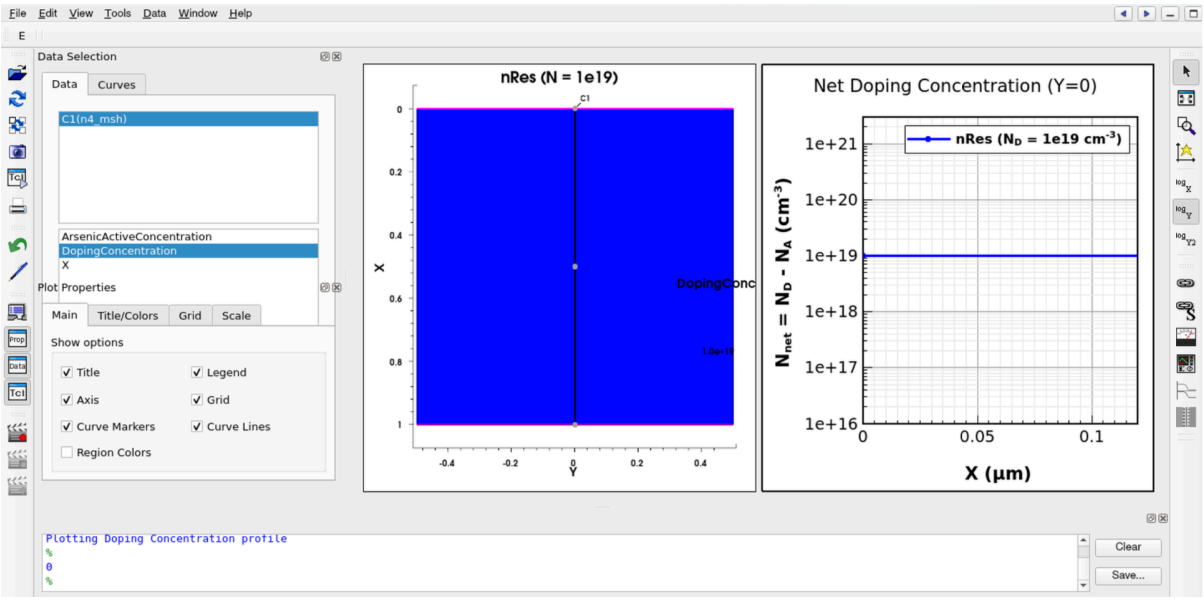
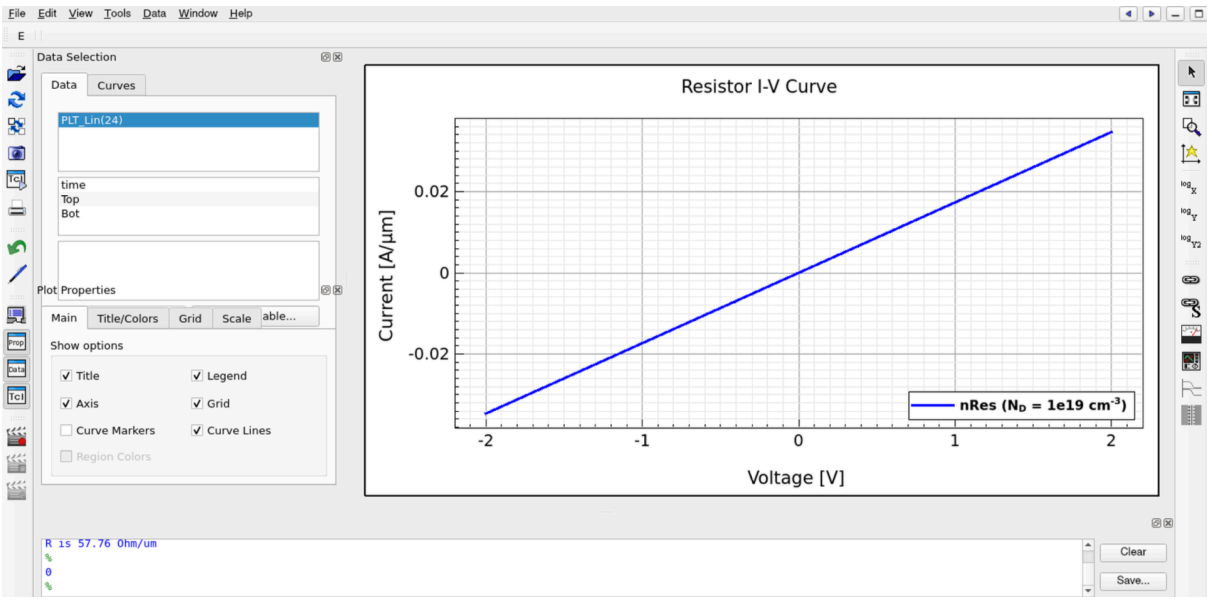
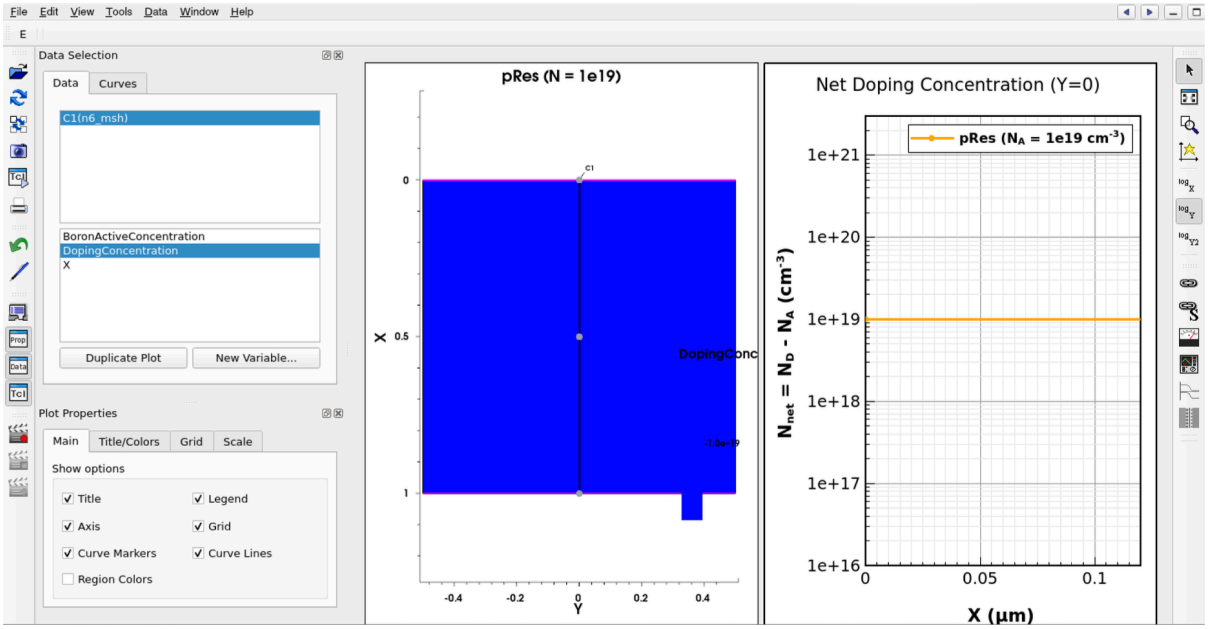
Supriya Anand Mishra - 24b1312
Semiconductor Fab 101
Tcad Resistor analysis



