Case Studies

GaNFET Simulation

*P. K. Saxena *at. el.,* Atomistic Level Process to Device Simulation of GaNFET Using TNL TCAD Tools, Book Chapter, © ***Springer Nature*** (2020) 176, Lecture Notes in Electrical Engineering ISBN 978-981-15-5261-8 ISBN 978-981-15-5262-5 (eBook)

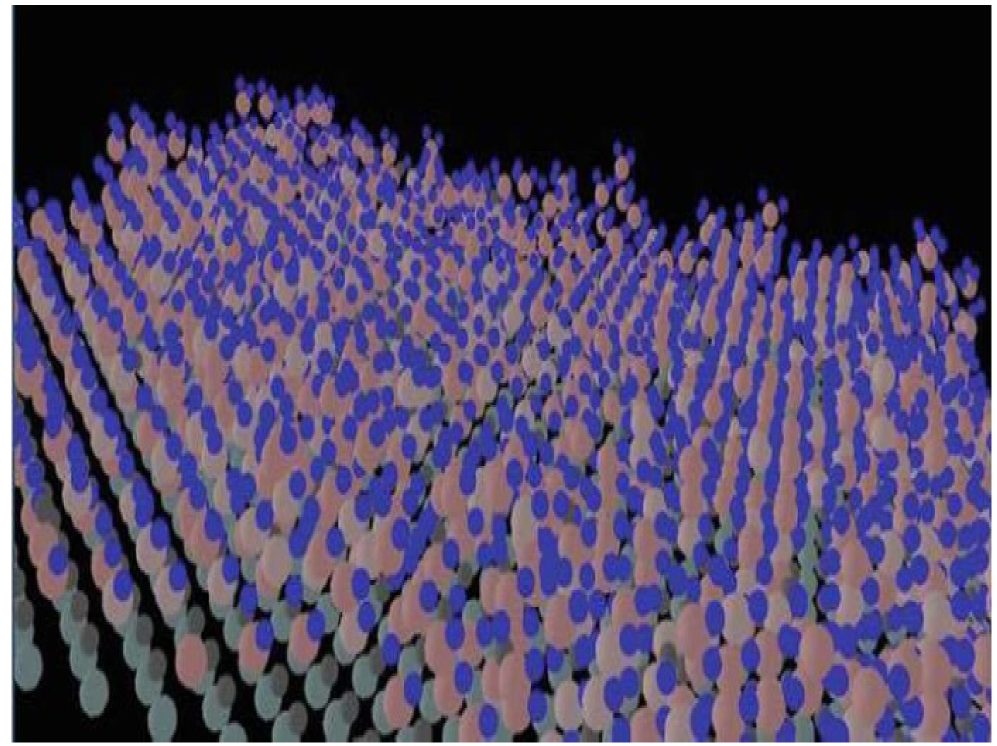
GaNFET Epitaxial Growth

Epi-growth has been done with the following process parameters:

Parameters	Values	Unit
Time	30	s
Temperature	800	°C
Surface energy	2	eV
Desorption barrier energy	4	eV
Schwoebel barrier	0.002	eV
Incorporation barrier	0.05	eV
Nearest neighbor attraction	0.05	eV

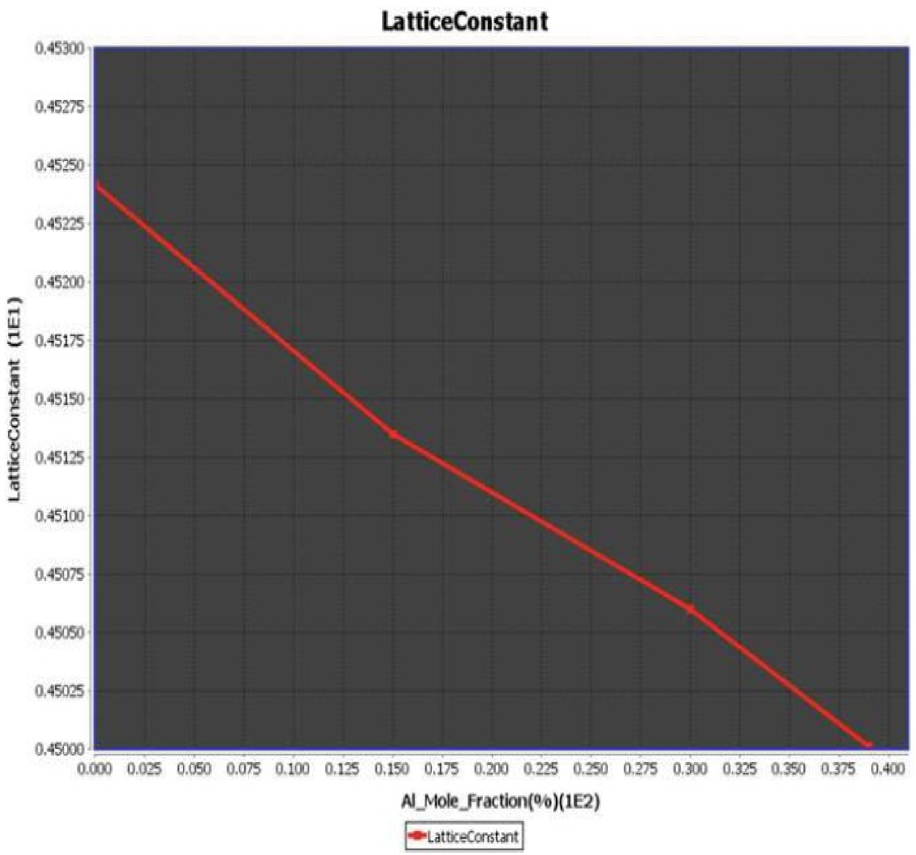
Precursors and gas ambience used during simulation

Materials	Partial pressure		
	Ga (mbar)	Al (mbar)	N2 (mbar)
GaN	0.3	0.0	3.0
$Ga_{0.85}Al_{0.15}N$	0.3	0.03	3.0
$Ga_{0.7}Al_{0.3}N$	0.28	0.05	3.0
$Ga_{0.61}Al_{0.39}N$	0.25	0.10	3.0

