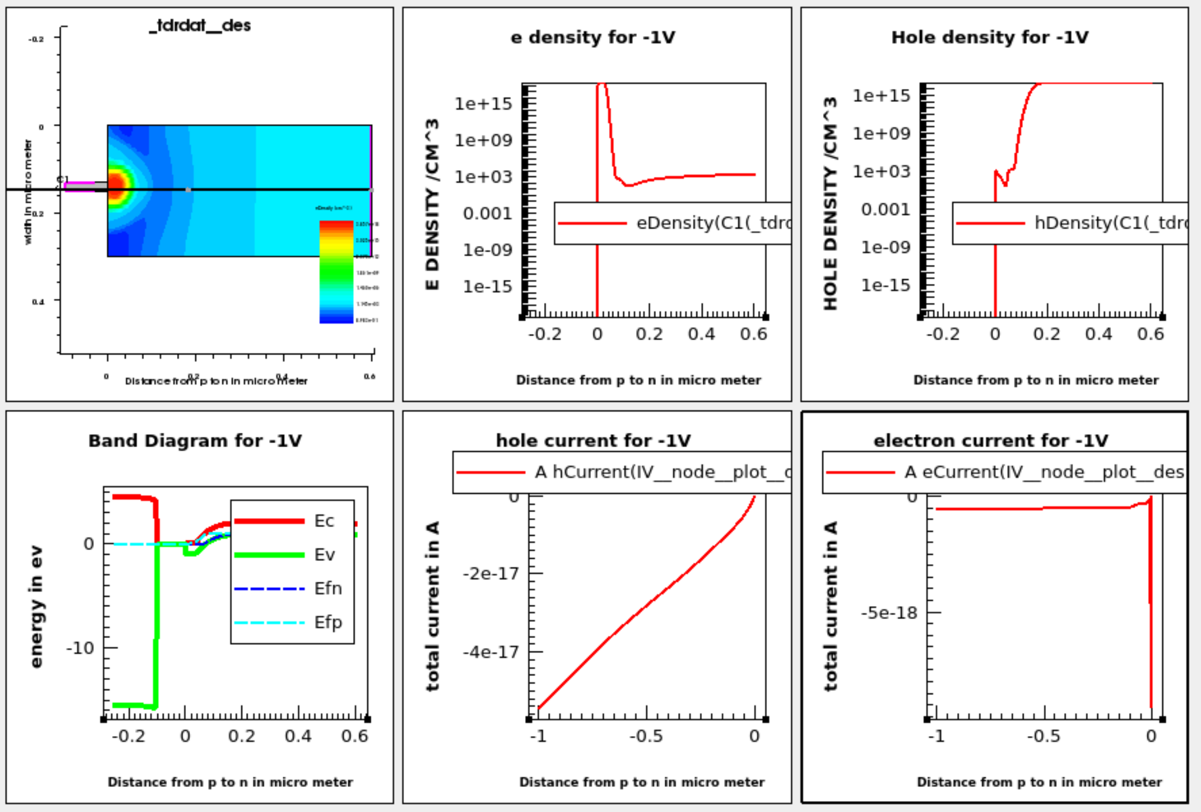
vs V and

check the nature of this curve. Also plot the CV characteristics in forward bias for 0 to 1 V.