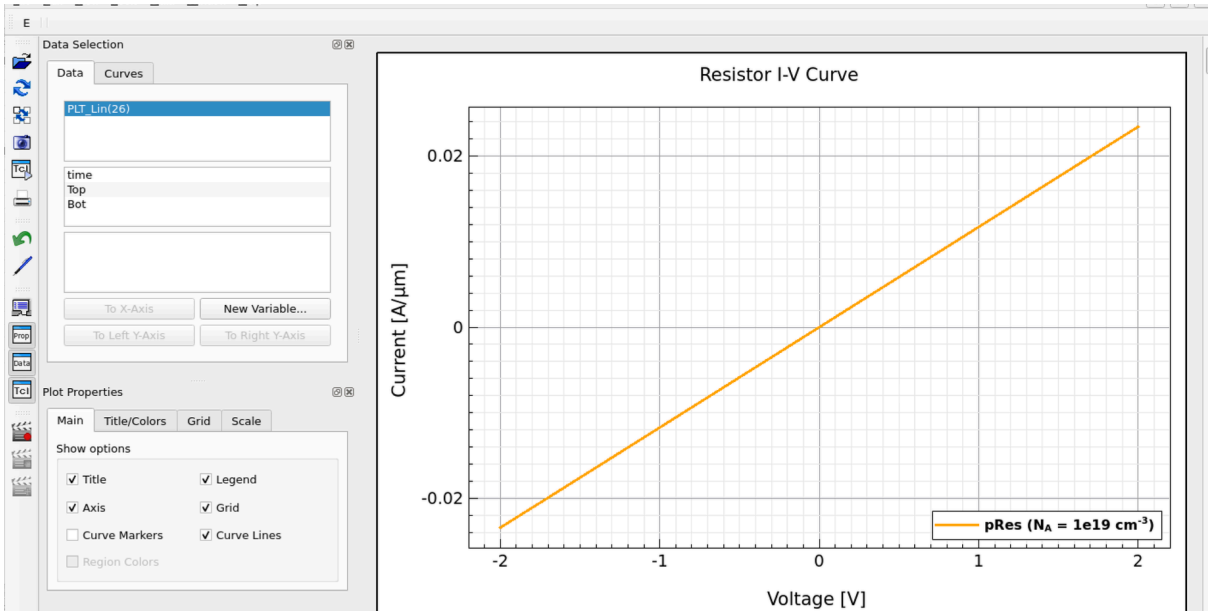
Sde plot for n type doping



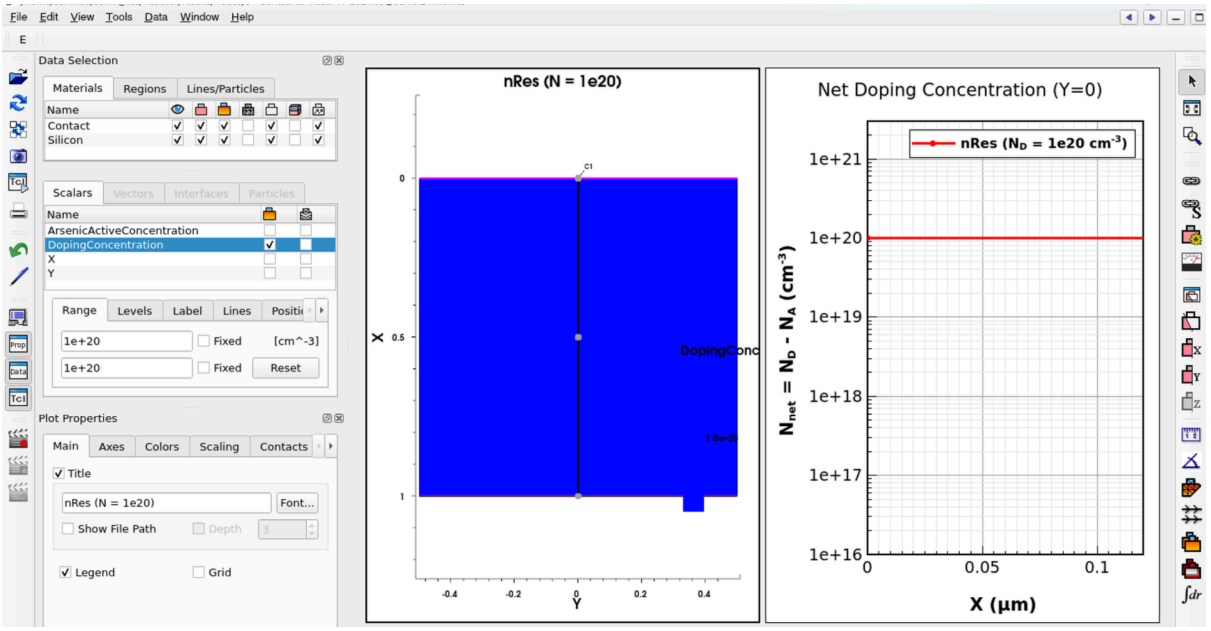
Iv plot for n type doping



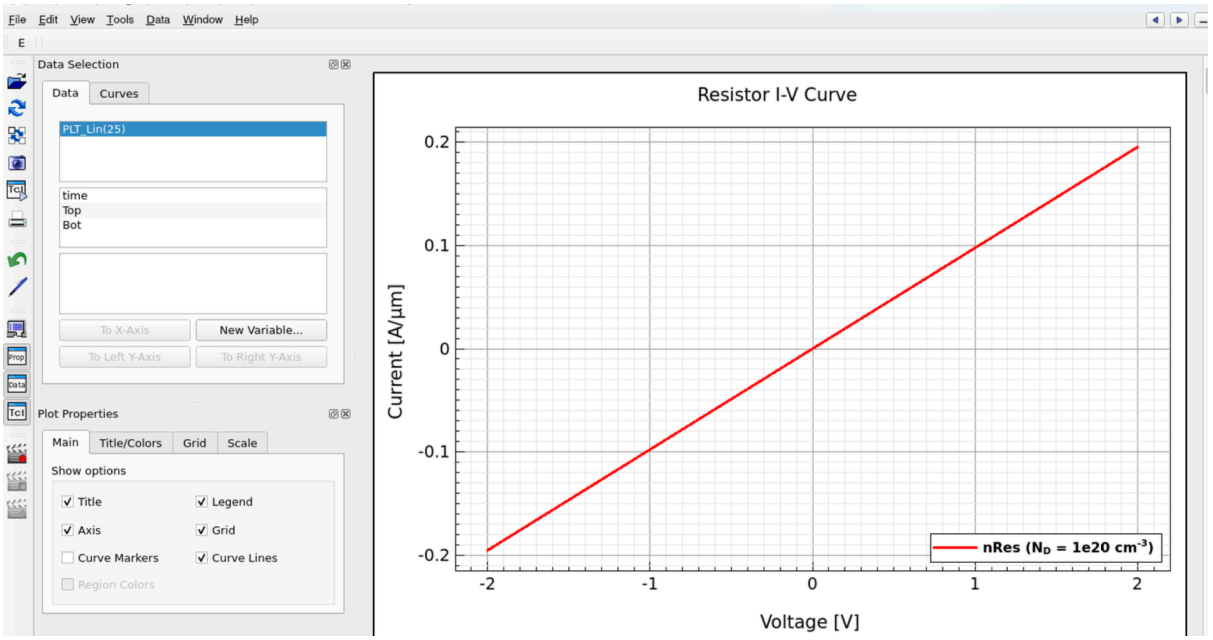
Sde plot for p type doping



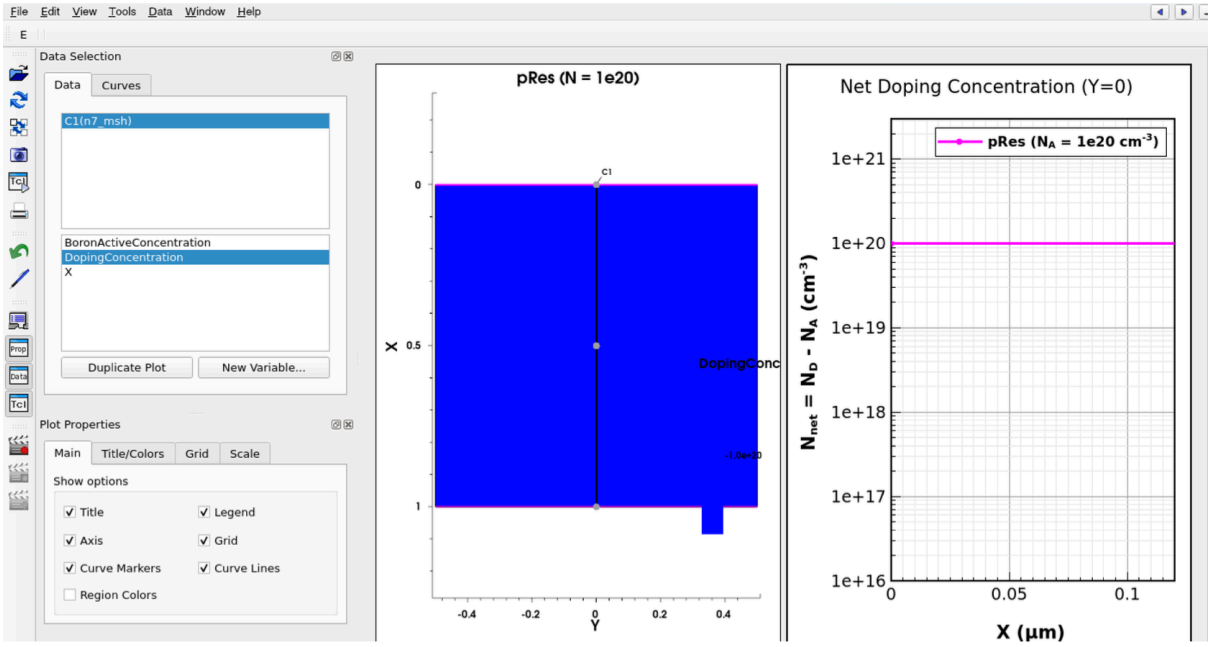
Iv plot for p type doping



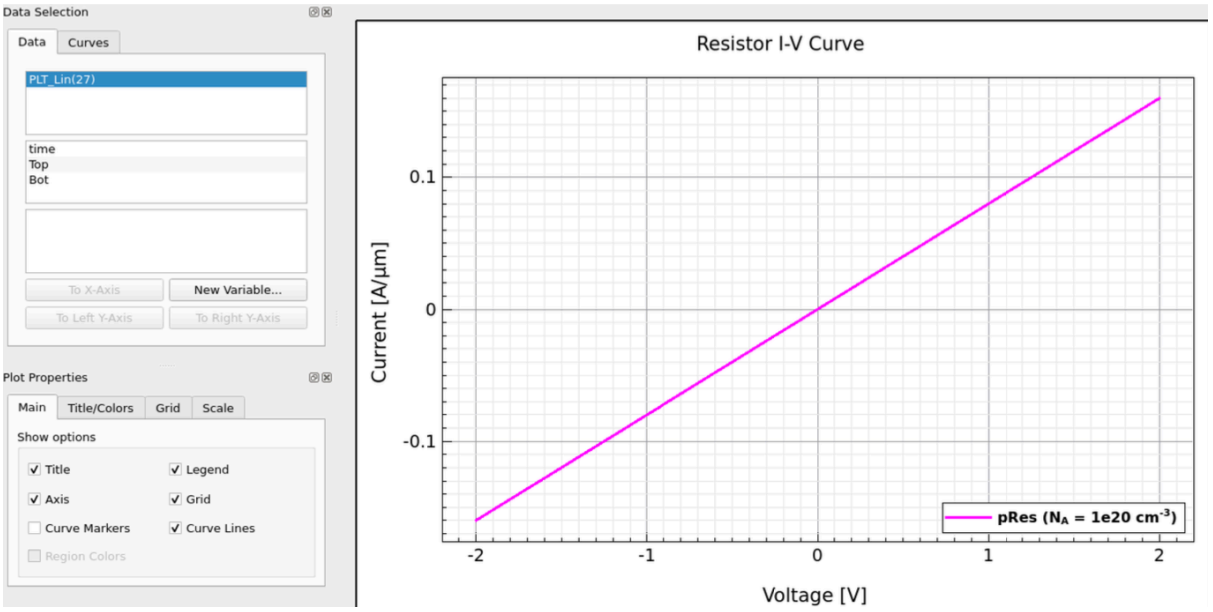
Sde plot for n type doping



Iv plot for p type doping



Sde plot for p type doping



Iv plot for p type doping

Table 1: Resistance Values for n-type and p-type Resistors

Block	Doping (cm^{-3})	Vneg (V)	Vpos (V)	Resistance (Ω)
nRes	1×10^{19}	-2	2	57.76
nRes	1×10^{20}	-2	2	10.25
pRes	1×10^{19}	-2	2	85.31
pRes	1×10^{20}	-2	2	12.52

Observation

Effect of Doping on SDE Plot

- The structure geometry remains the same for both doping values.
- The color intensity in the resistor region increases as doping concentration increases.
- Higher doping (e.g., 1×10^{20} cm^{-3}) appears darker compared to lower doping (1×10^{19} cm^{-3}).