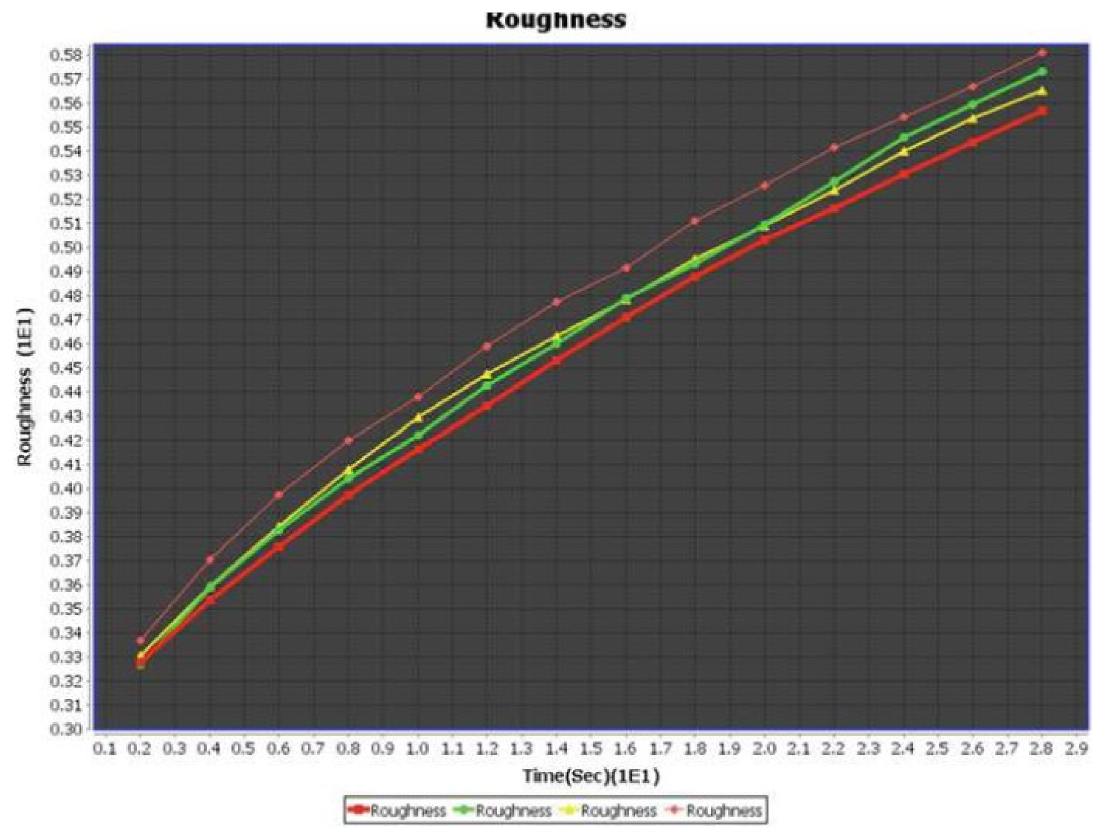


GaNFET Case Studies

Variation of lattice constant with Al mole fraction



Surface roughness at the interface of AlGaN/GaN



GaNFET Case Studies

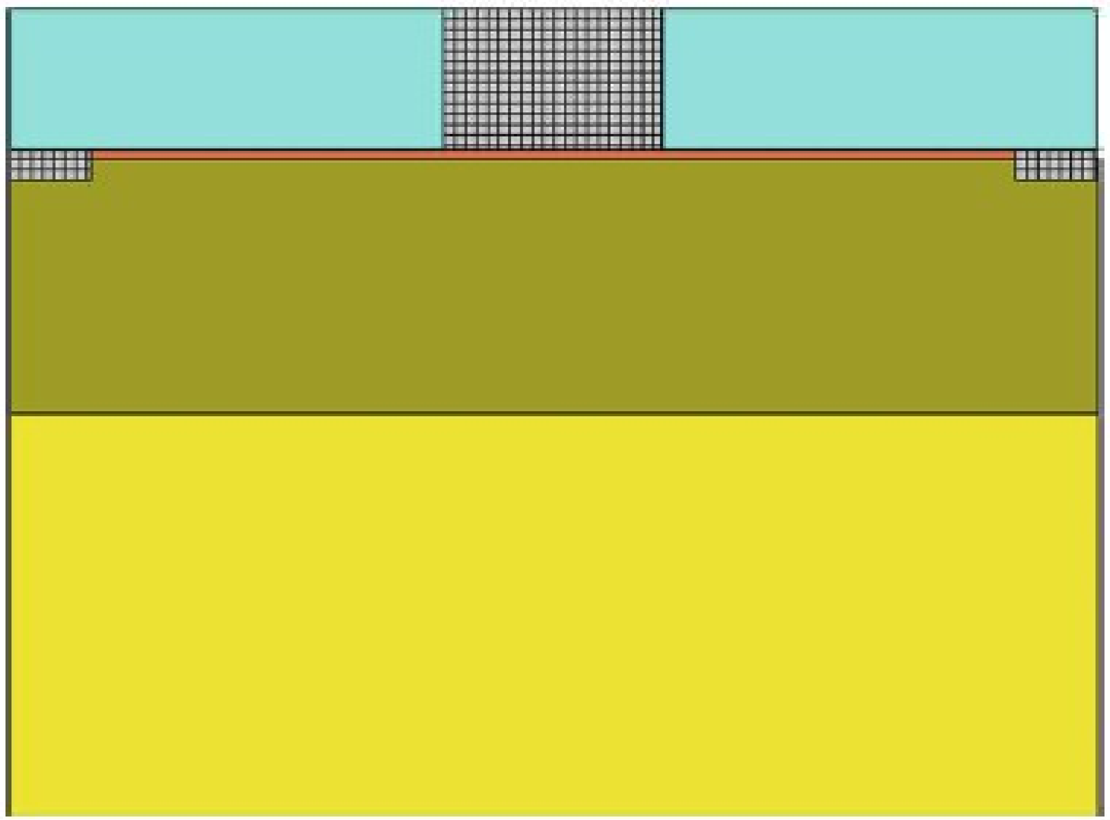
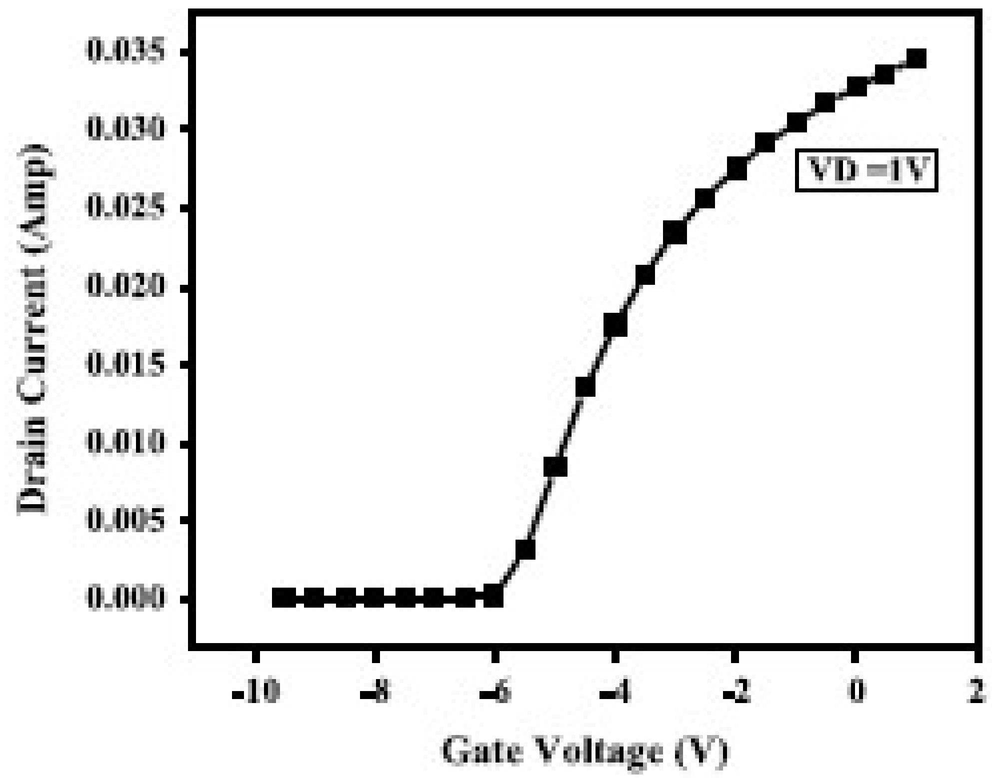
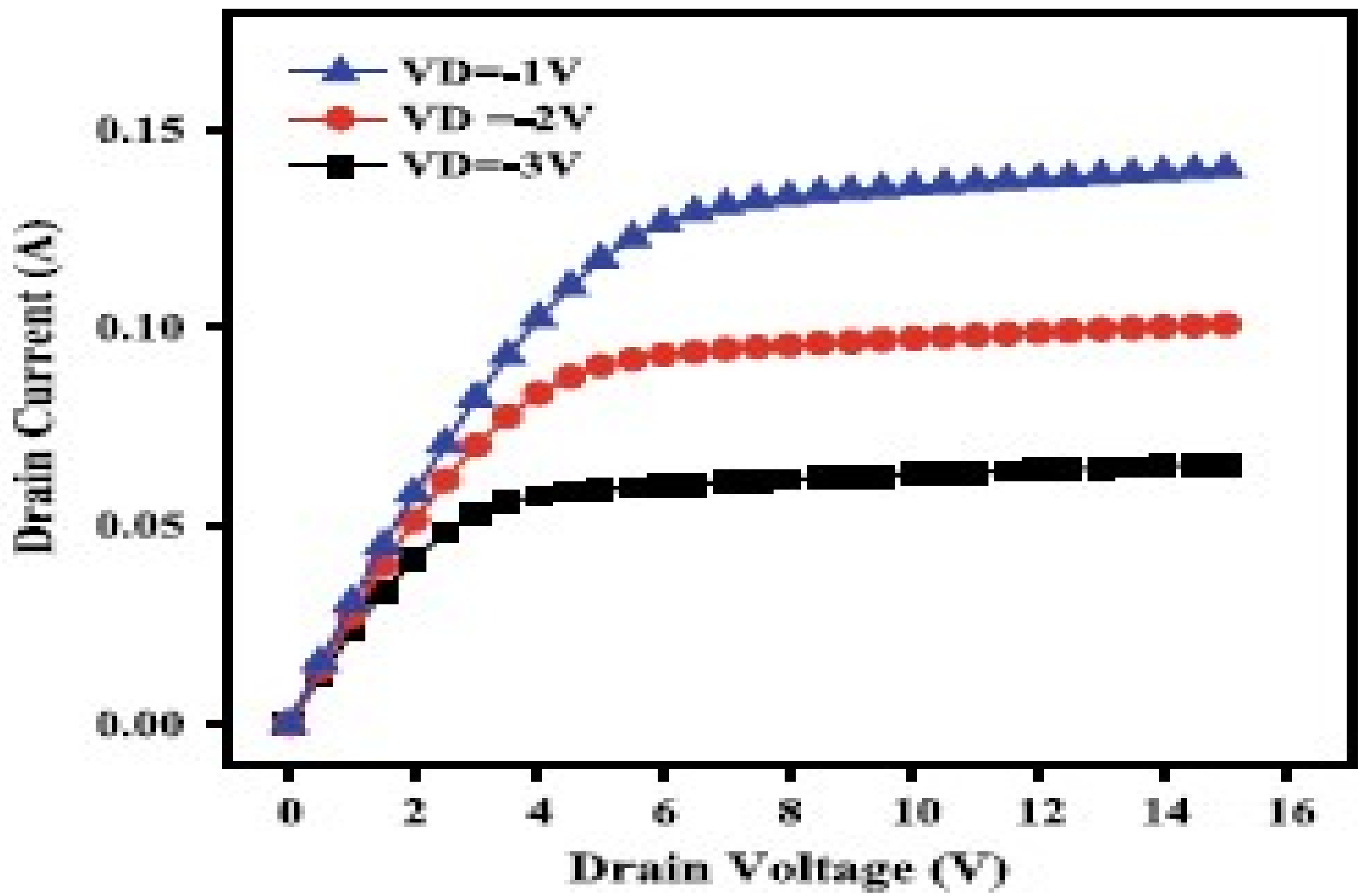