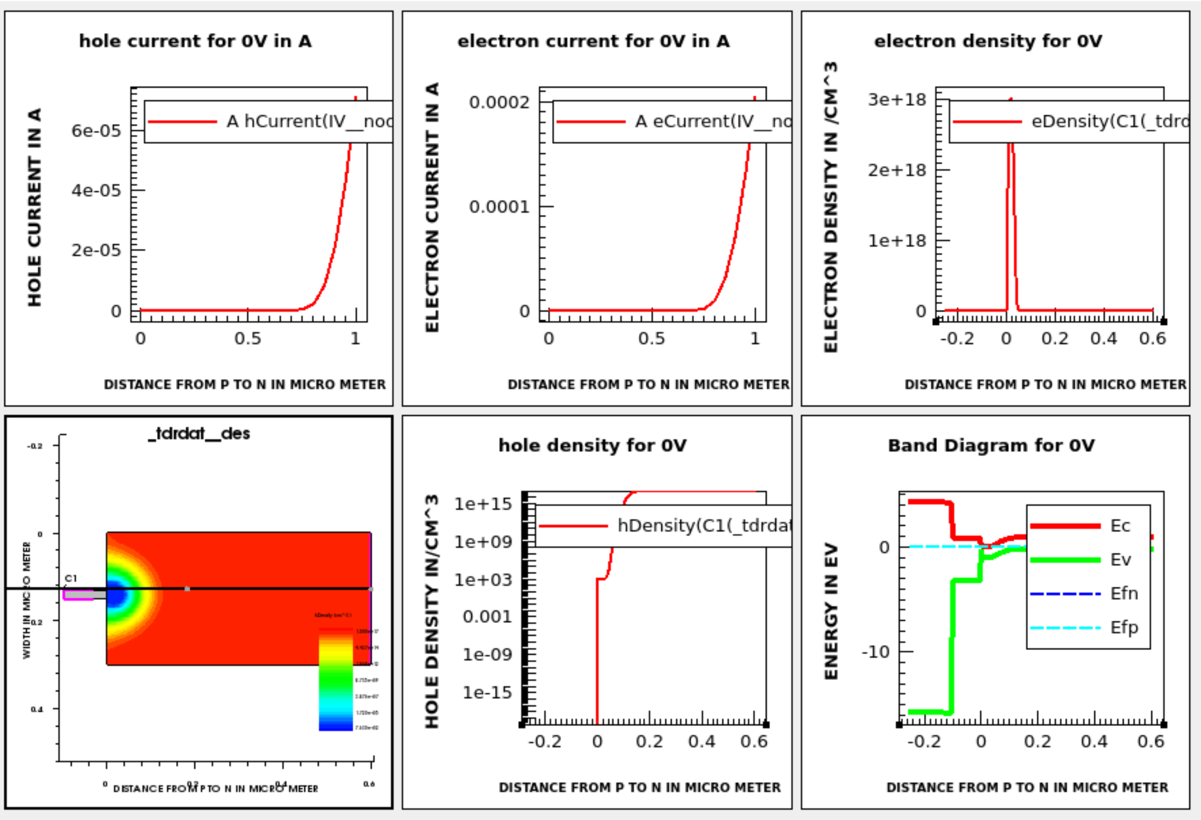
ans :


I-V char in linear scale for voltage range -5 to 1V
A TotalCurrent(IV__node__plot__des)
0.0002
0.0001
0
-4
-2
0
TOTAL CURRENT (A)
applied voltage (volt)