Inference:
Increasing the n-type doping concentration increases the electron concentration in the resistor region. This change is reflected in the SDE plot through higher color intensity, while the physical structure of the device remains unchanged.

Effect of Doping on IV Plot

- The IV curves are linear, indicating ohmic behavior.
- For higher doping concentration, the slope of the IV curve is steeper.
- Lower doping shows smaller current for the same applied voltage.
- The extracted resistance decreases with an increase in doping concentration.

Comparison of nRes and pRes for Doping Concentration 1e19 cm^{-3}

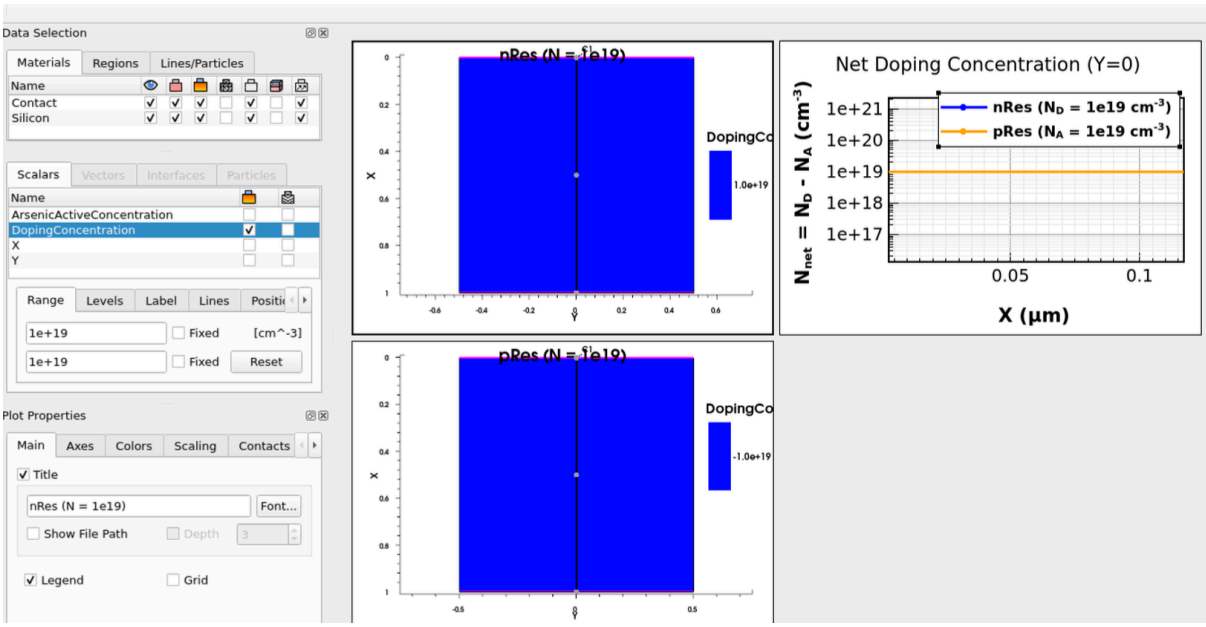
SDE Plot

- Both n-type and p-type resistors exhibit identical physical geometry in the SDE plots.
- The difference lies only in the type of dopant introduced.
- Although the structure dimensions remain unchanged, the color distribution differs due to variations in carrier type and concentration.

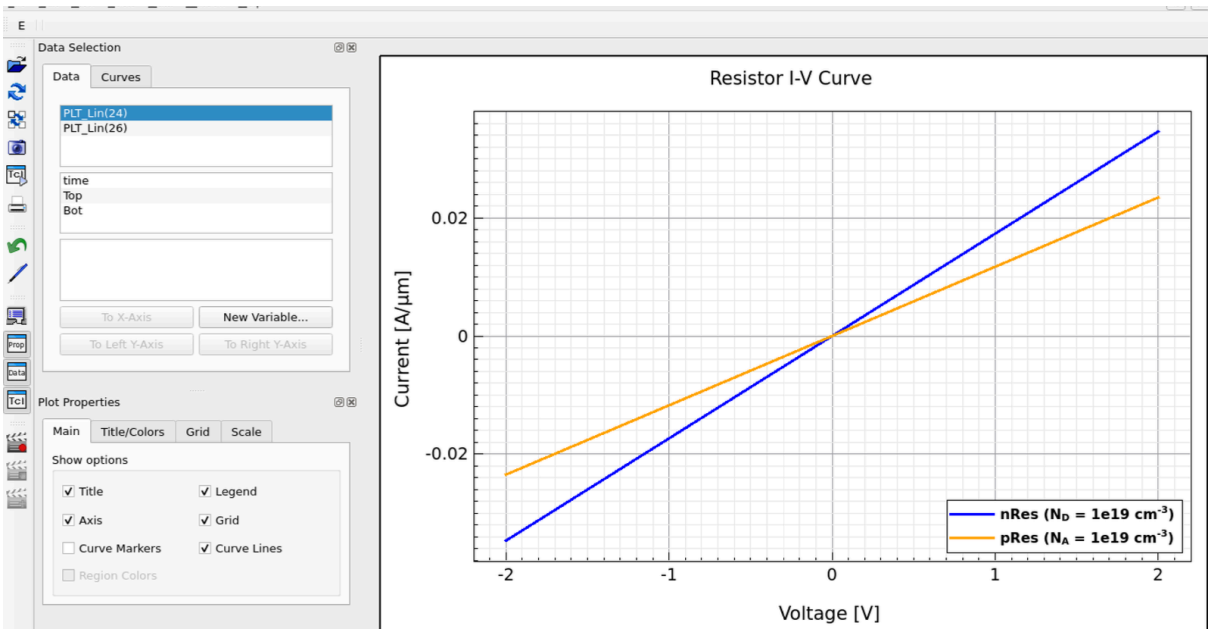
IV Plot

- The IV characteristics of both nRes and pRes show linear behavior, confirming ohmic conduction.
- The slope of the IV curve for the n-type resistor is steeper than that of the p-type resistor.
- For the same applied voltage, the n-type resistor allows higher current flow.

Inference:
At a doping concentration of 1e19, both n-type and p-type resistors exhibit linear IV characteristics, confirming ohmic behavior. However, the n-type resistor shows lower resistance than the p-type resistor due to higher electron mobility. The SDE plots confirm that the observed electrical differences arise from carrier type rather than changes in physical structure.



Sde plot for n res and p res



Iv plot for n res and p res

Comparison of nRes and pRes for Doping Concentration 1e20 cm^{-3}

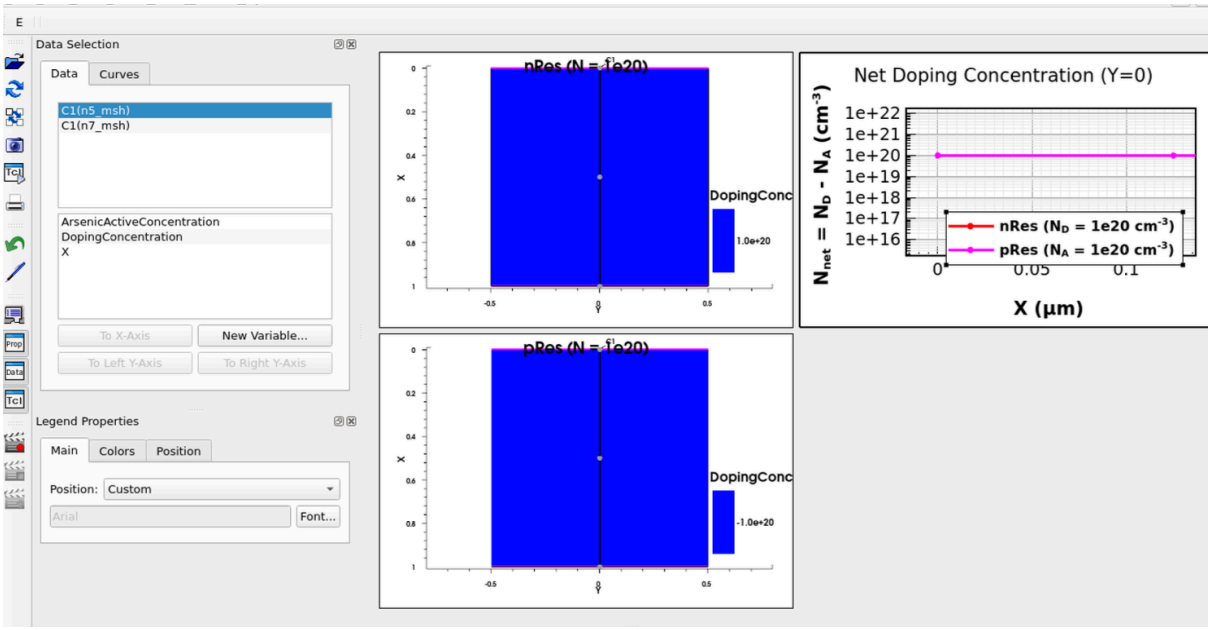
SDE Plot

- Both show increased dopant concentration compared to 1e19.
- Structural dimensions remain unchanged.