Fig. 9 Device structure with 25 nm thick AlGaN/GaN layer grown on SiC (100) substrate



GaNFET Case Studies

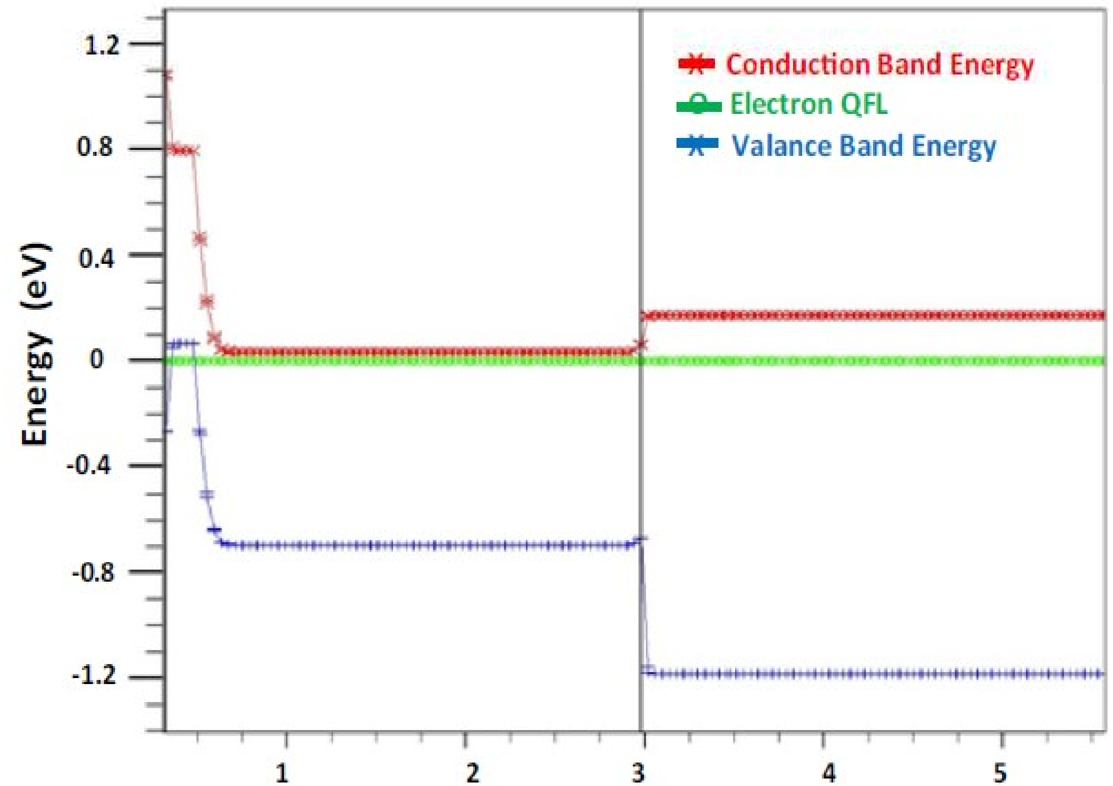


InGaAs/InP Infrared Photodetector

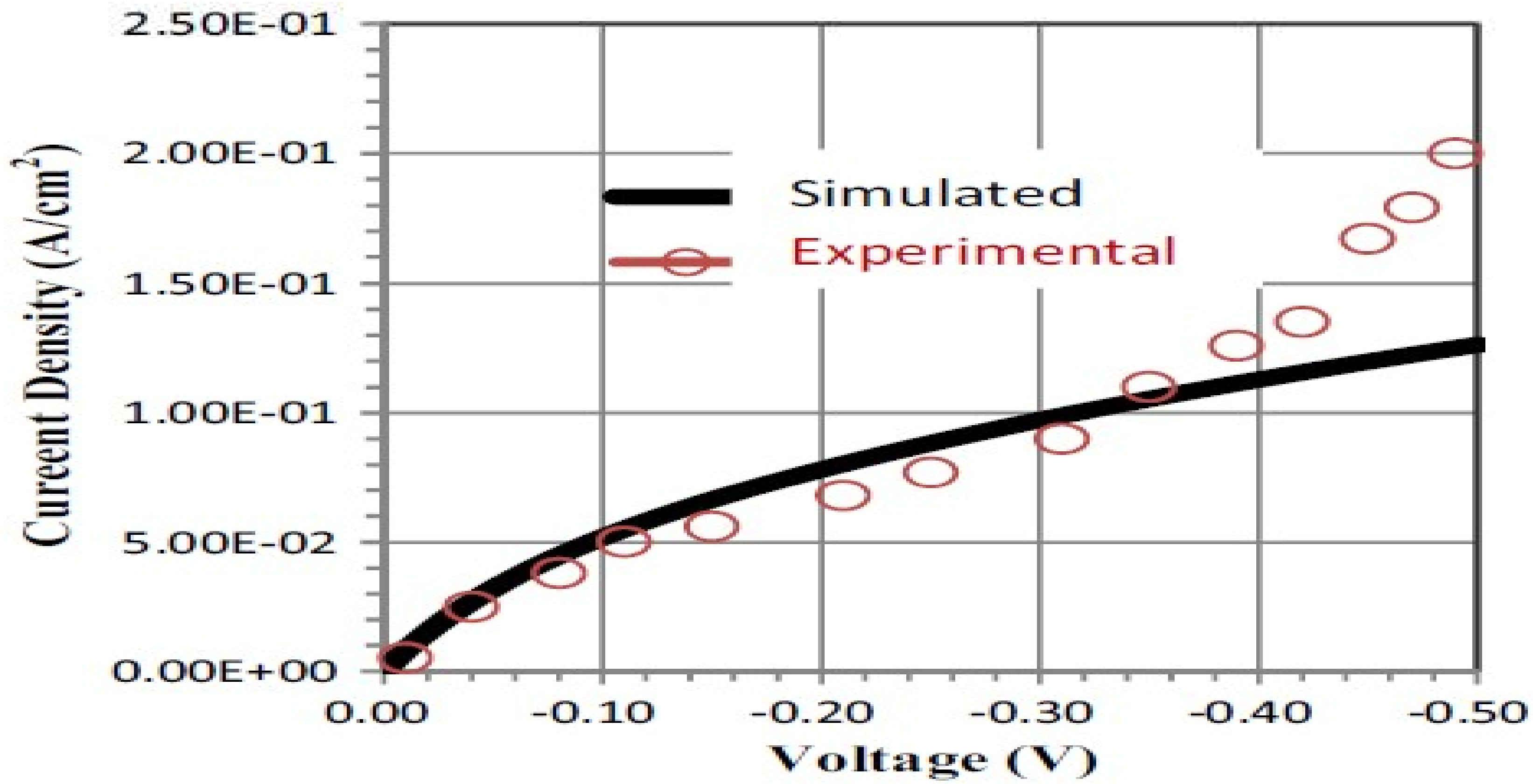
*P. K. Saxena *at. el.,* Numerical simulation of InxGa1−xAs/InP PIN photodetector for optimum performance at 298 K, *Optical and Quantum Electronics* (2020) **52**:374