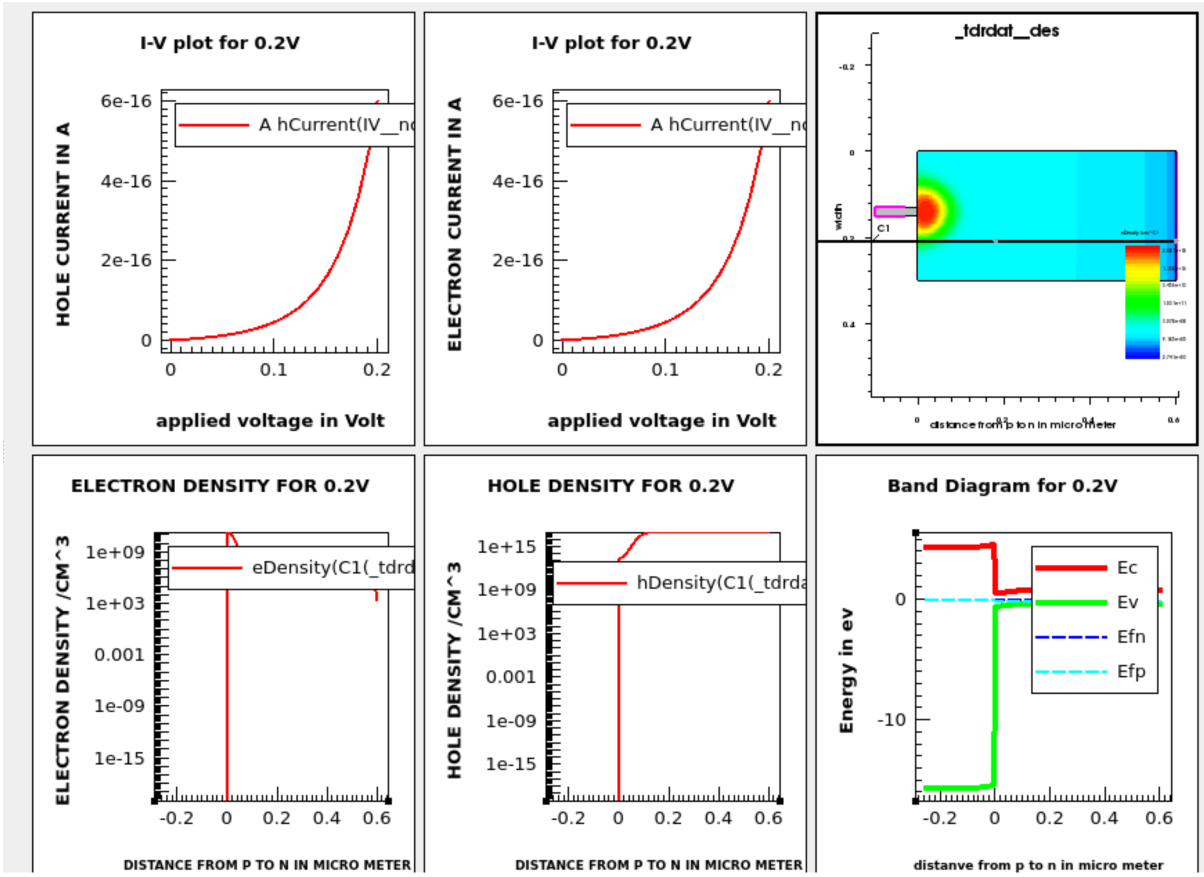

I-V char in log scale for voltage range -5 to 1V
A TotalCurrent(IV__node__plot__des)
1e-05
1e-07
1e-09
1e-11
1e-13
1e-15
1e-17
-4
-2
0
TOTAL CURRENT (A)
applied voltage (volt)