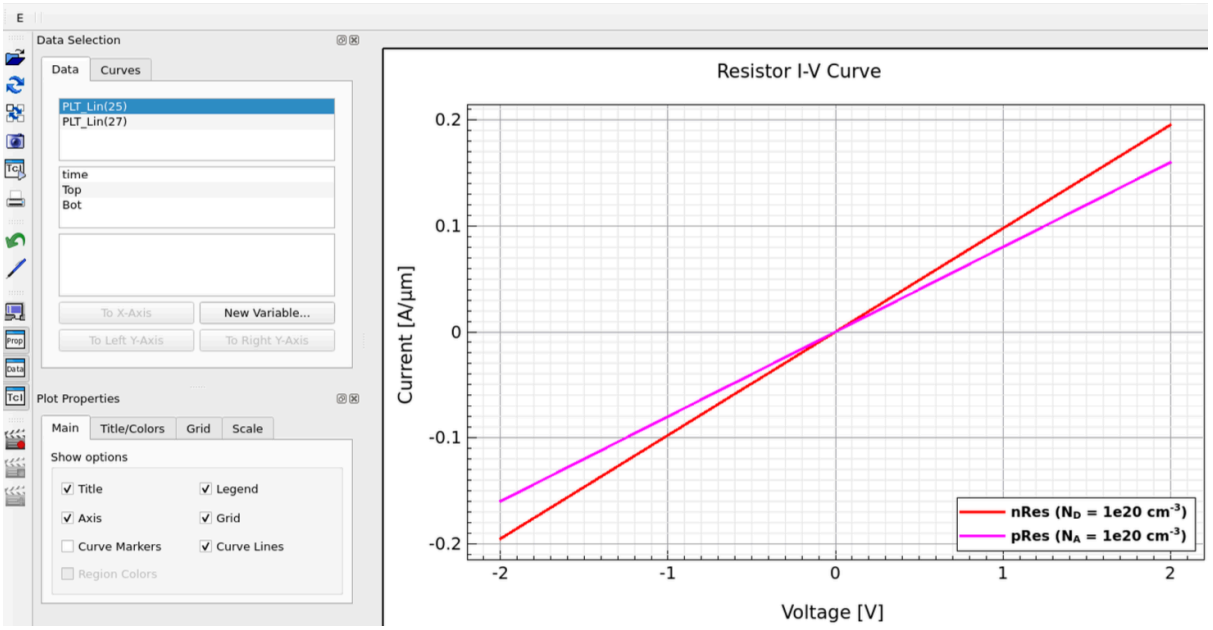
IV Plot

- Both nRes and pRes show higher current than at 1e19.
- nRes still has a steeper slope.
- Resistance further decreases for both.

Inference:
Increasing doping increases carrier density without affecting physical structure. At higher doping levels, resistance decreases further due to increased carrier concentration. However, n-type resistors consistently show lower resistance because of higher electron mobility.



Sde plot for n res and p res



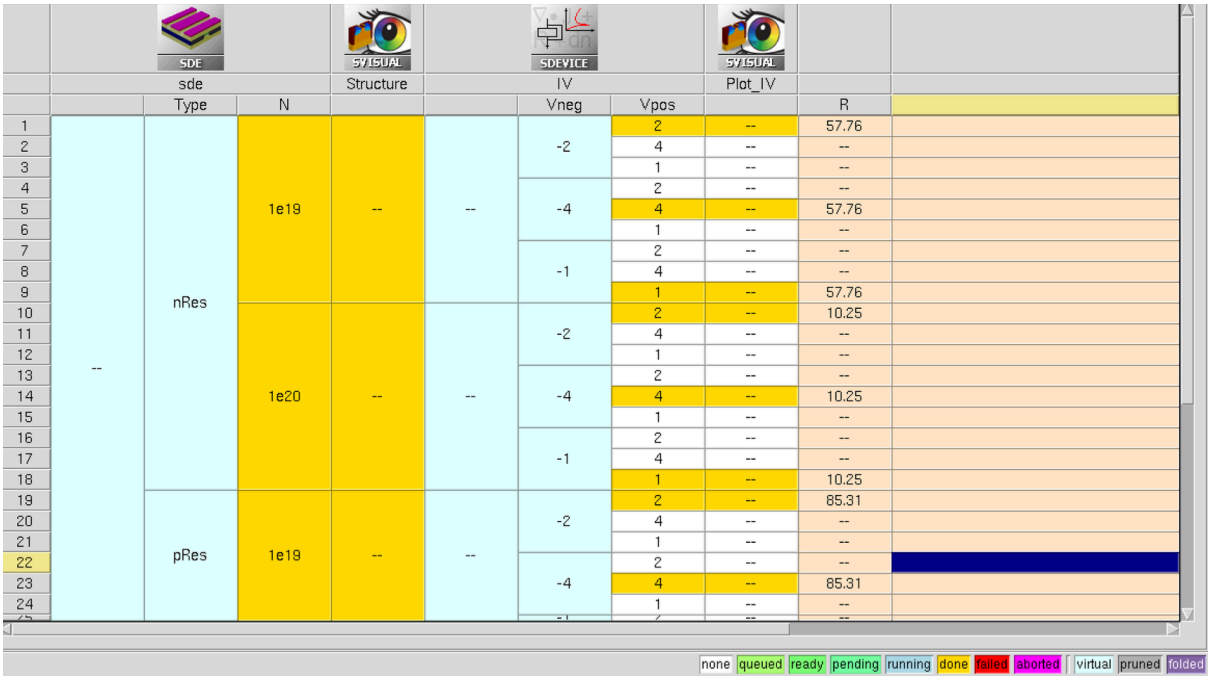
Iv plot for n res and p res

Task 1

To analyze the effect of varying the applied voltage range (±1 V and ±4 V) on the resistance and IV characteristics of n-type and p-type resistors, and to verify that the physical structure and resistance remain unchanged.

Table 2: Resistance Values for n-type and p-type Resistors

Block	Doping (cm^{-3})	Vneg (V)	Vpos (V)	Resistance (Ω)
nRes	1×10^{19}	-4	4	57.76
nRes	1×10^{19}	-1	1	57.76
nRes	1×10^{20}	-4	4	10.25
nRes	1×10^{20}	-1	1	10.25
pRes	1×10^{19}	-4	4	85.31
pRes	1×10^{19}	-1	1	85.31
pRes	1×10^{20}	-4	4	12.52
pRes	1×10^{20}	-1	1	12.52

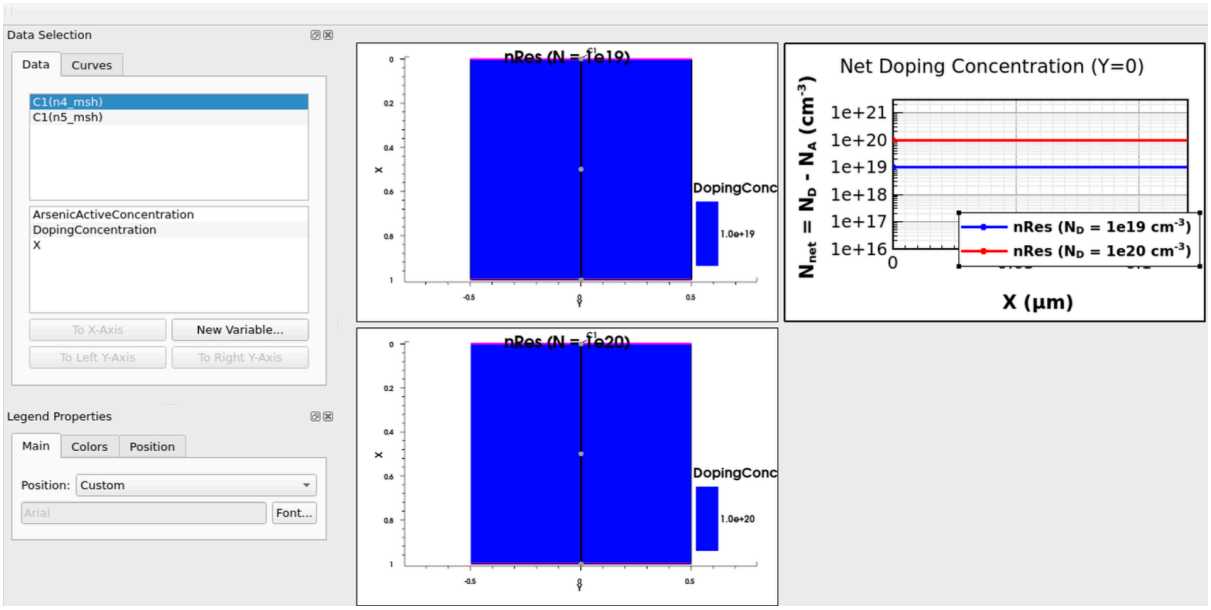


	SDE			SVISUAL	SDEVICE			SVISUAL	
	sde			Structure	IV			Plot_IV	
		Type	N			Vneg	Vpos		R
1	--	nRes	1e19	--	--	-2	2	--	57.76
2							4	--	--
3							1	--	--
4						-4	2	--	--
5							4	--	57.76
6							1	--	--
7						-1	2	--	--
8							4	--	--
9							1	--	57.76
10			1e20	--	--	-2	2	--	10.25
11							4	--	--
12							1	--	--
13						-4	2	--	--
14							4	--	10.25
15							1	--	--
16						-1	2	--	--
17							4	--	--
18							1	--	10.25
19		pRes	1e19	--	--	-2	2	--	85.31
20							4	--	--
21							1	--	--
22						-4	2	--	--
23							4	--	85.31
24							1	--	--