Infrared Detector

p^+- $In_{0.53}Ga_{0.47}As$ (150 nm)	p- InP	*i*- $In_{0.53}Ga_{0.47}$ As (2.5µm)	n-InP (2.6 µm)



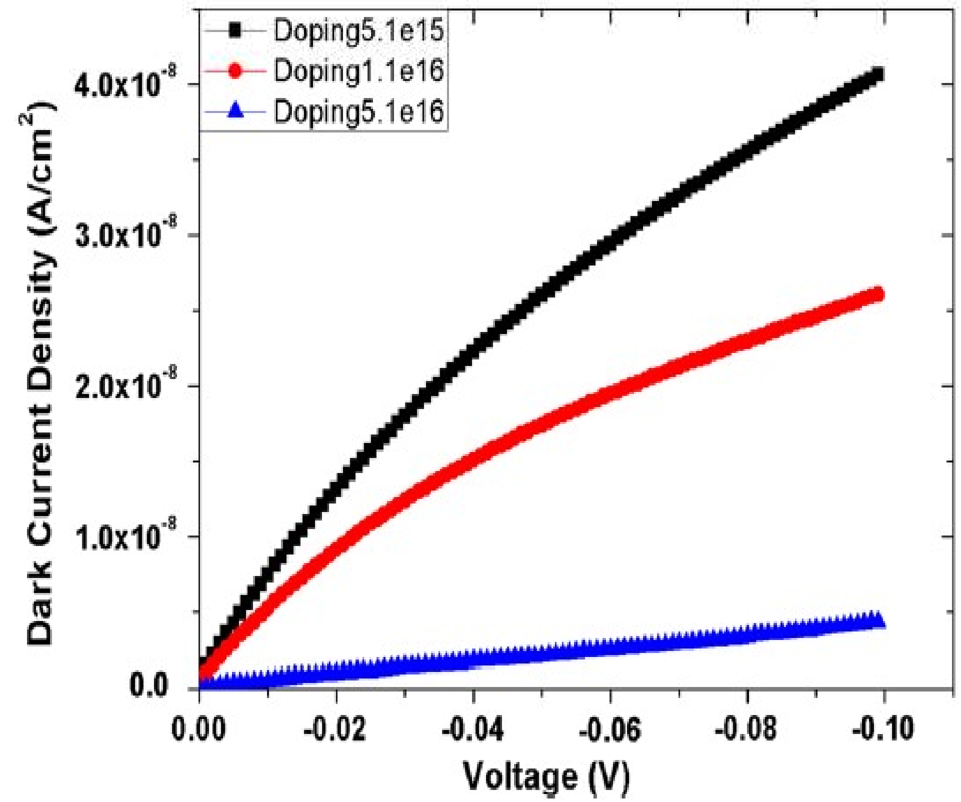
I – V Characteristics



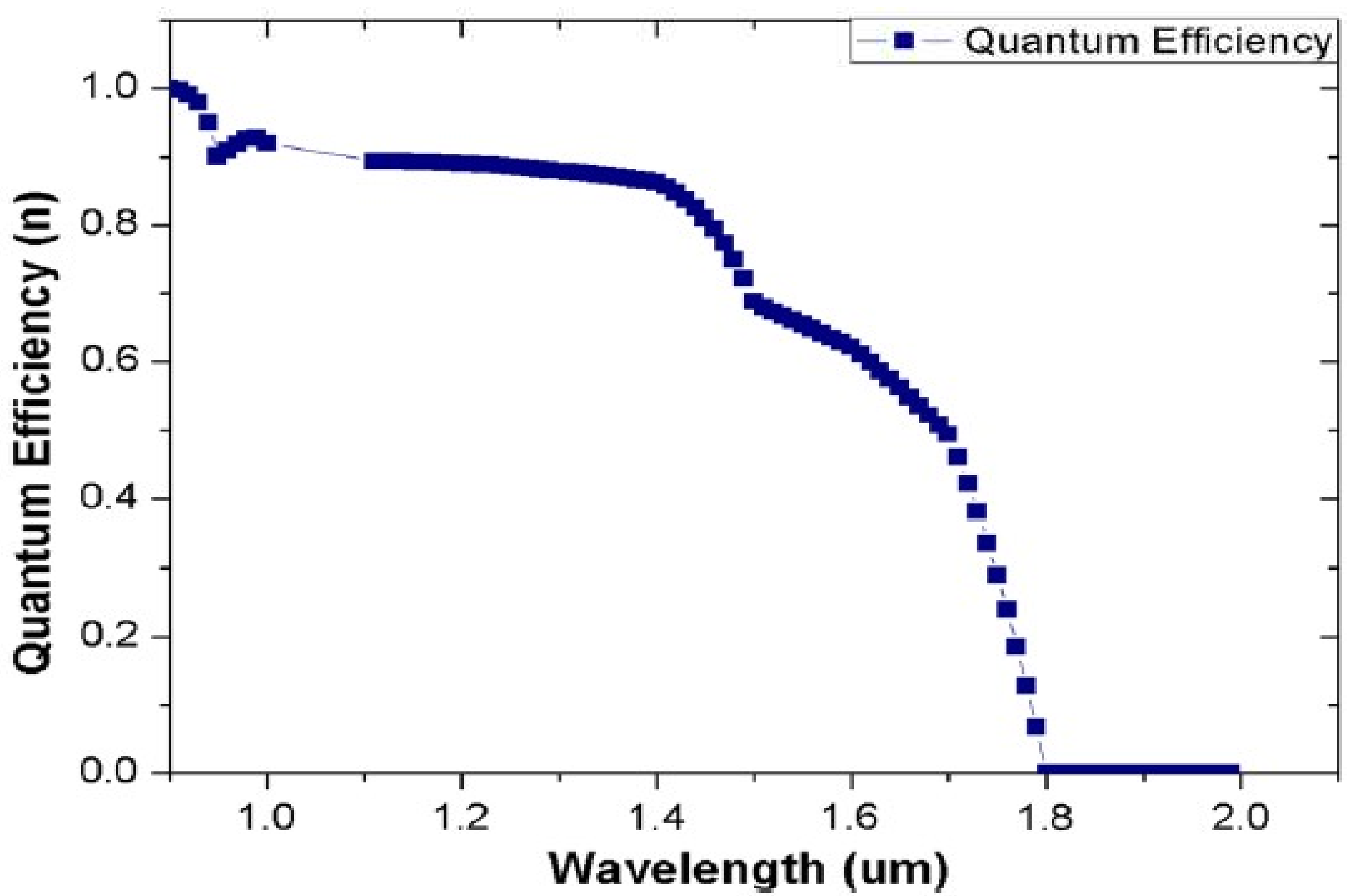
Infrared Detector

Table 1 The current density values for different doping dose at specified absorbing layer thickness

Doping dose (cm^{-3})	Current density at specified absorbing layer thickness (A/cm^2)		
	2 μm	2.5 μm	3 μm
5.1×10^{15}	2.53×10^{-07}	2.53926×10^{-07}	2.54×10^{-07}
1.1×10^{16}	1.62×10^{-07}	1.63×10^{-07}	1.63×10^{-07}
5.1×10^{16}	2.6456×10^{-08}	2.6898×10^{-08}	2.7595×10^{-08}