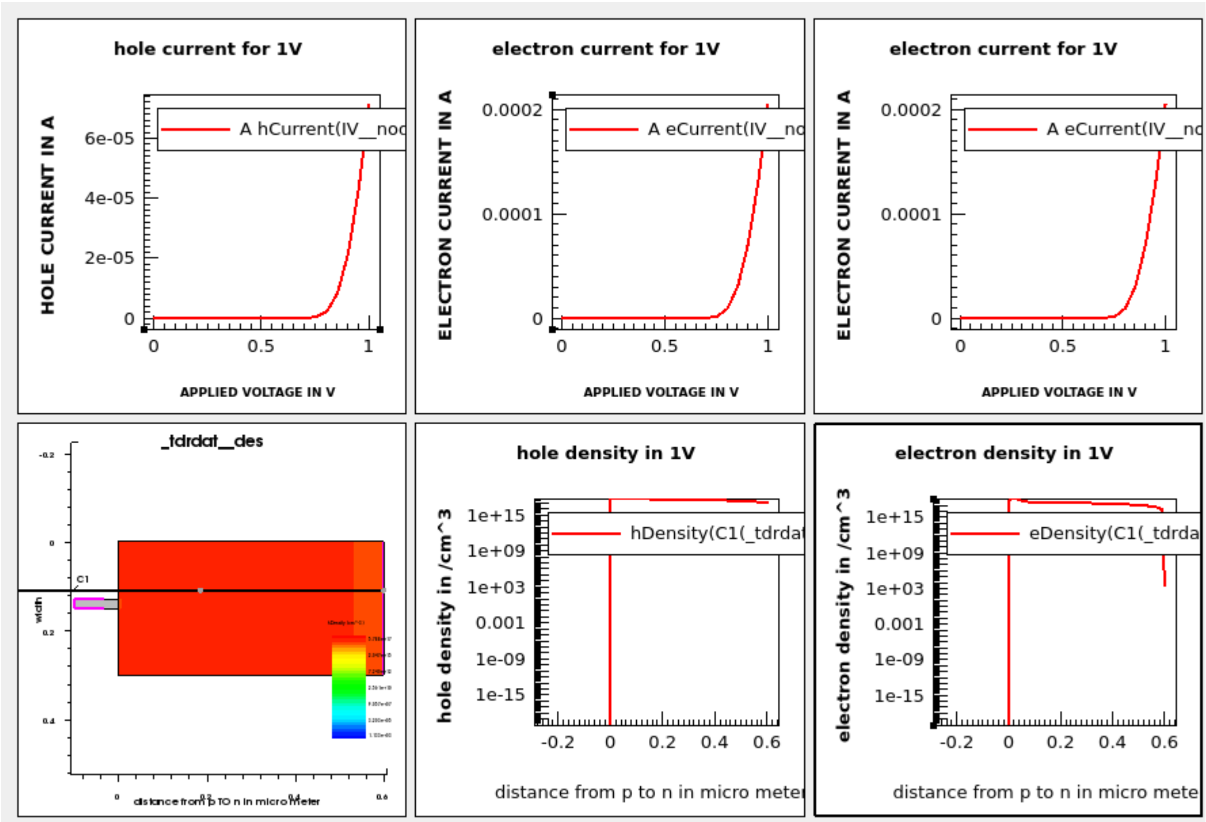


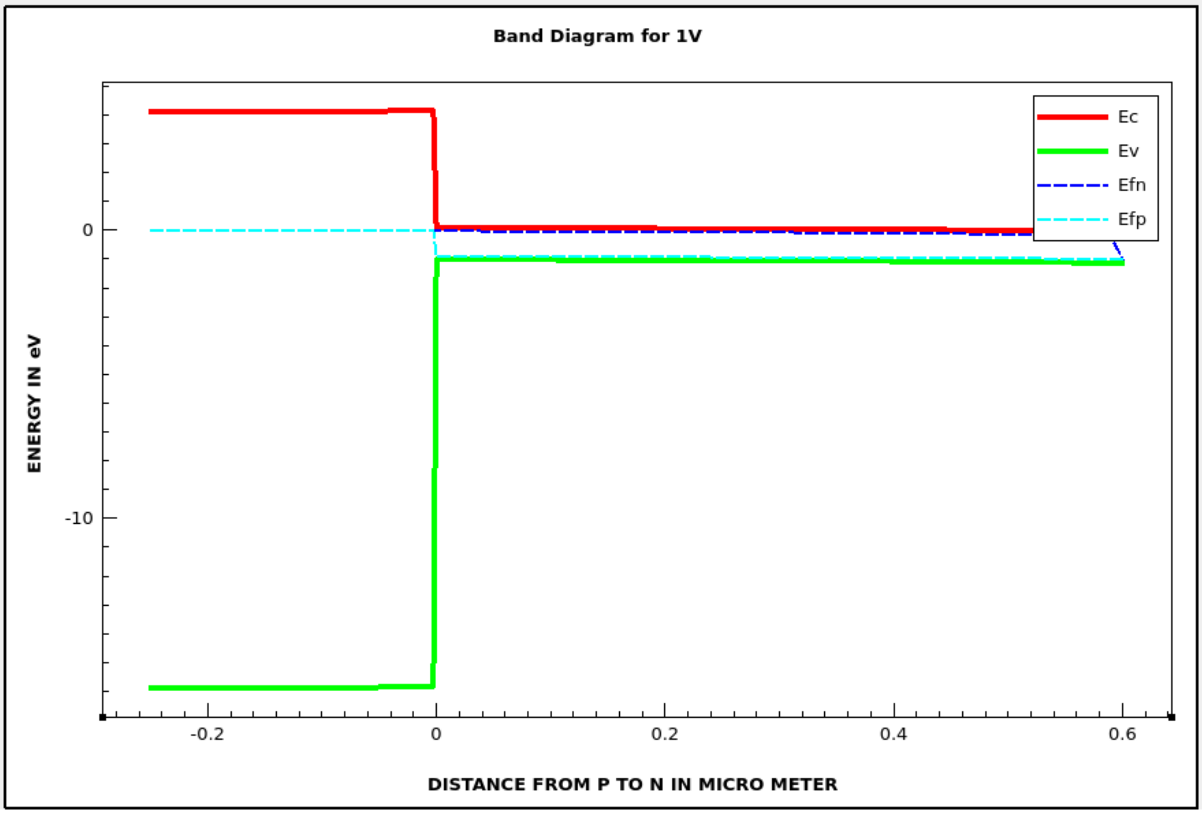
_tdrdat__des
width in micro meter
Distance from p to n in micro meter
e density for -1V
E DENSITY /CM^3
eDensity(C1(_tdrd
Distance from p to n in micro meter
Hole density for -1V
HOLE DENSITY /CM^3
hDensity(C1(_tdrd
Distance from p to n in micro meter
Band Diagram for -1V
energy in ev
Ec
Ev
Efn
Efp
Distance from p to n in micro meter
hole current for -1V
total current in A
A hCurrent(IV__node__plot__d
Distance from p to n in micro meter
electron current for -1V
total current in A
A eCurrent(IV__node__plot__des
Distance from p to n in micro meter