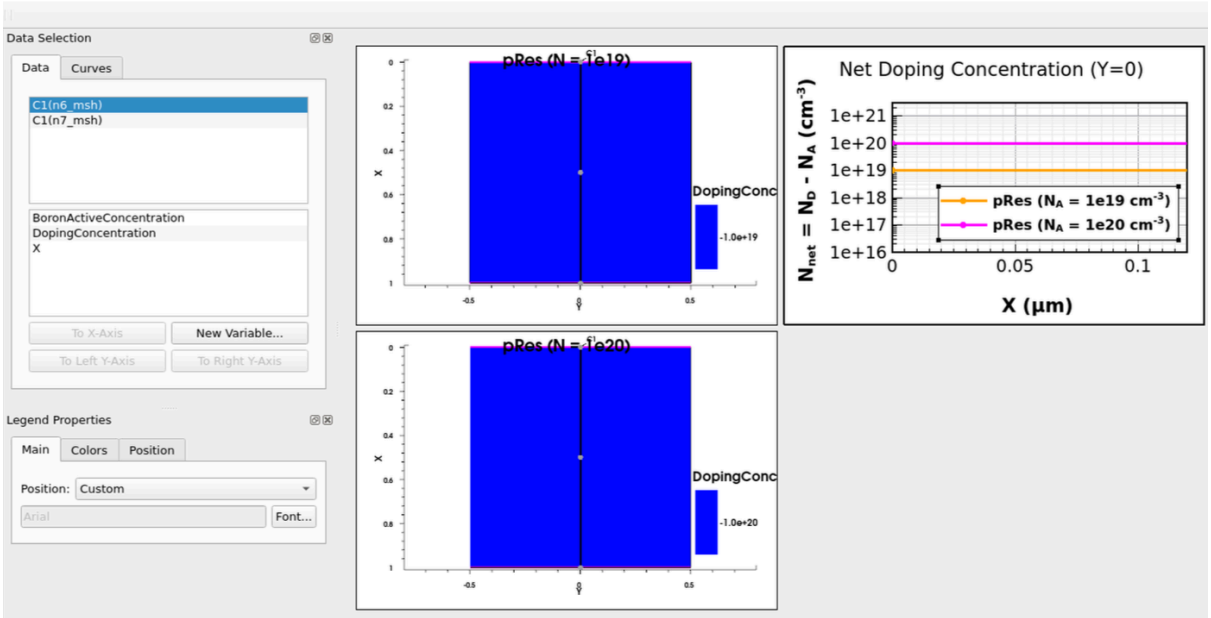
none queued ready pending running done failed aborted | virtual pruned folded

SDE			VISUAL	SDEVICE			VISUAL	
sde			Structure	IV			Plot_IV	
	Type	N			Vneg	Vpos		R
--	nRes	1e20	--	--	-4	1	--	--
					-1	2	--	--
						4	--	--
						1	--	10.25
	pRes	1e19	--	--	-2	2	--	85.31
						4	--	--
						1	--	--
					-4	2	--	--
						4	--	85.31
						1	--	--
					-1	2	--	--
						4	--	--
						1	--	85.31
		1e20	--	--	-2	2	--	12.52
						4	--	--
						1	--	--
					-4	2	--	--
						4	--	12.52
						1	--	--
					-1	2	--	--
						4	--	--
						1	--	12.52

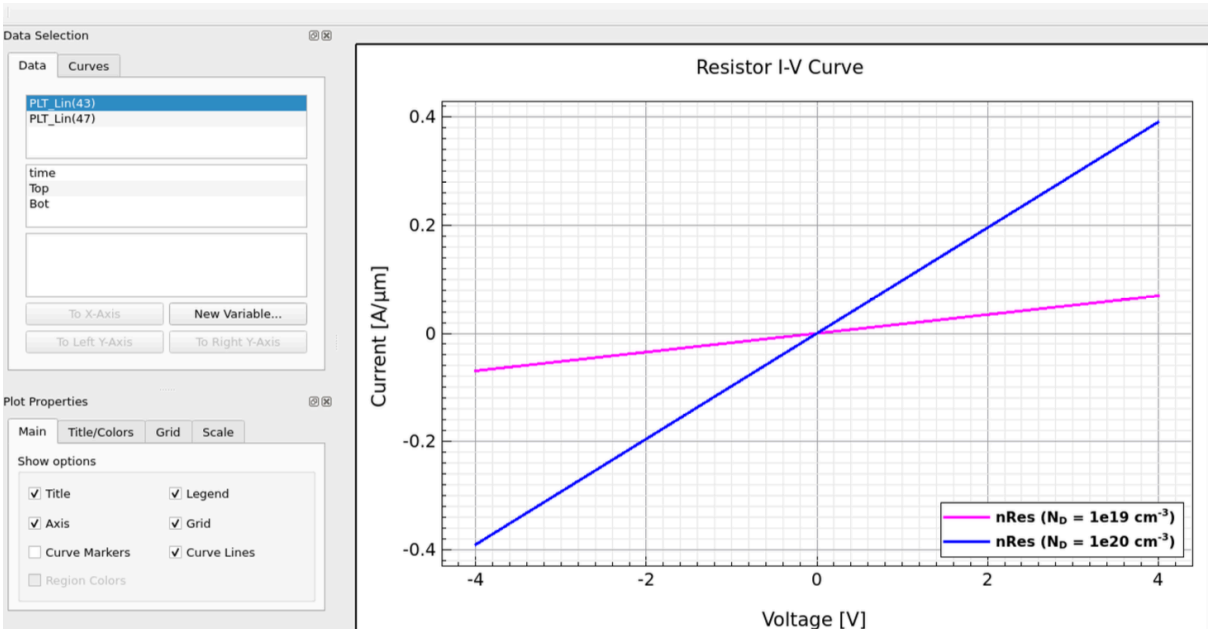
none queued ready pending running done failed aborted virtual pruned folded



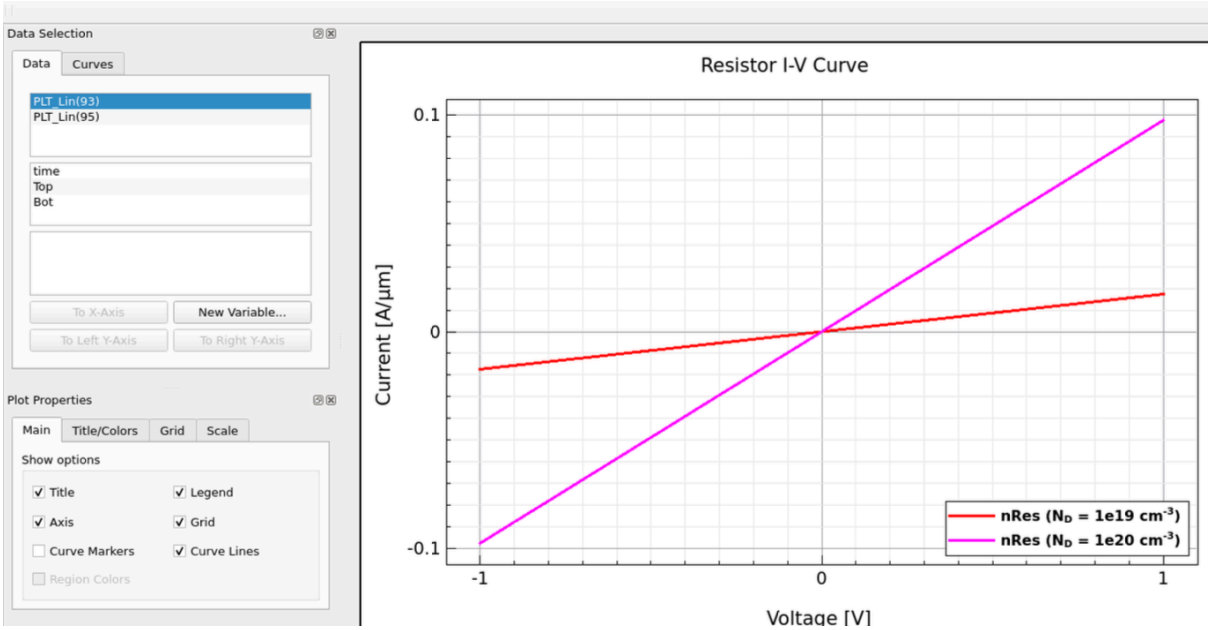
SDE plot for nRes multiple doping concentration