Quantum Efficiency

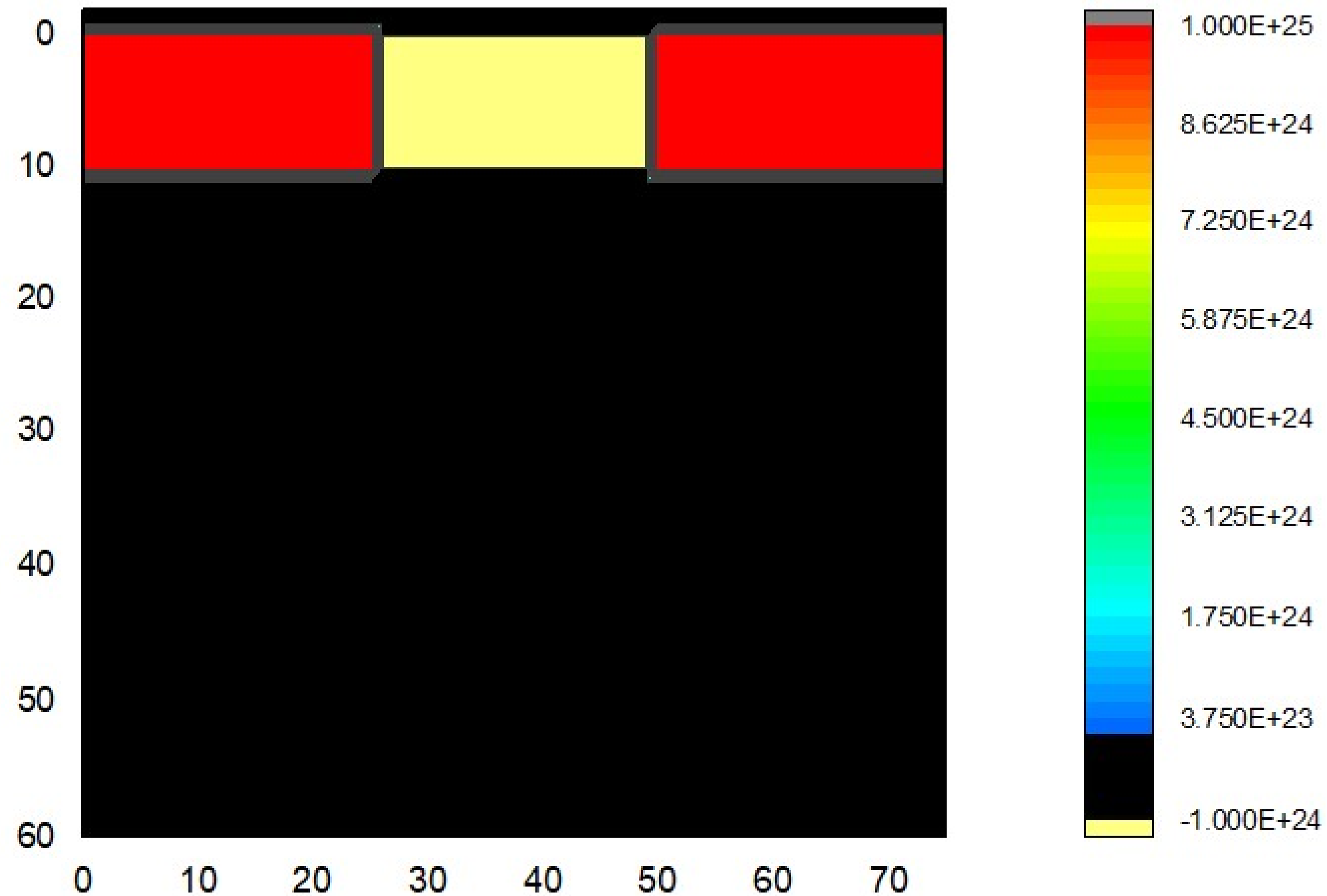


FDSOI MOSFET

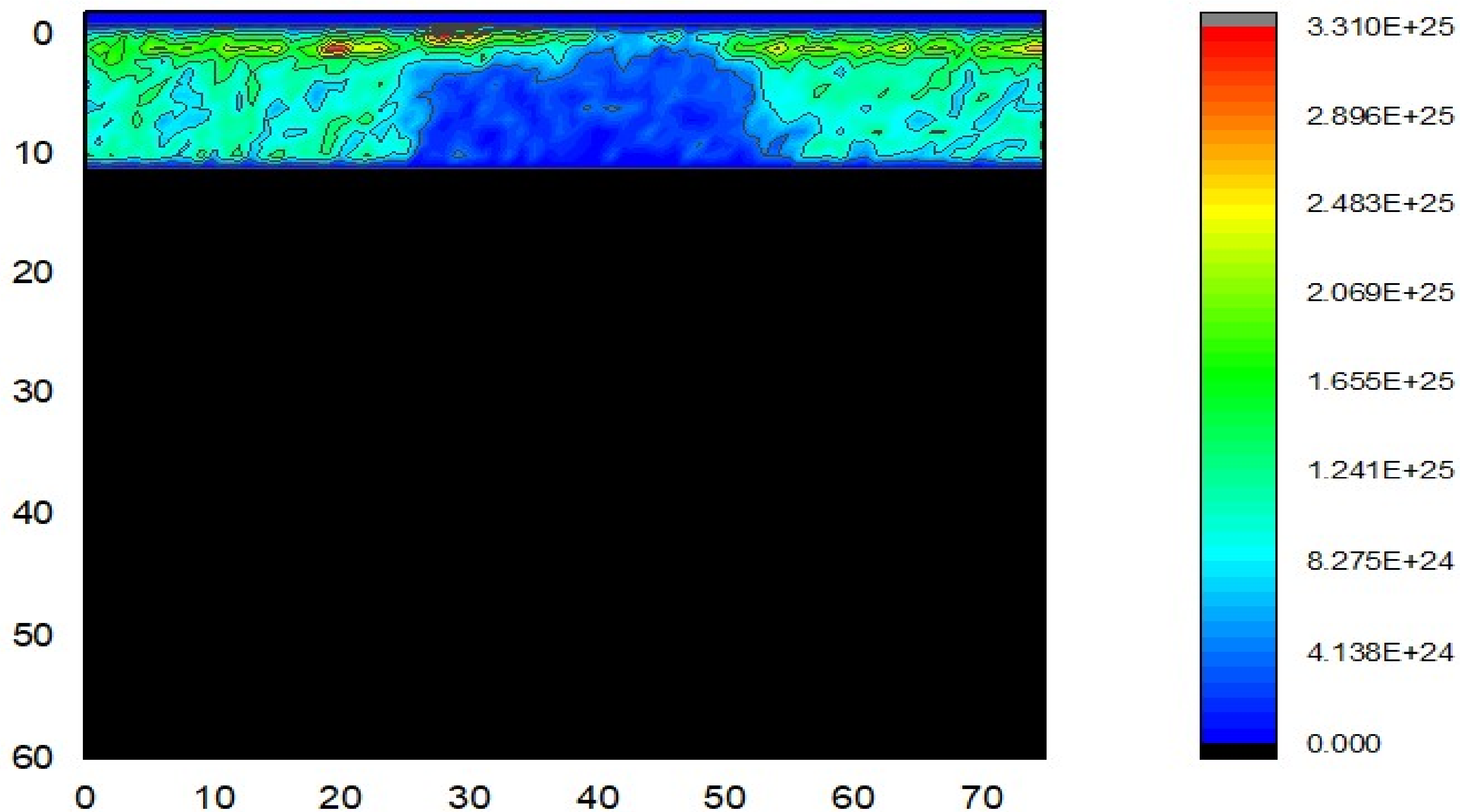
FDSOI MOSFET

*P. K. Saxena *at. el.,* A Comparative Study for Scaling FDSOI Technology up to 7nm –Based on Particle device Simulation, *Jaournal of Nano & Optoelectronics*(2020), under Review.

FDSOI MOSFET



FDSOI : CARRIERS DENSITY



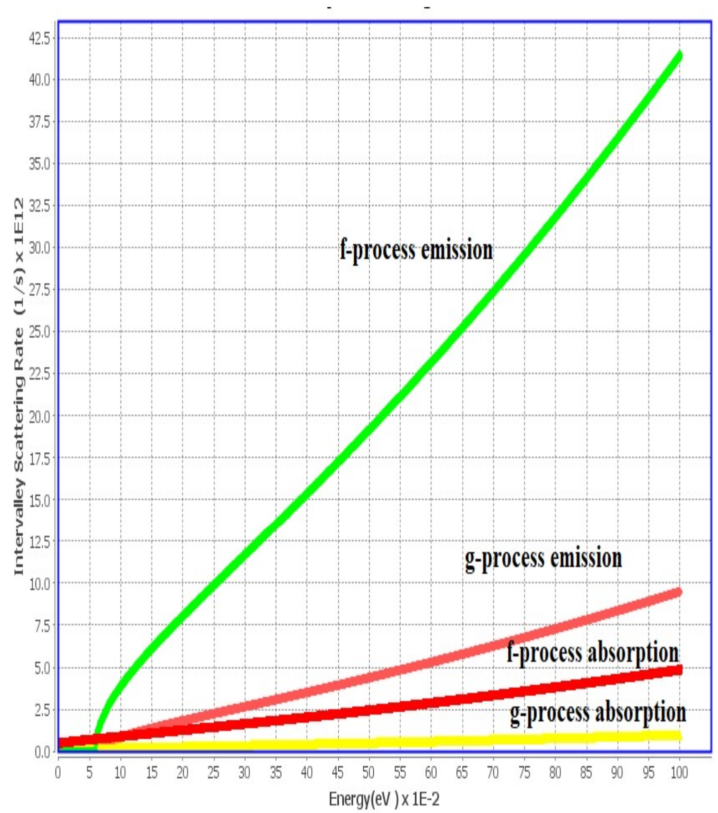
FDSOI MOSFET RESULTS

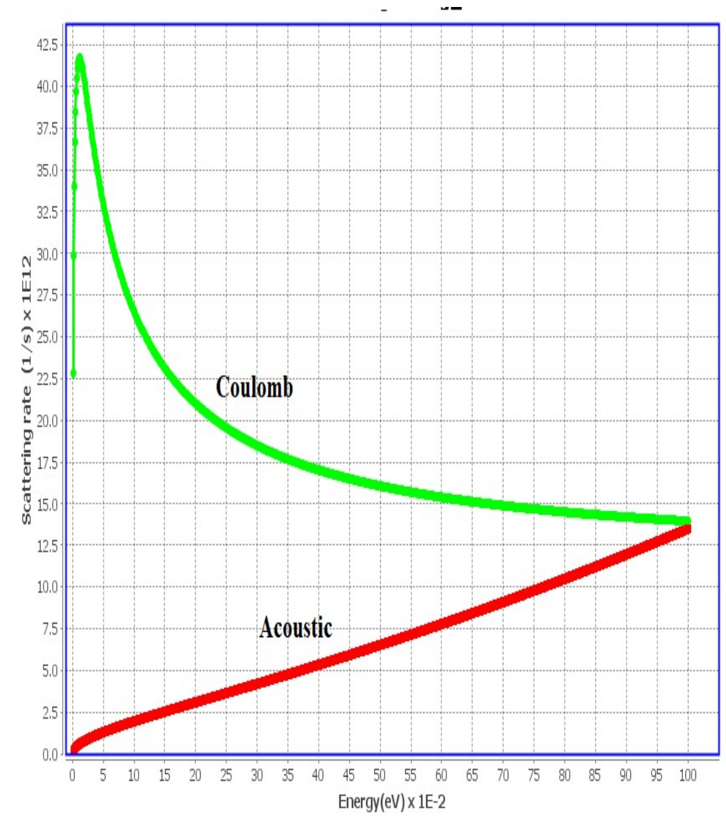
	Nodes (nm)	14nm	10nm	7nm	14nm	10nm	7nm
Structure Parameters		Single Gate			Double Gate		
	L_{eff} (nm)	22	14	10	22	14	10
	W_{eff} (nm)	10		8	10		8
	T_{ox} (nm)	1	0.85	0.75	0.75	0.85	0.75
	Doping (/cm^3)	1×10^{24}	5×10^{24}	2×10^{25}	2×10^{25}	5×10^{24}	2×10^{25}
	T_{SOI} (nm)	40	30	20	20	30	20
Device Parameters	Vth (mV)	0.3	0.22	0.2	0.2	0.4	0.5
	SS (/mV/dec)	63.3	67.9	82.9	82.9	87.4	72.2
	gm (mS/µm)	0.252	0.437	0.499	0.499	0.494	0.449