hole current for 0V in A
HOLE CURRENT IN A
A hCurrent(IV__noc
DISTANCE FROM P TO N IN MICRO METER
electron current for 0V in A
ELECTRON CURRENT IN A
A eCurrent(IV__no
DISTANCE FROM P TO N IN MICRO METER
electron density for 0V
ELECTRON DENSITY IN /CM^3
eDensity(C1(_tdrd
DISTANCE FROM P TO N IN MICRO METER
_tdrdat__des
C1
DISTANCE FROM P TO N IN MICRO METER
hole density for 0V
HOLE DENSITY IN/CM^3
hDensity(C1(_tdrdat
DISTANCE FROM P TO N IN MICRO METER
Band Diagram for 0V
ENERGY IN EV
Ec
Ev
Efn
Efp
DISTANCE FROM P TO N IN MICRO METER


I-V plot for 0.2V
HOLE CURRENT IN A
A hCurrent(IV__no
applied voltage in Volt
I-V plot for 0.2V
ELECTRON CURRENT IN A
A hCurrent(IV__no
applied voltage in Volt
_tdrdat_des
width
C1
distance from p to n in micro meter
ELECTRON DENSITY FOR 0.2V
ELECTRON DENSITY /CM^3
eDensity(C1(_tdrd
DISTANCE FROM P TO N IN MICRO METER
HOLE DENSITY FOR 0.2V
HOLE DENSITY /CM^3
hDensity(C1(_tdrda
DISTANCE FROM P TO N IN MICRO METER
Band Diagram for 0.2V
Energy in ev
Ec
Ev
Efn
Efp
distanve from p to n in micro meter


hole current for 1V
HOLE CURRENT IN A
A hCurrent(IV__no
APPLIED VOLTAGE IN V
electron current for 1V
ELECTRON CURRENT IN A
A eCurrent(IV__no
APPLIED VOLTAGE IN V
electron current for 1V
ELECTRON CURRENT IN A
A eCurrent(IV__no
APPLIED VOLTAGE IN V
_tdrdat_des
width
C1
distance from p TO n in micro meter
hole density in 1V
hole density in /cm^3
hDensity(C1(_tdrdat
distance from p to n in micro meter
electron density in 1V
electron density in /cm^3
eDensity(C1(_tdrda
distance from p to n in micro mete