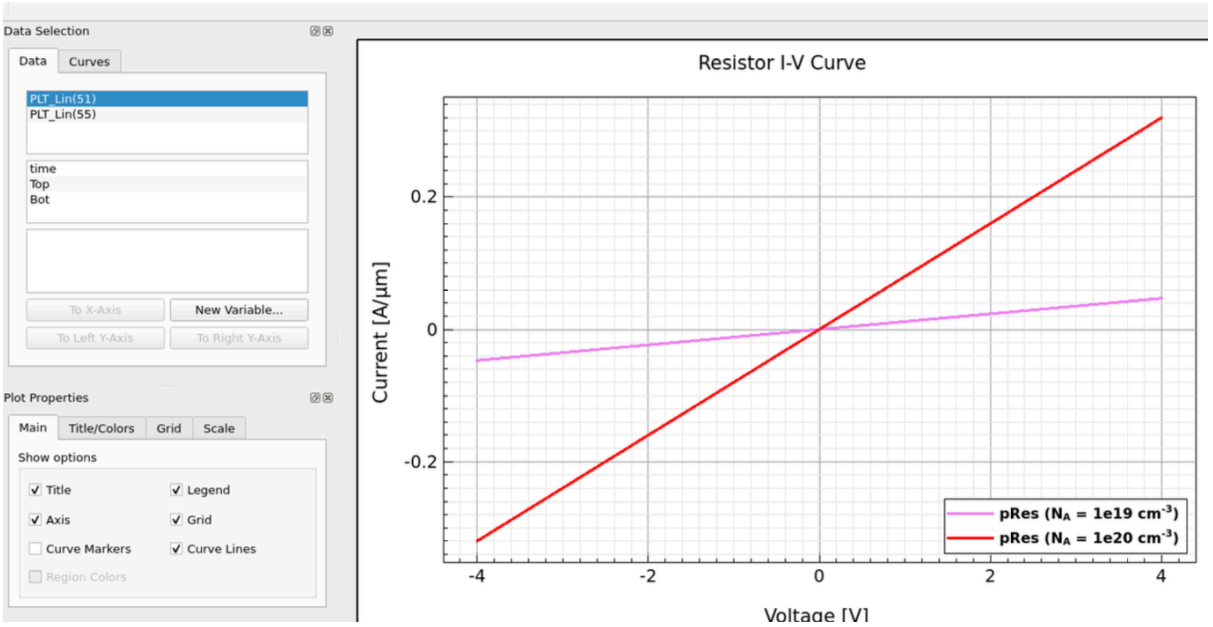
SDE plot for pRes multiple doping concentration