FDSOI TECHNOLOGY UP TO 7NM

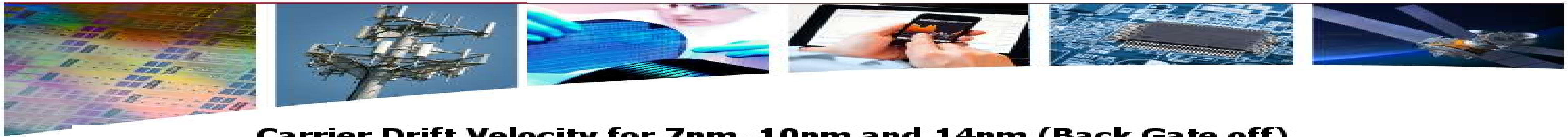
Scattering Rates

- Intervalley,
- Acoustic and
- Coulomb

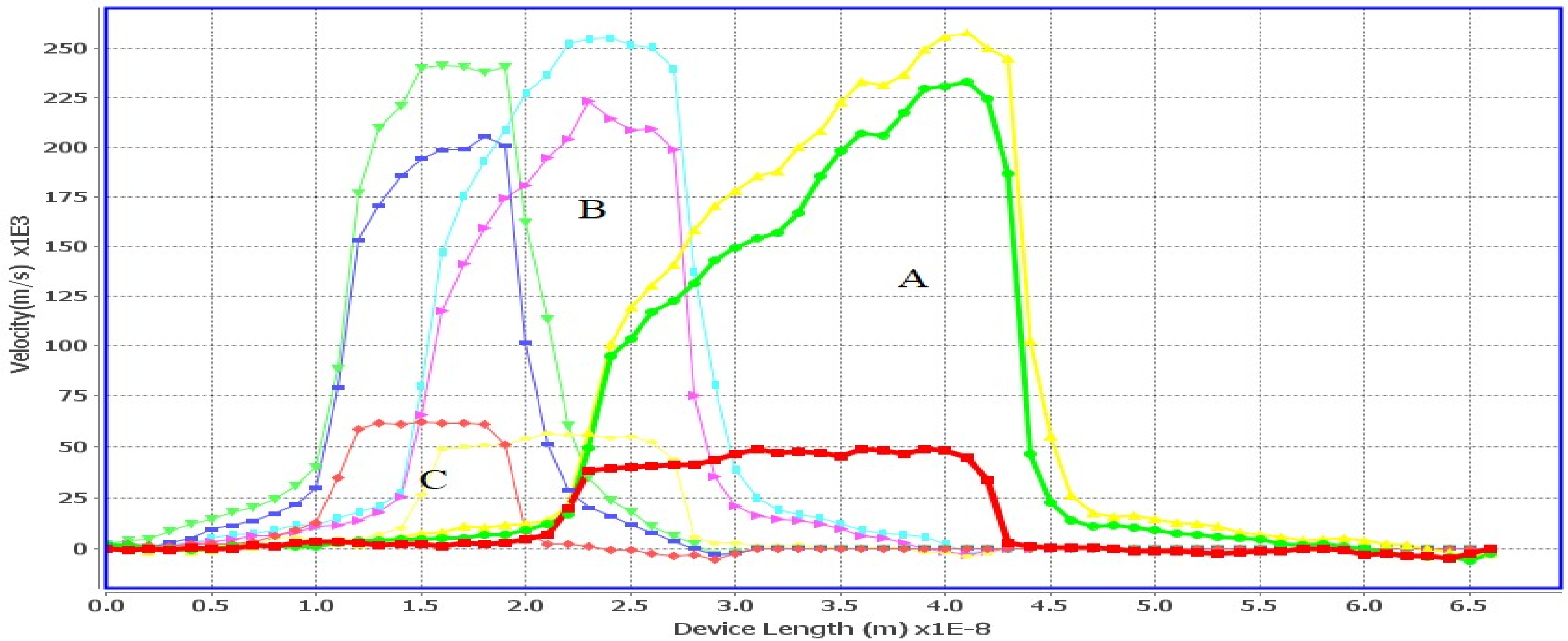




DRIFT VELOCITY

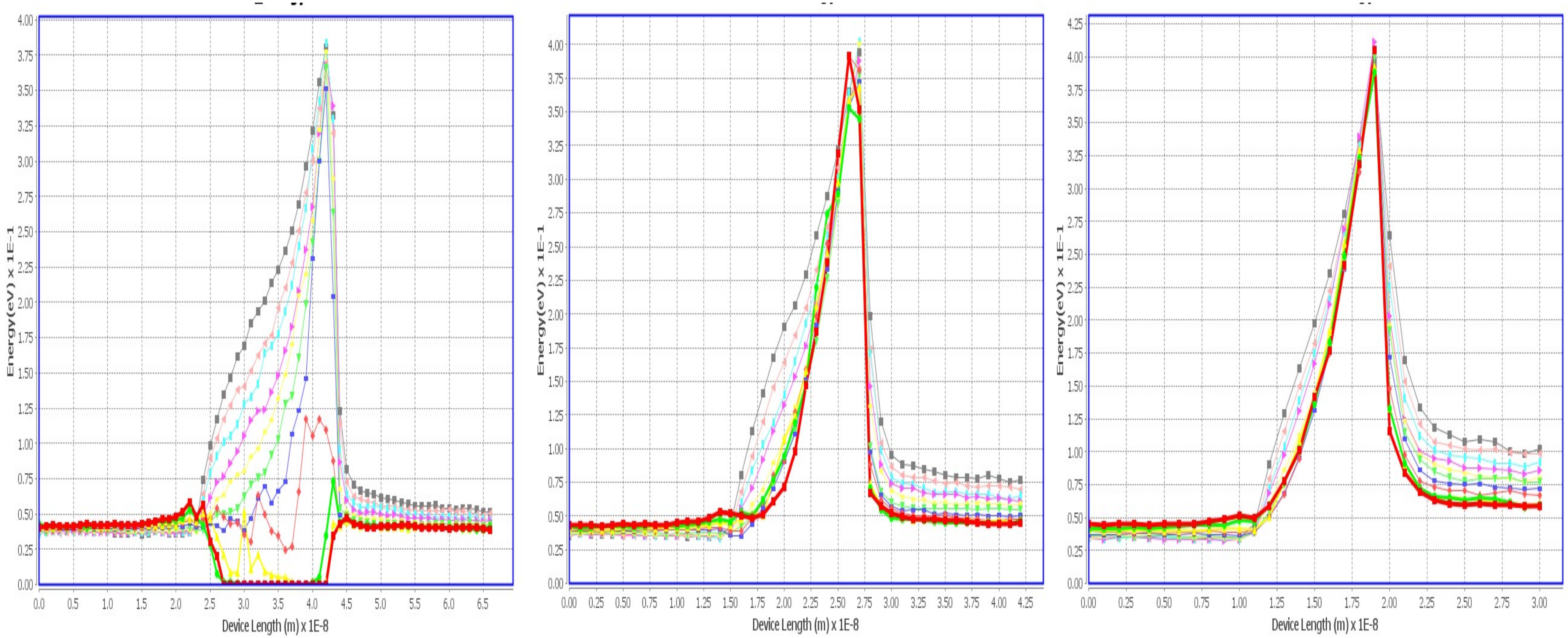


Carrier Drift Velocity for 7nm, 10nm and 14nm (Back Gate off)



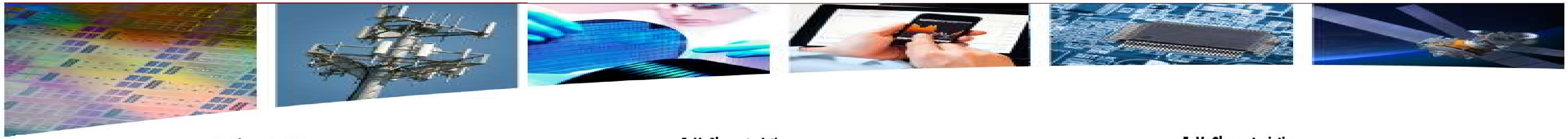
Carrier Drift velocity a) 14nm b) 10nm c) 7nm

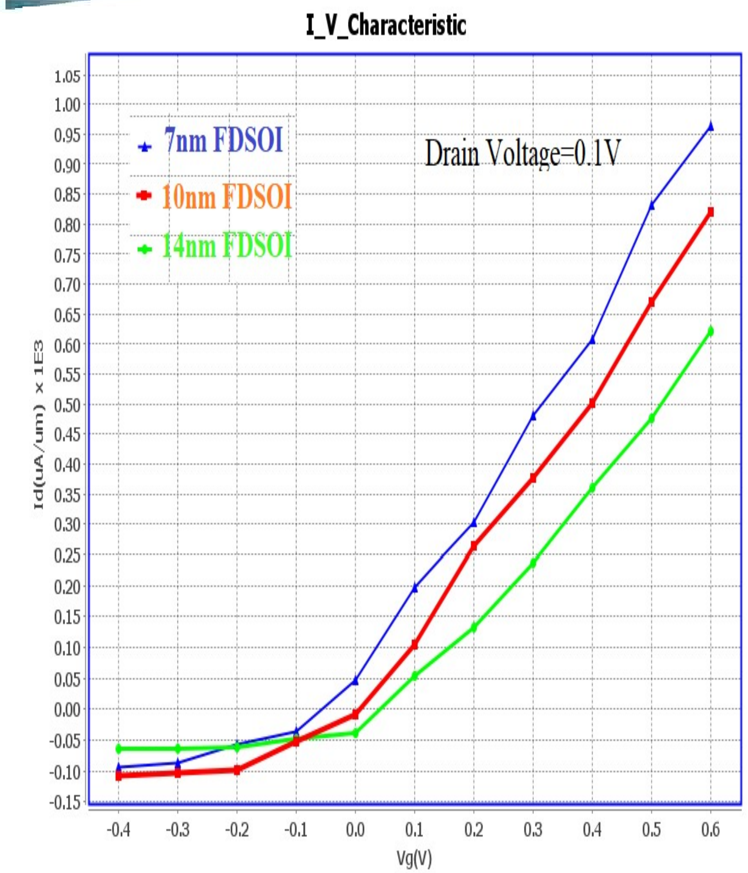
CARRIER AVERAGE ENERGY

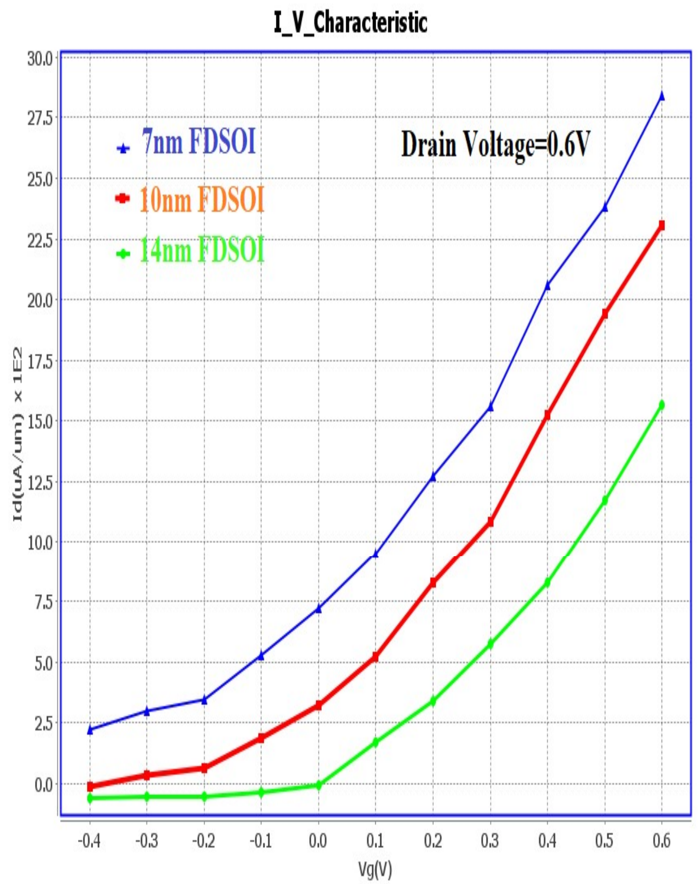


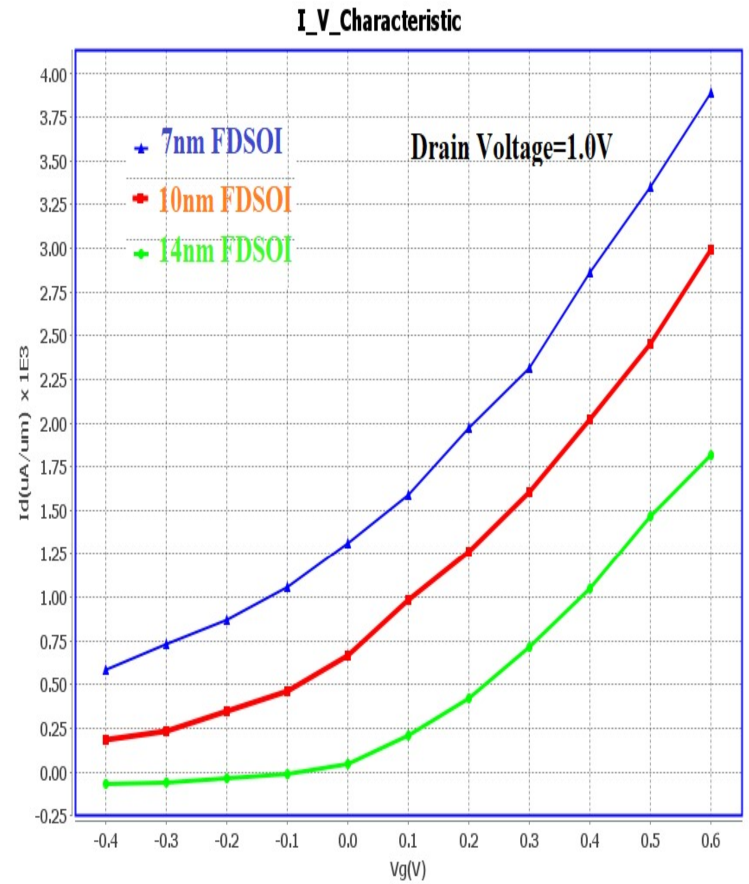
a) 14nm FDSOI MOSFET b) 10nm FDSOI MOSFET c) 7nm FDSOI MOSFET