Band Diagram for 1V
Ec
Ev
Efn
Efp
ENERGY IN eV
0
-10
-0.2
0
0.2
0.4
0.6
DISTANCE FROM P TO N IN MICRO METER

theoretically:-

$$I_0 = qA\,n_i^2 \left[\frac{D_p}{L_p N_A} + \frac{D_n}{L_n N_D}\right]$$

where A = total length x width

$L_p = \sqrt{D_p \tau_p}$, $L_n = \sqrt{D_n \tau_n}$, $n_i = 1.5\times10^{10}$, $\mu_n = 1417\ cm^2/Vsec$,

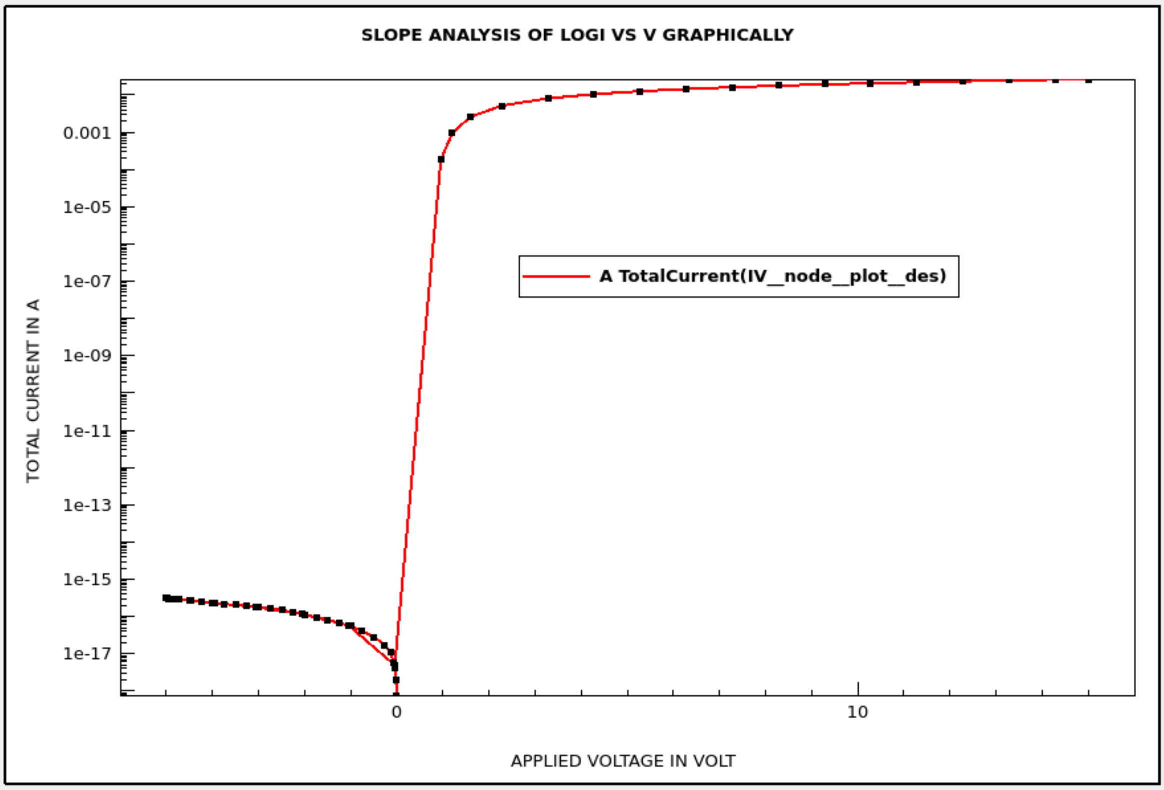
$\mu_p = 470\ cm^2/Vsec$, $V_T = 0.0258$, $q = 1.6\times10^{-19}$, $N_D = N_A = 10^{18}$

$\tau_p = 0.25\times10^{-12}$, $\tau_n = 0.3\times10^{-12}$

$I_0 = 5.8\times10^{-16}$ Amp.