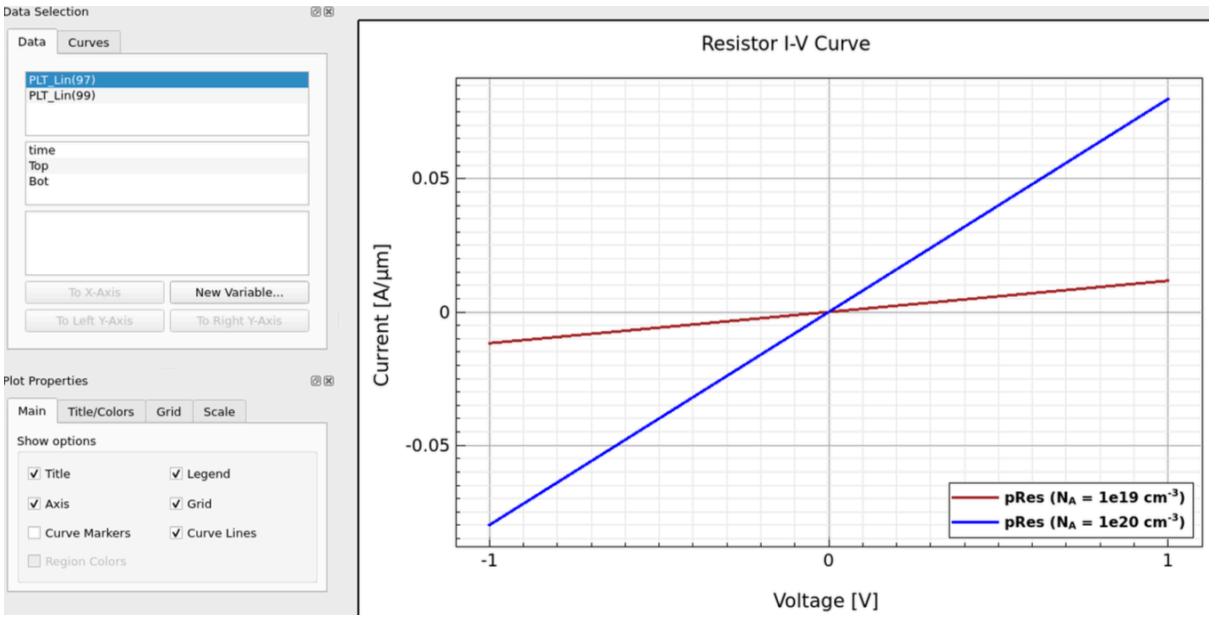
I–V plot for nRes at bias ±4V



I–V plot for nRes at bias ±1V

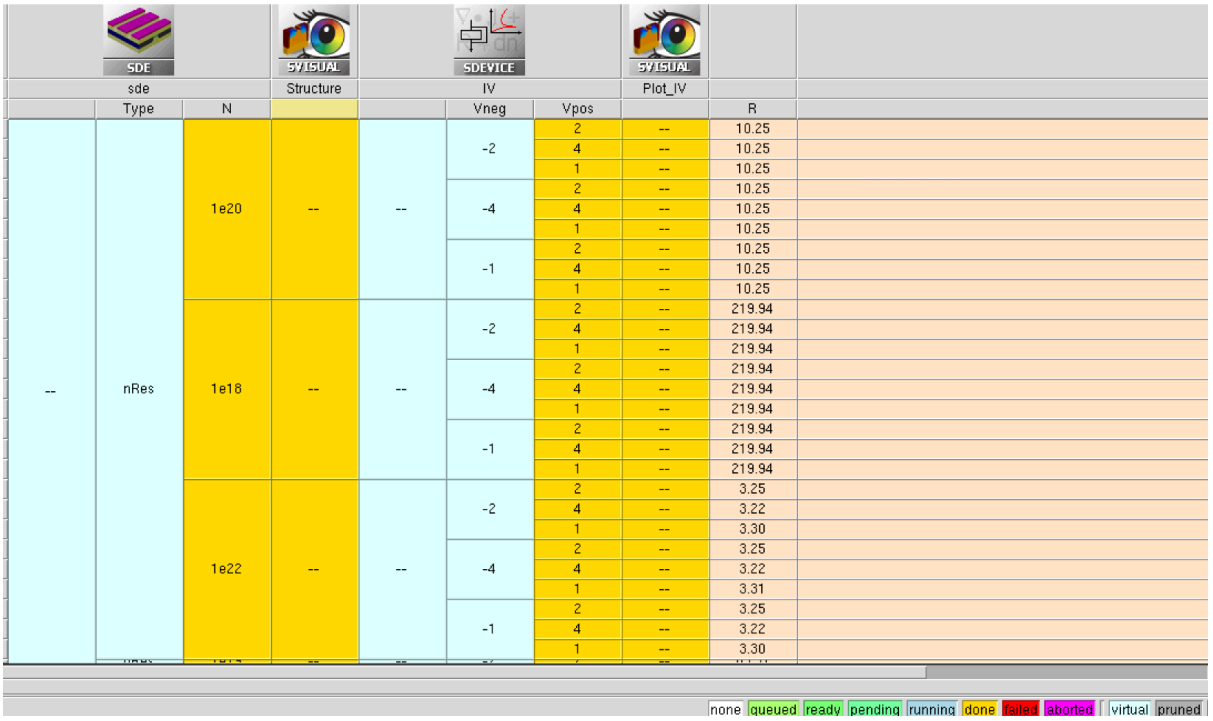


I–V plot for pRes at bias ±4V



I–V plot for pRes at bias ±1V

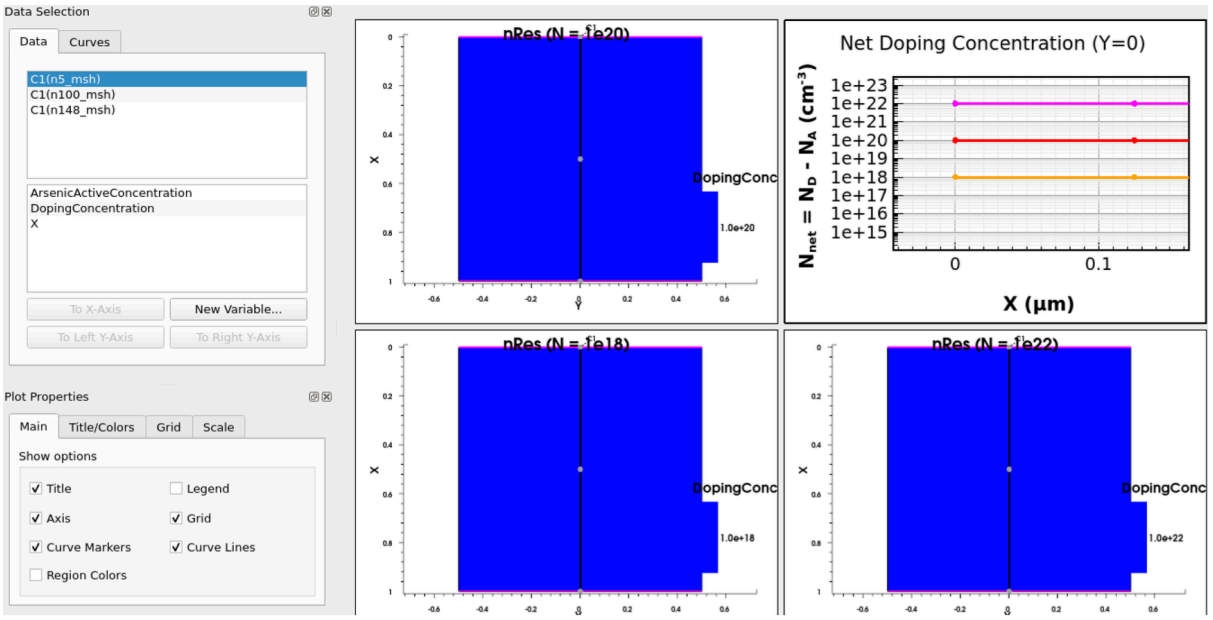
Task 2



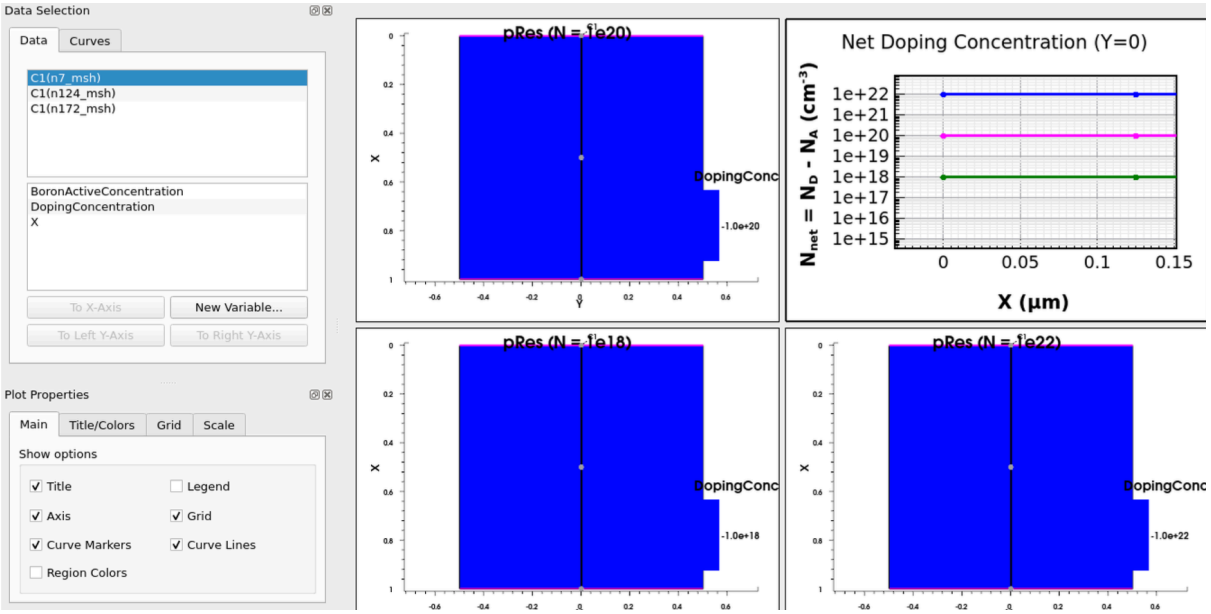
SDE			SVISUAL	SDEVICE			SVISUAL	
sde			Structure	IV			Plot_IV	
	Type	N			Vneg	Vpos		R
--	nRes	1e20	--	--	-2	2	--	10.25
						4	--	10.25
						1	--	10.25
					-4	2	--	10.25
						4	--	10.25
						1	--	10.25
					-1	2	--	10.25
						4	--	10.25
						1	--	10.25
		1e18	--	--	-2	2	--	219.94
						4	--	219.94
						1	--	219.94
					-4	2	--	219.94
						4	--	219.94
						1	--	219.94
					-1	2	--	219.94
						4	--	219.94
						1	--	219.94
		1e22	--	--	-2	2	--	3.25
						4	--	3.22
						1	--	3.30
					-4	2	--	3.25
						4	--	3.22
						1	--	3.31
					-1	2	--	3.25
						4	--	3.22
						1	--	3.30

none queued ready pending running done failed aborted virtual pruned

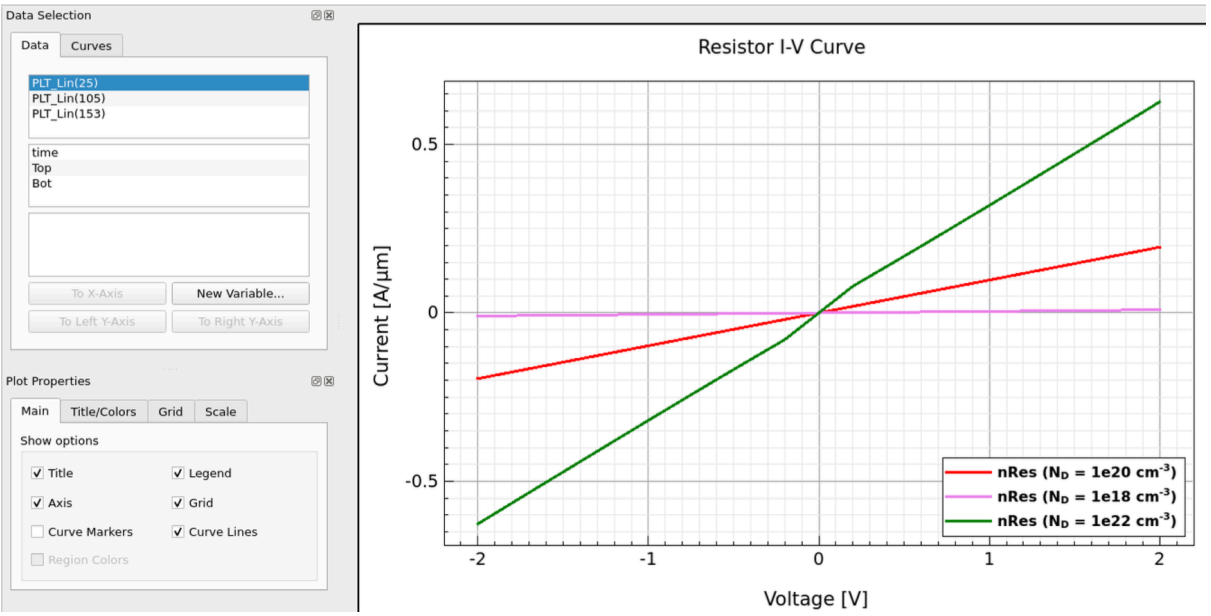
SDE			SVISUAL	SDEVICE			SVISUAL	
sde			Structure	IV			Plot_IV	
	Type	N			Vneg	Vpos		R
--	pRes	1e20	--	--	-2	2	--	12.52
						4	--	12.52
						1	--	12.52
					-4	2	--	12.52
						4	--	12.52
						1	--	12.52
					-1	2	--	12.52
						4	--	12.52
						1	--	12.52
		1e18	--	--	-2	2	--	389.33
						4	--	389.33
						1	--	389.33
					-4	2	--	389.33
						4	--	389.33
						1	--	389.33
					-1	2	--	389.33
						4	--	389.33
						1	--	389.33
		1e22	--	--	-2	2	--	1.78
						4	--	1.77
						1	--	1.81
					-4	2	--	1.78
						4	--	1.77
						1	--	1.82
					-1	2	--	1.78
						4	--	1.77
						1	--	1.81



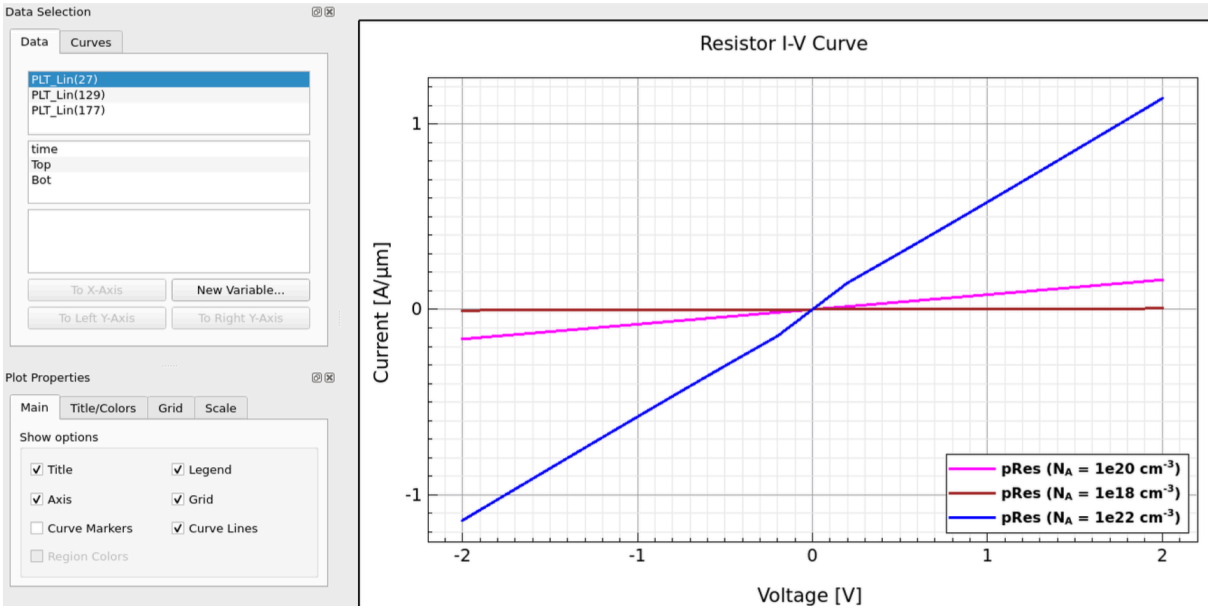
SDE plot for nRes multiple doping concentration