Transfer I_d - V_g Characteristics

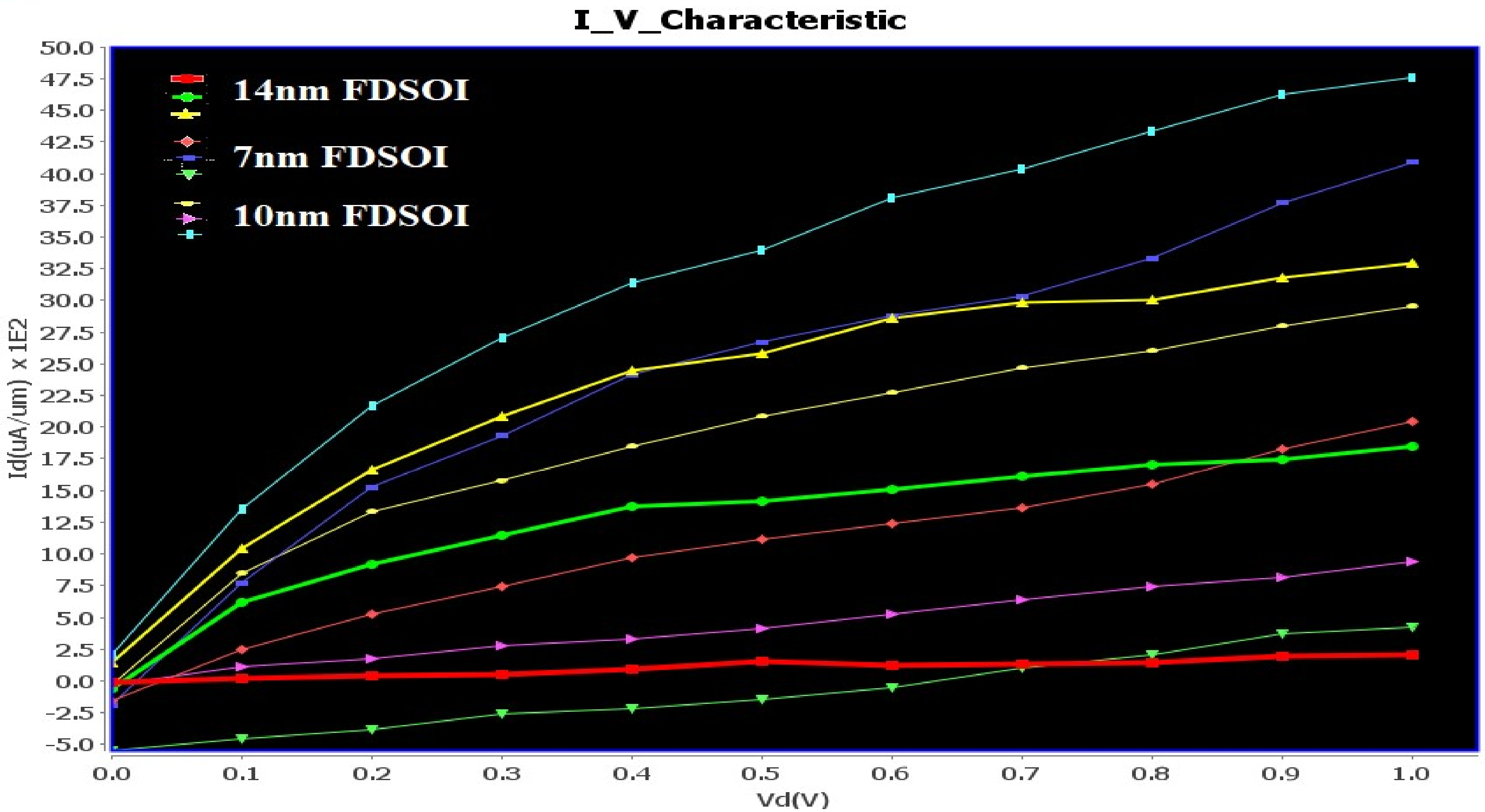




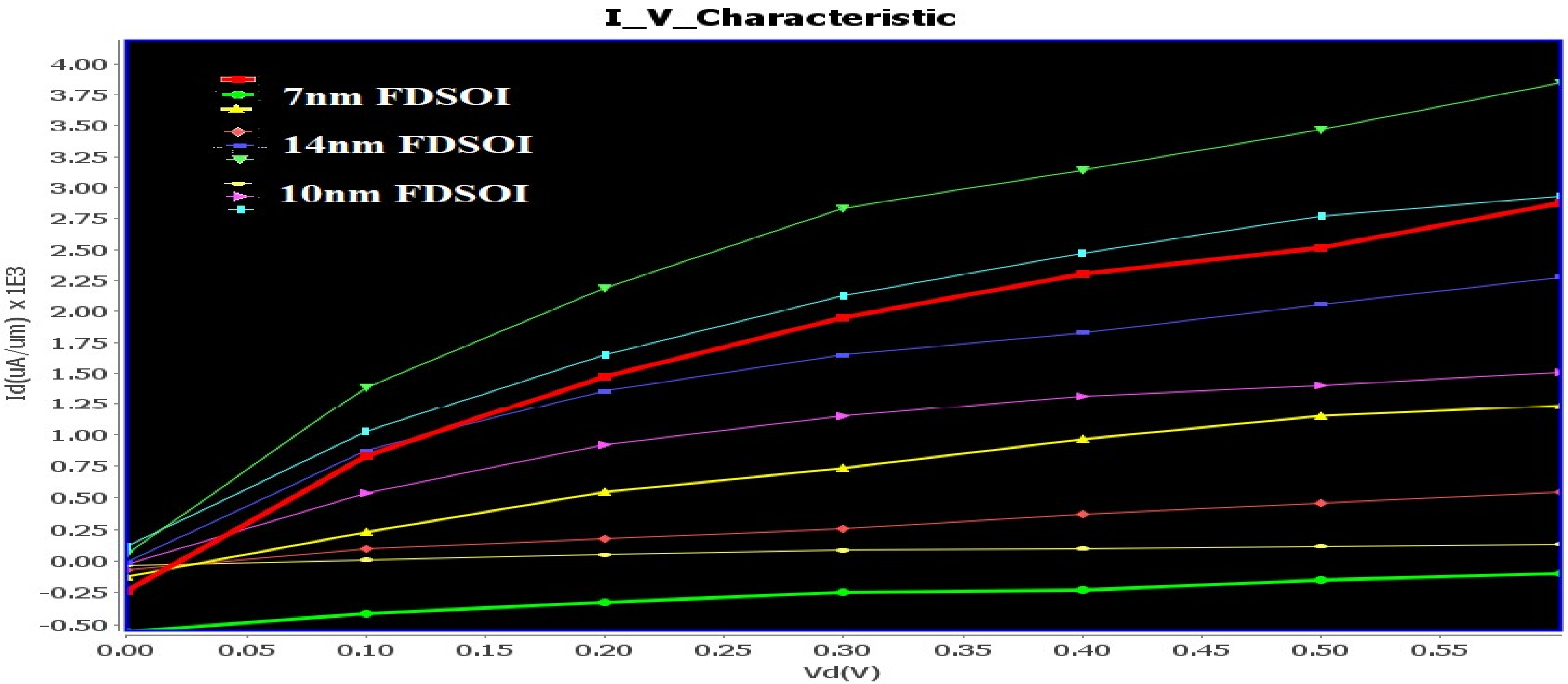




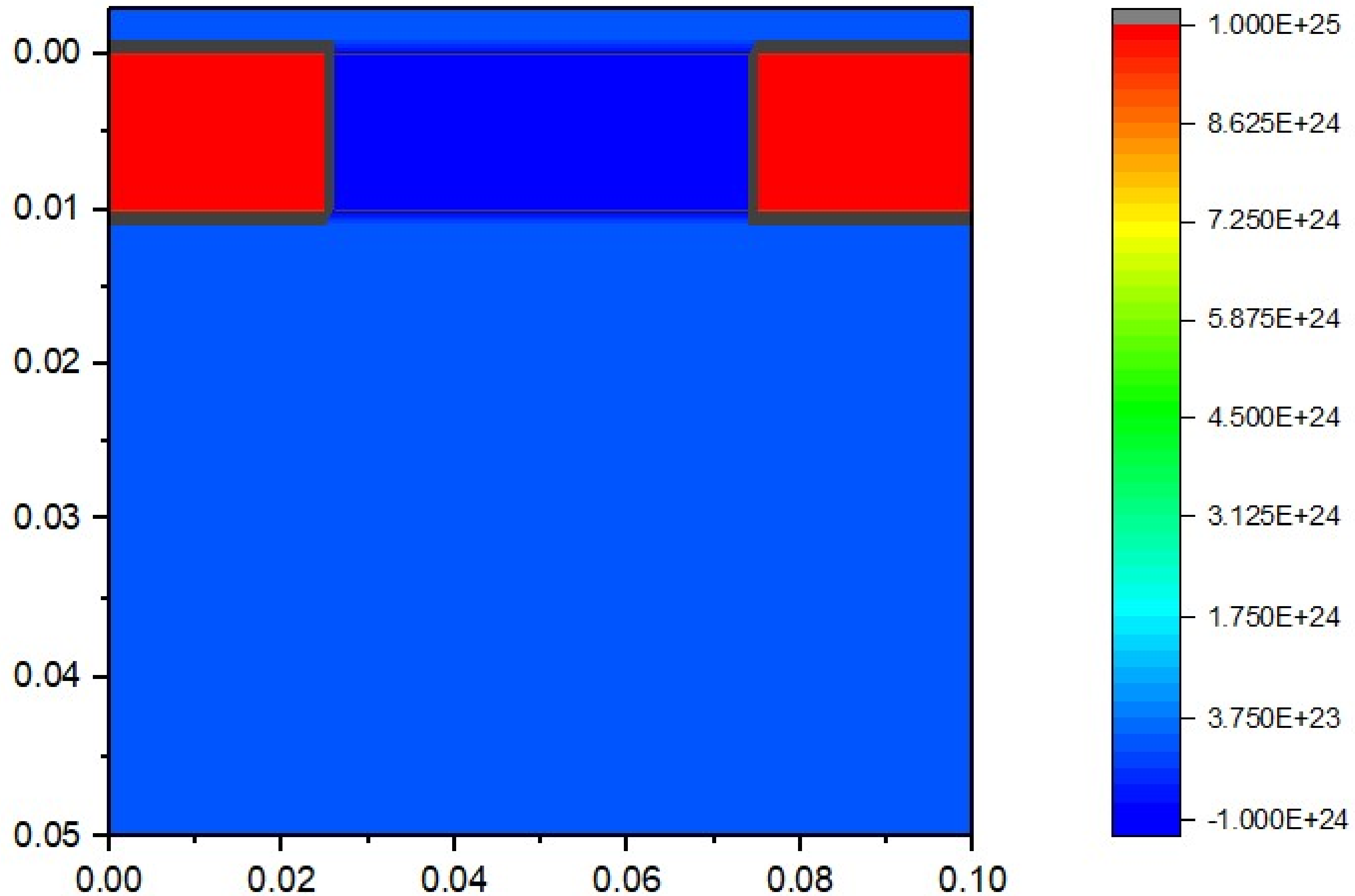
Single Gate I_d - V_d Characteristics



Dual Gate I_d - V_d Characteristics

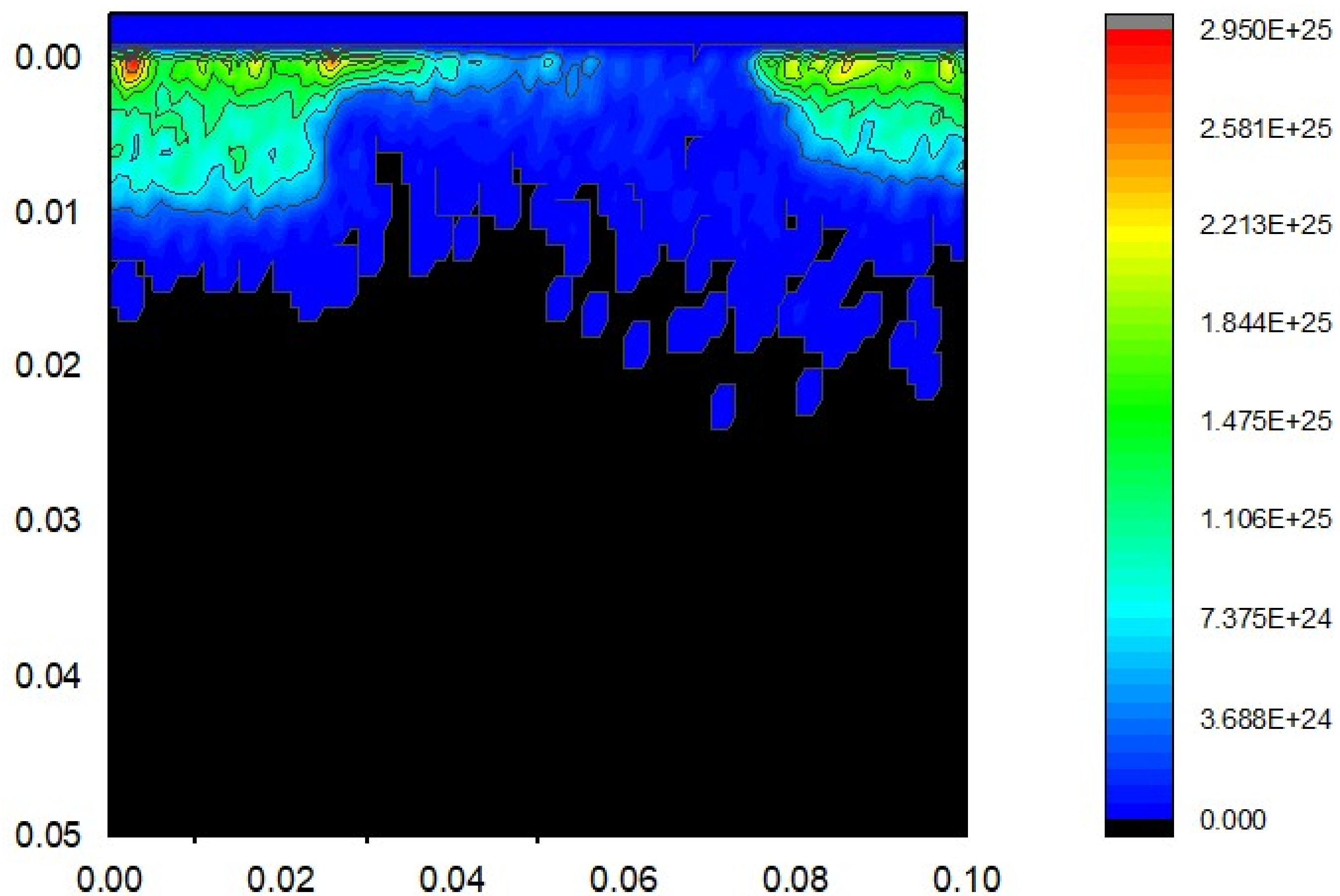


MOSFET

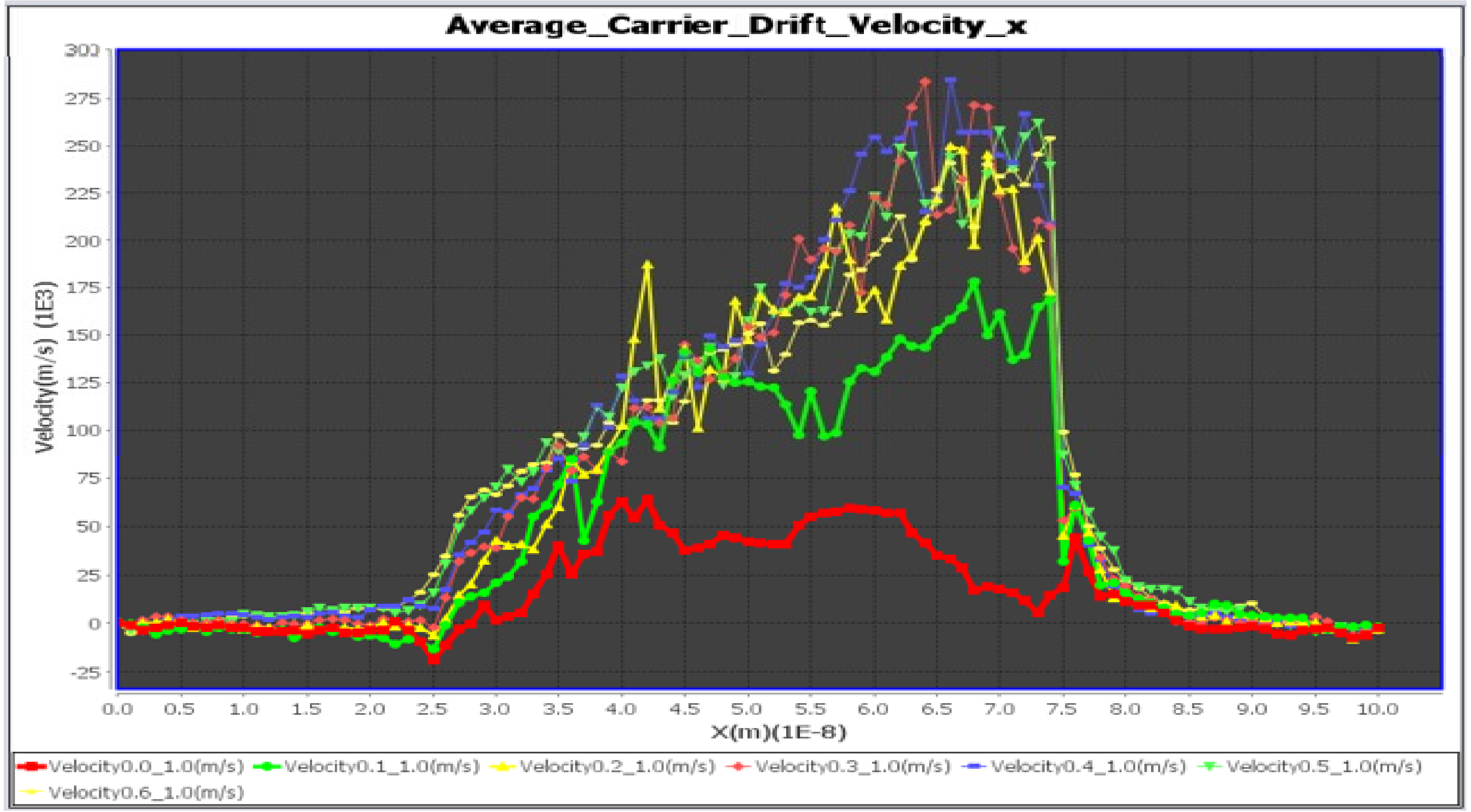


0.00
0.01
0.02
0.03
0.04
0.05
0.00
0.02
0.04
0.06
0.08
0.10
1.000E+25
8.625E+24
7.250E+24
5.875E+24
4.500E+24
3.125E+24
1.750E+24
3.750E+23
-1.000E+24