By graphically

$I_0 = 8\times10^{-16}$ Amp.



Graphically:

Reg (1)

Reg ① Pt ① $(7.49\times10^{-1}, 6.27\times10^{-8})$ Pt ② $(6.62\times10^{-1}, 1.14\times10^{-8})$

$$\text{Slope} = \frac{1.4\times10^{-8}-6.27\times10^{-8}}{6.62\times10^{-1}-7.49\times10^{-1}} = \frac{-4.97\times10^{-8}}{-0.86\times10^{-1}} = 5.77\times10^{-7}$$

Pt ① $(9.79\times10^{-1}, 1.79\times10^{-4})$, Pt ② $(1.23, 9.2\times10^{-4})$

$$\text{Slope} = \frac{y_2-y_1}{x_2-x_1} = \frac{9.2\times10^{-4}-1.79\times10^{-4}}{1.23-.979} = 29.52\times10^{-4}$$

Reg ② Pt ① $(2.3, 5.14\times10^{-3})$ Pt ② $(3.30, 7.74\times10^{-3})$

$$\text{Slope} = \frac{y_2-y_1}{x_2-x_1} = \frac{7.74\times10^{-3}-5.14\times10^{-3}}{3.3-2.3} = 2.6\times10^{-3}$$

Reg ③ Pt ① $(6.29, 1.26\times10^{-2})$ Pt ② $(7.29, 1.6\times10^{-2})$

$$\text{Slope} = \frac{y_2-y_1}{x_2-x_1} = \frac{1.6\times10^{-2}-1.26\times10^{-2}}{7.29-6.29} = \frac{0.34\times10^{-2}}{1}$$

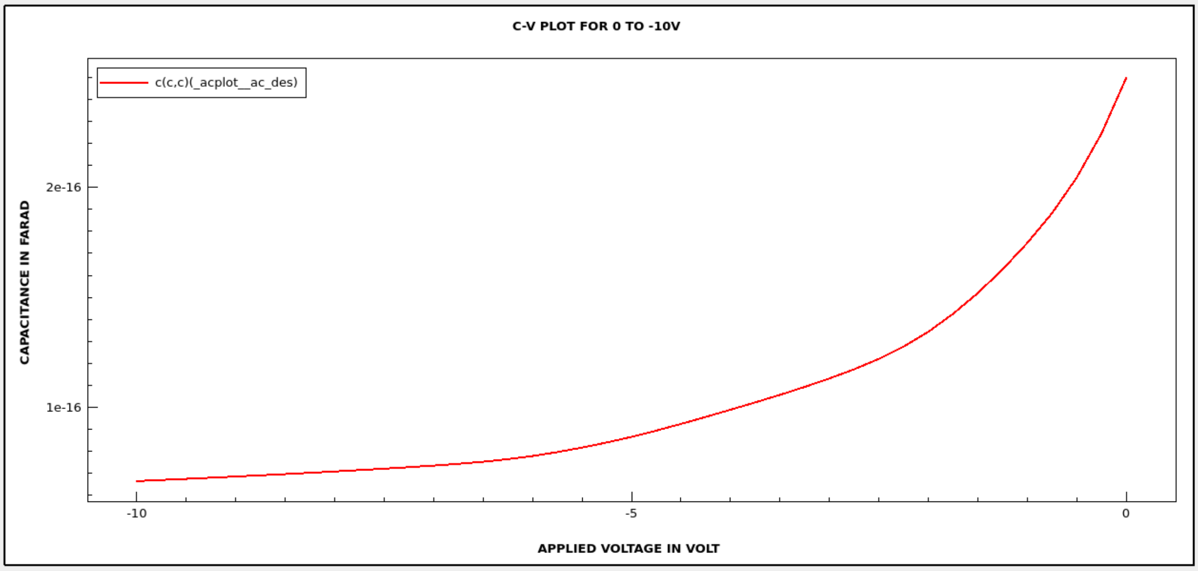
Theoretically:

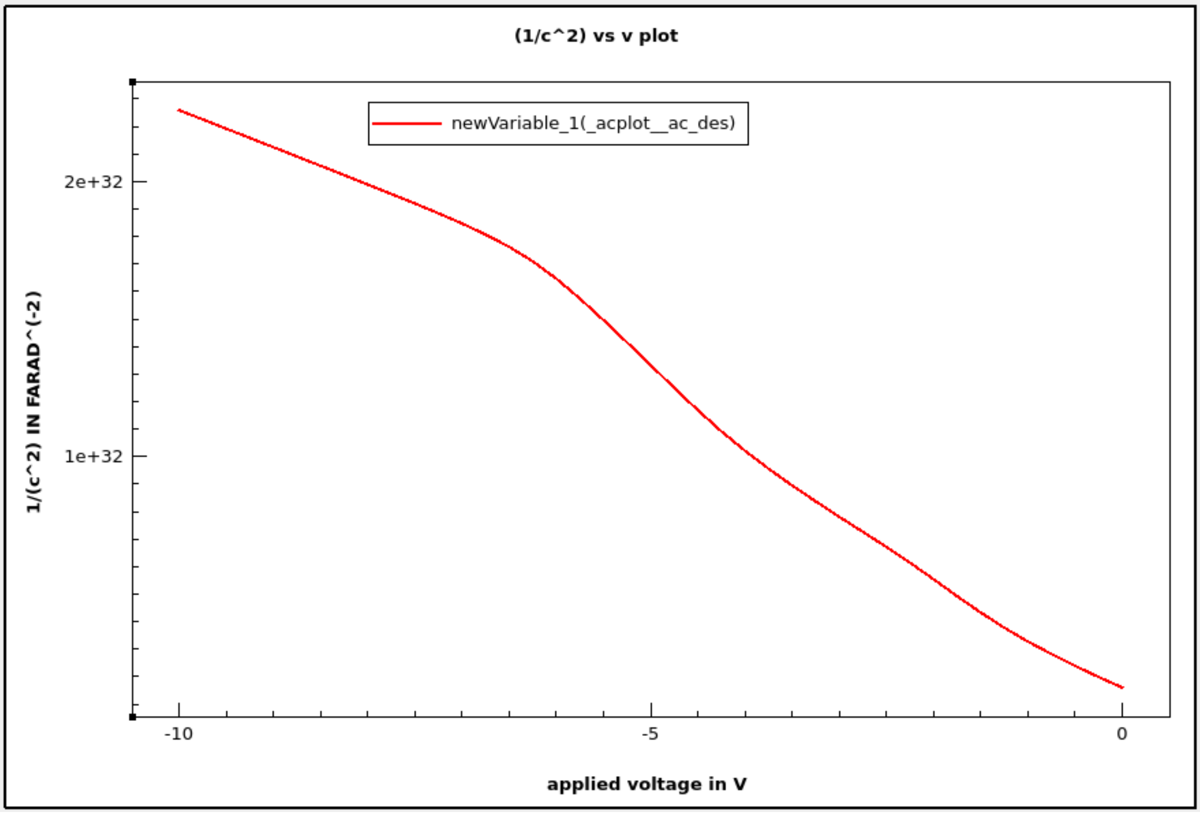
$$I = I_0\left(e^{V/V_T}-1\right)$$

$$\approx \quad I = I_0\, e^{V/V_T}$$

$$\log I = \log I_0 + V/V_T$$

$$\text{Slope} = 1/V_T = 1/0.0258 = 38.759$$





Nature of slope first decreases till around -5 then increases.