SDE plot for pRes multiple doping concentration

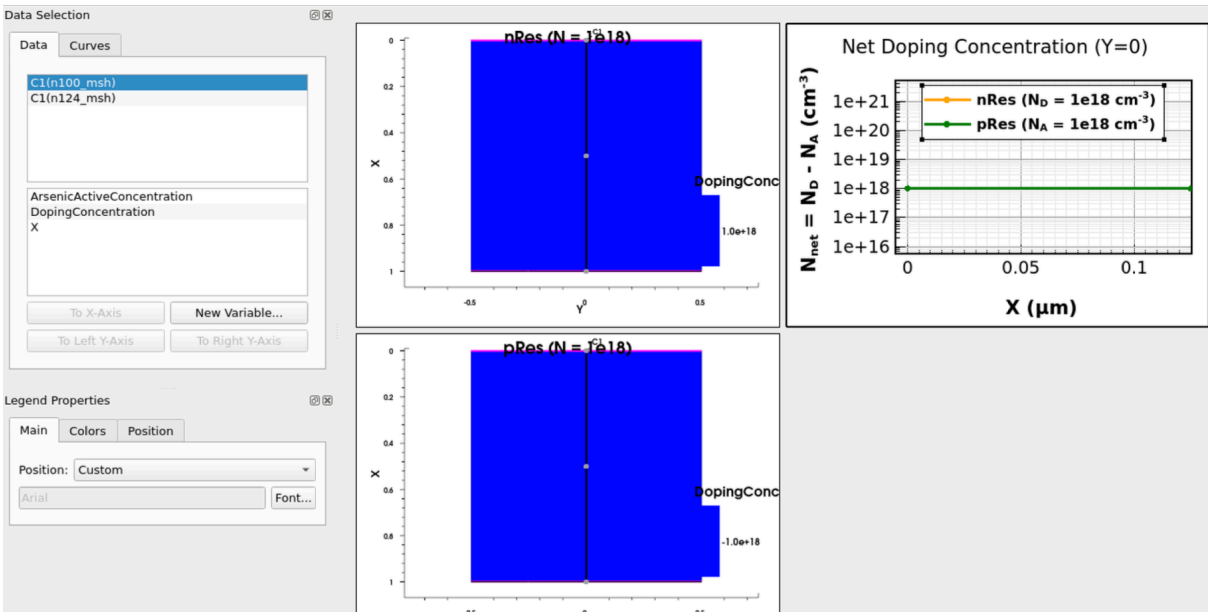


I-V plot for nRes multiple doping concentration



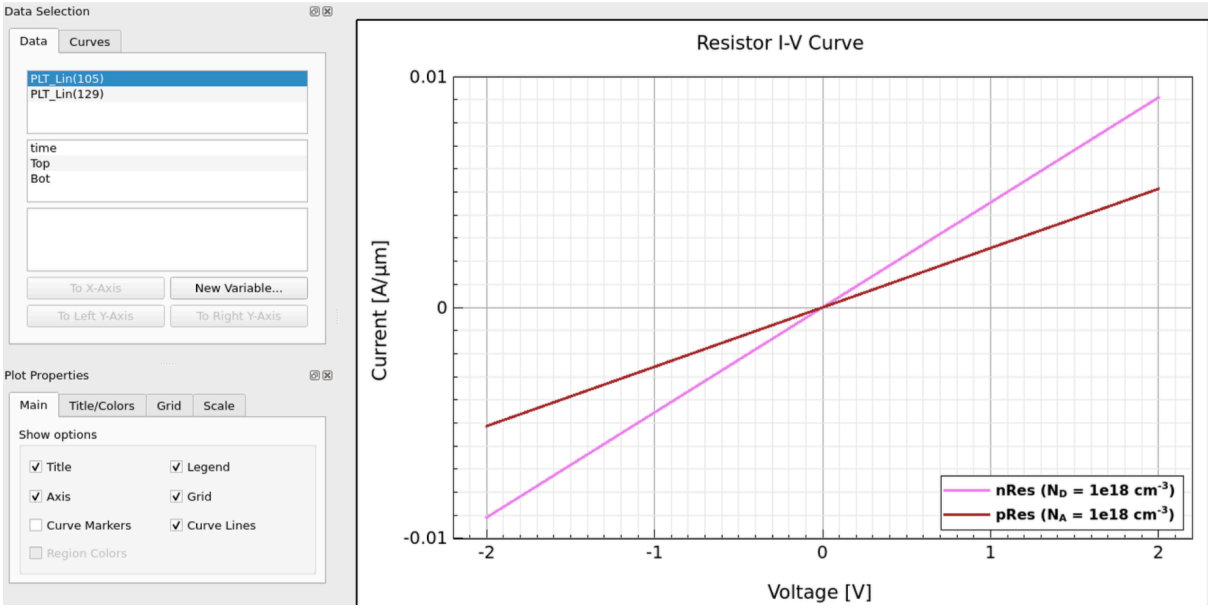
I-V plot for pRes multiple doping concentration

Comparison of nRes and pRes for Doping Concentra- tion 1e18 cm-3

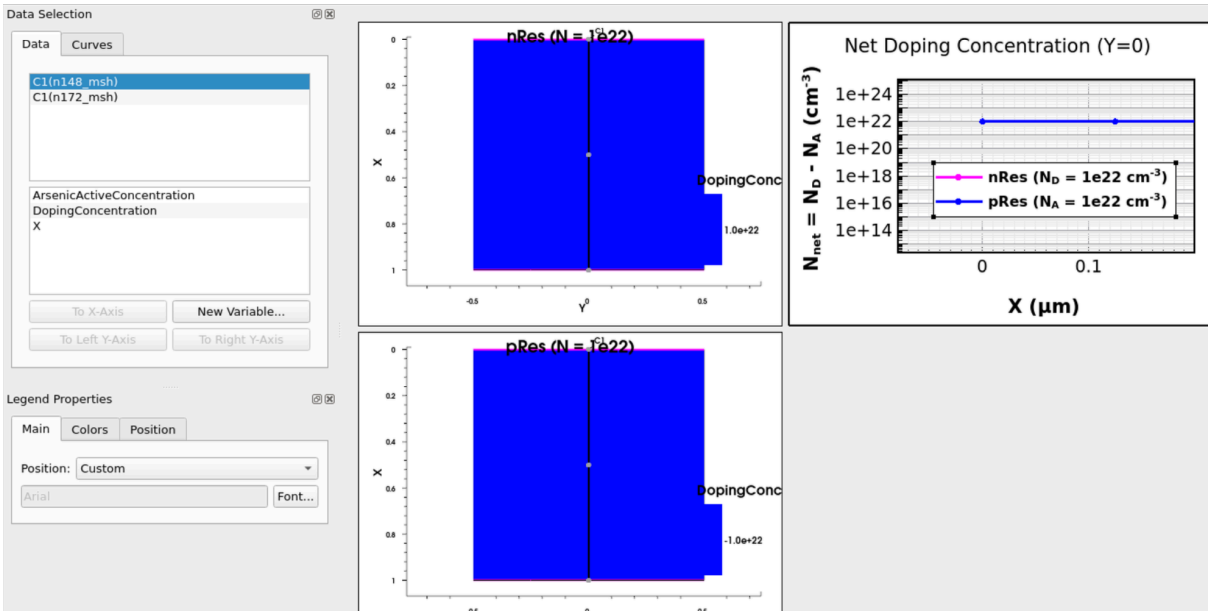


SDE plot for nres and pres

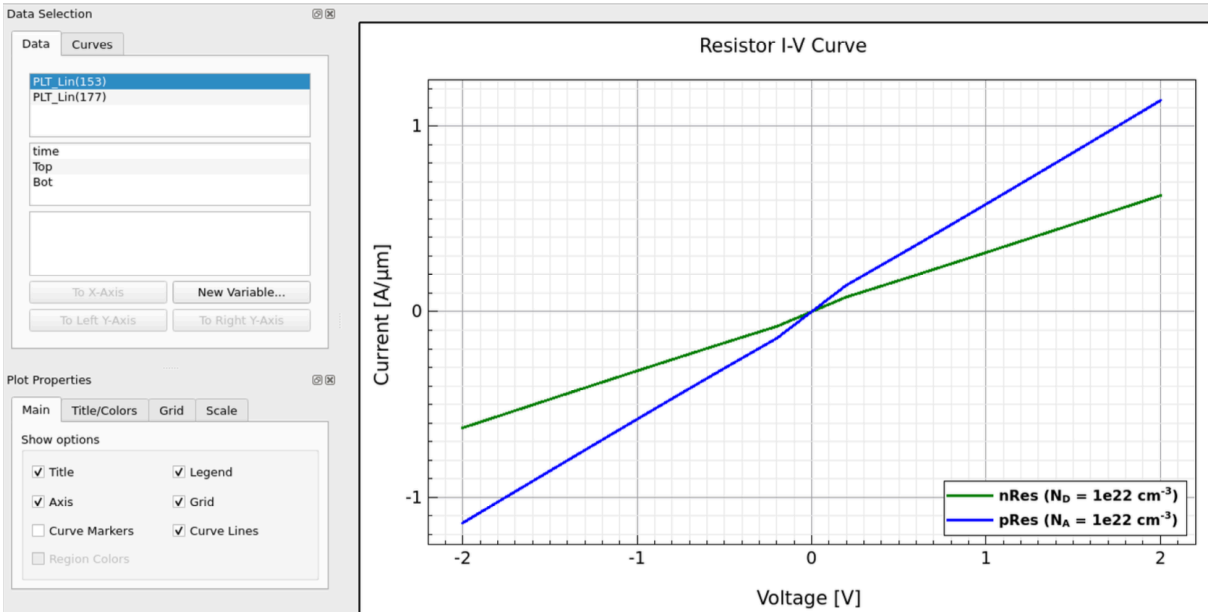
Comparison of nRes and pRes for Doping Concentra- tion 1e22 cm−3



I-V plot for nres and pres



SDE plot for nres and pres



I-V plot for nres and pres

Overall Conclusion:

The SDE plots show that the resistor geometry remains unchanged while increasing doping from 1e18 to 1e22 uniformly increases carrier concentration for both nRes and pRes. The I–V characteristics remain linear across all doping levels, confirming ideal ohmic behavior, with steeper slopes at higher doping indicating increased conductivity and reduced resistance. Hence, the resistor value is primarily governed by doping concentration rather than the applied voltage.