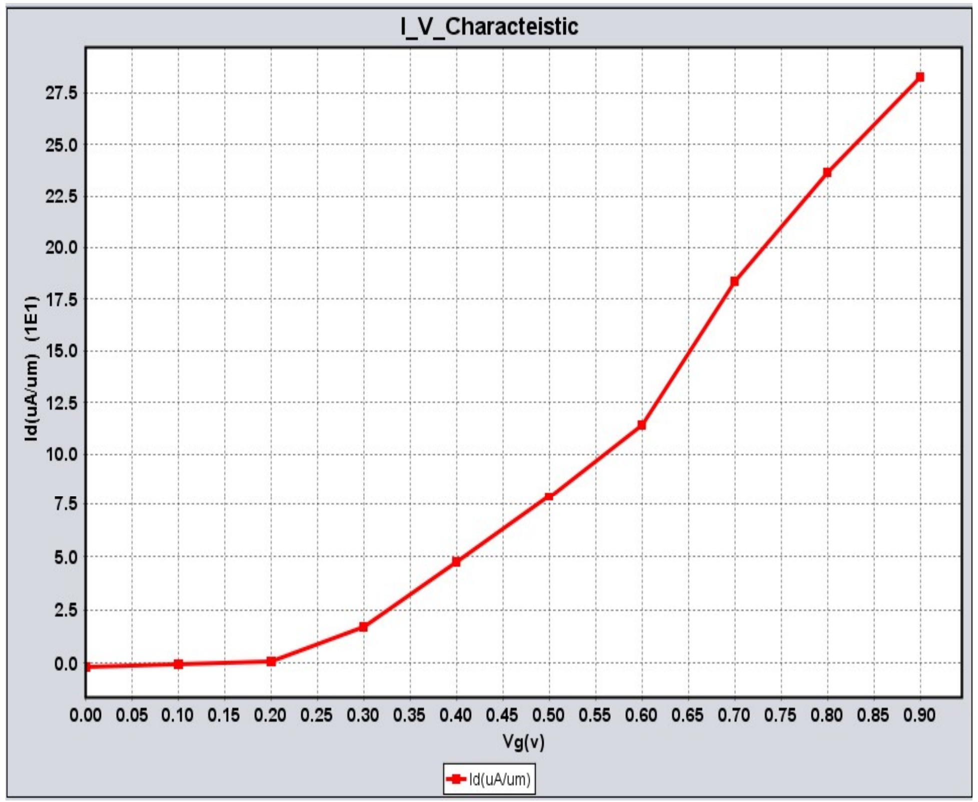
MOSFET: Carrier Density

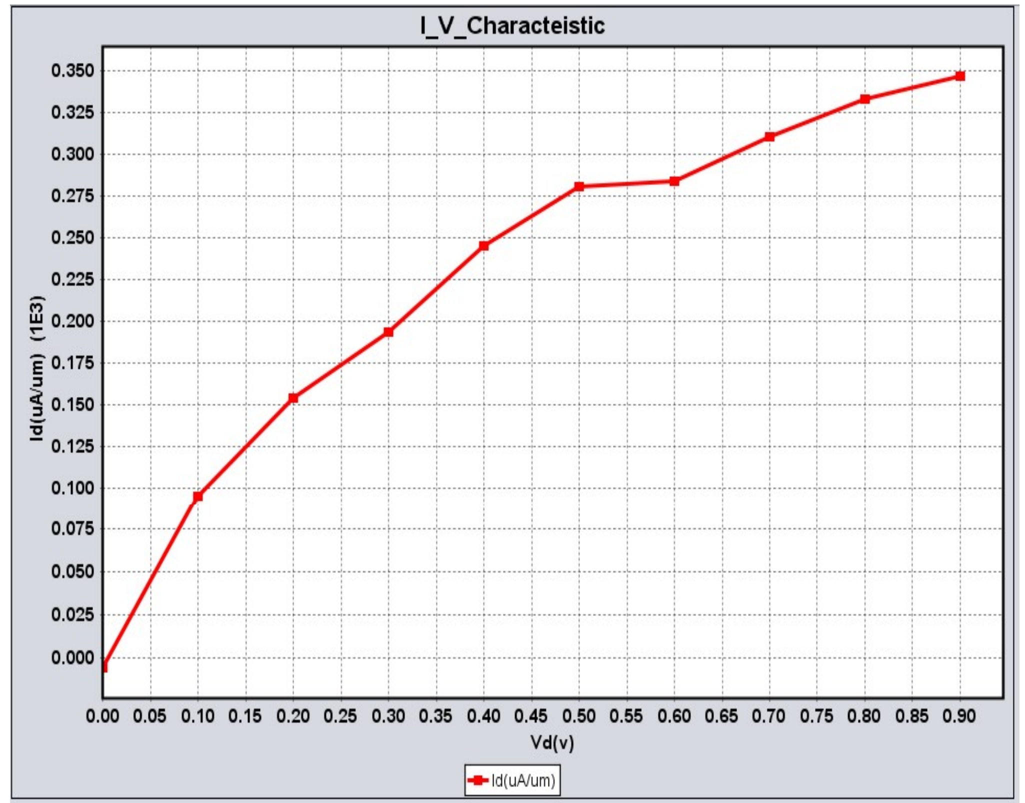


MOSFET: Carrier Drift Velocity

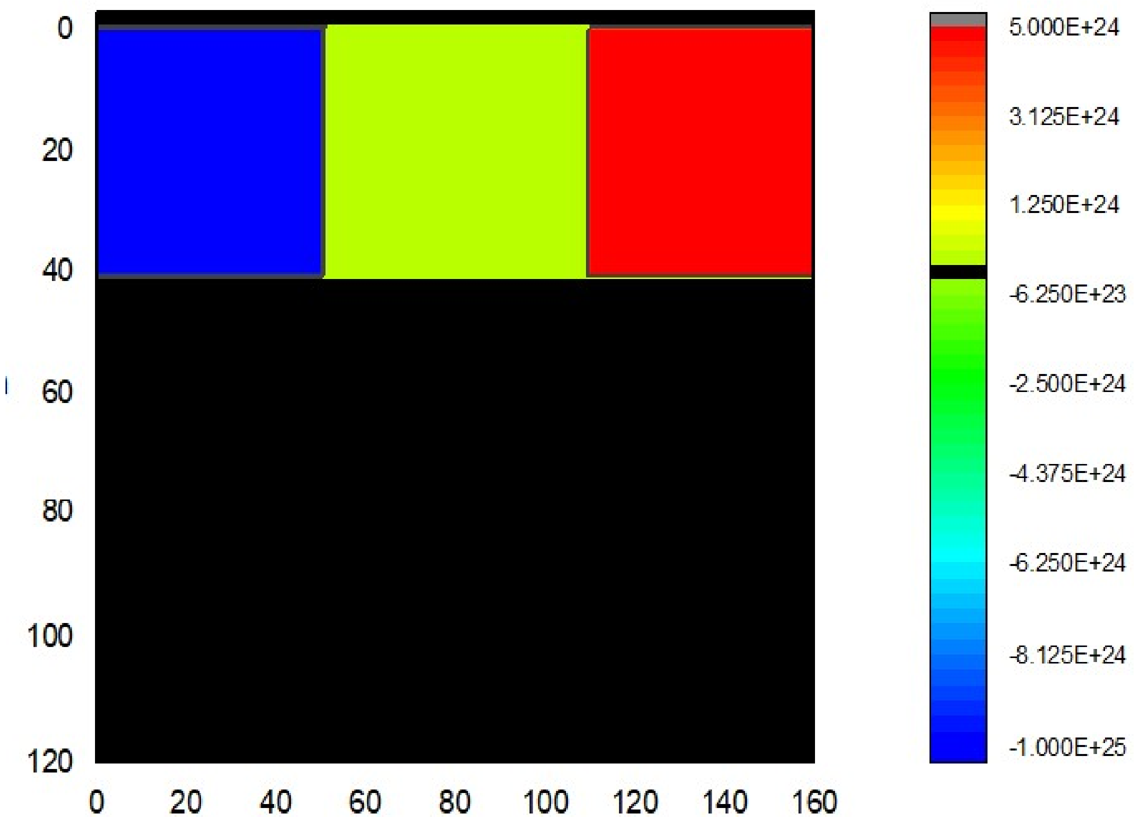


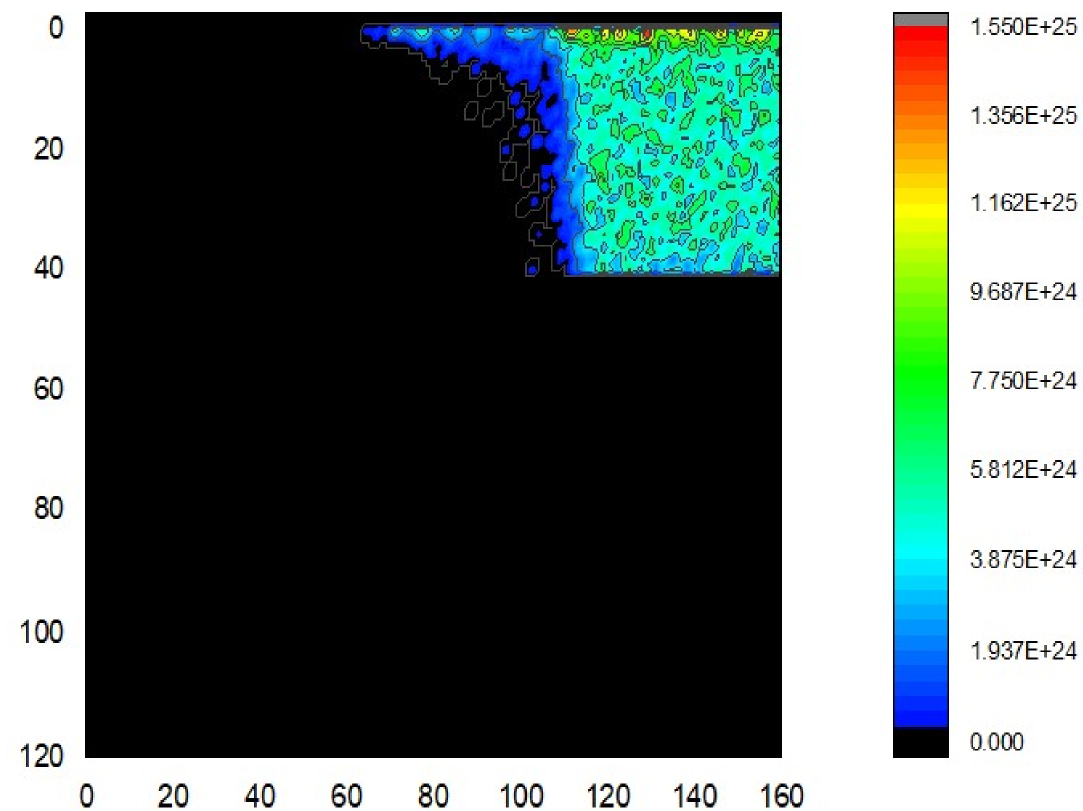
MOSFET Transfer Characteristics



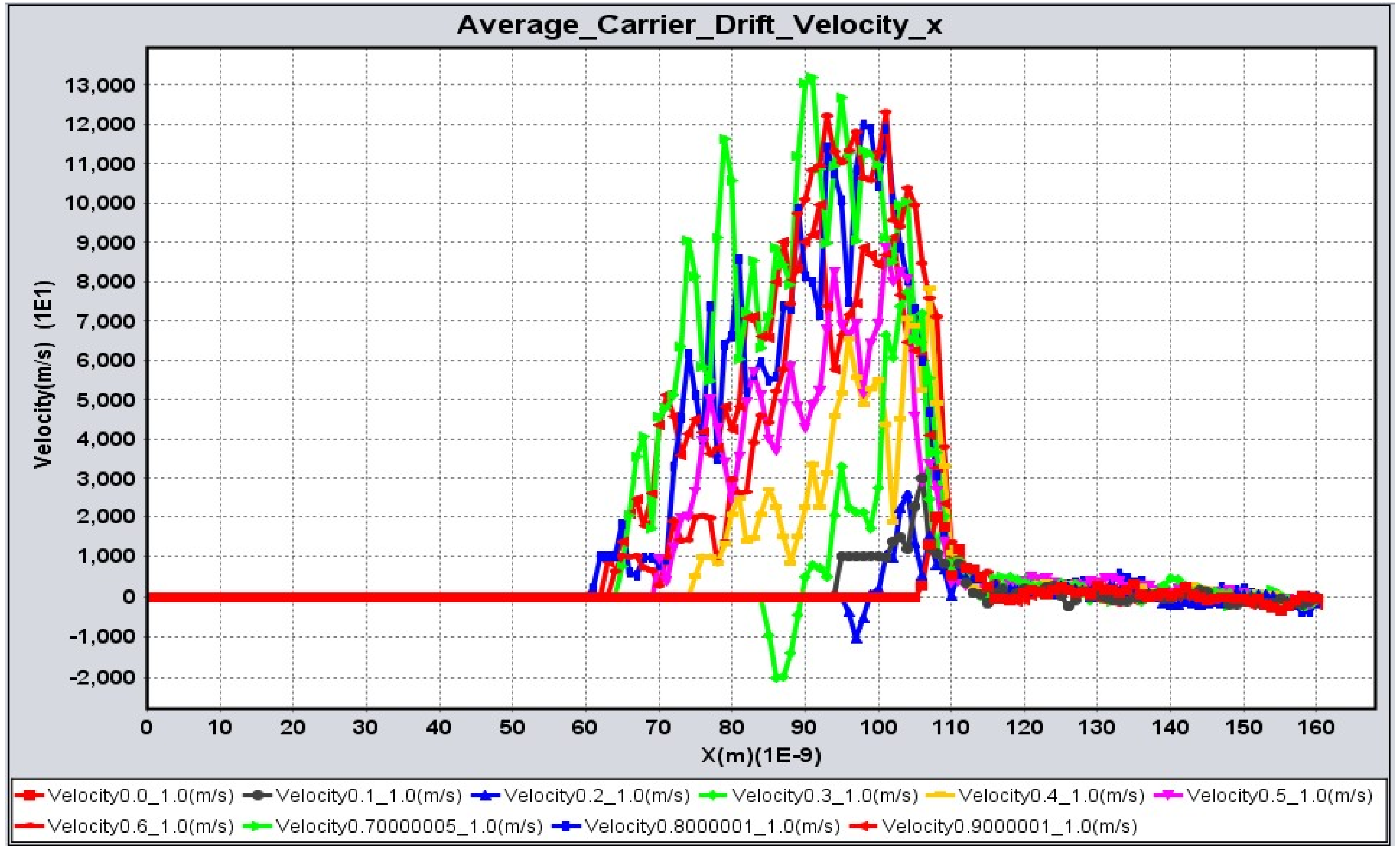


Tunneling FET

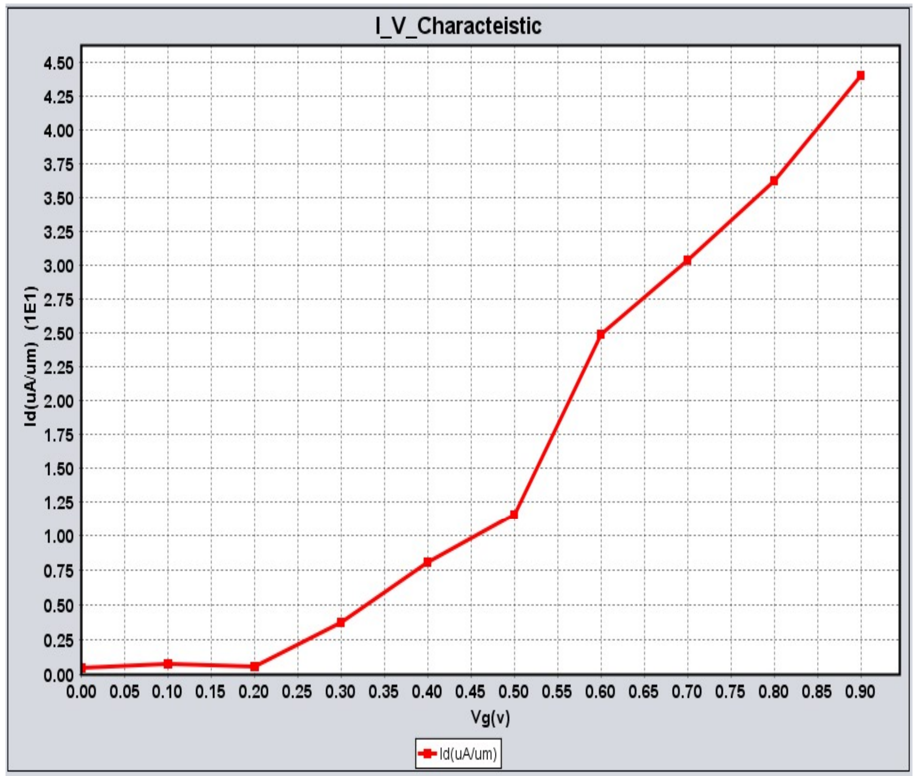


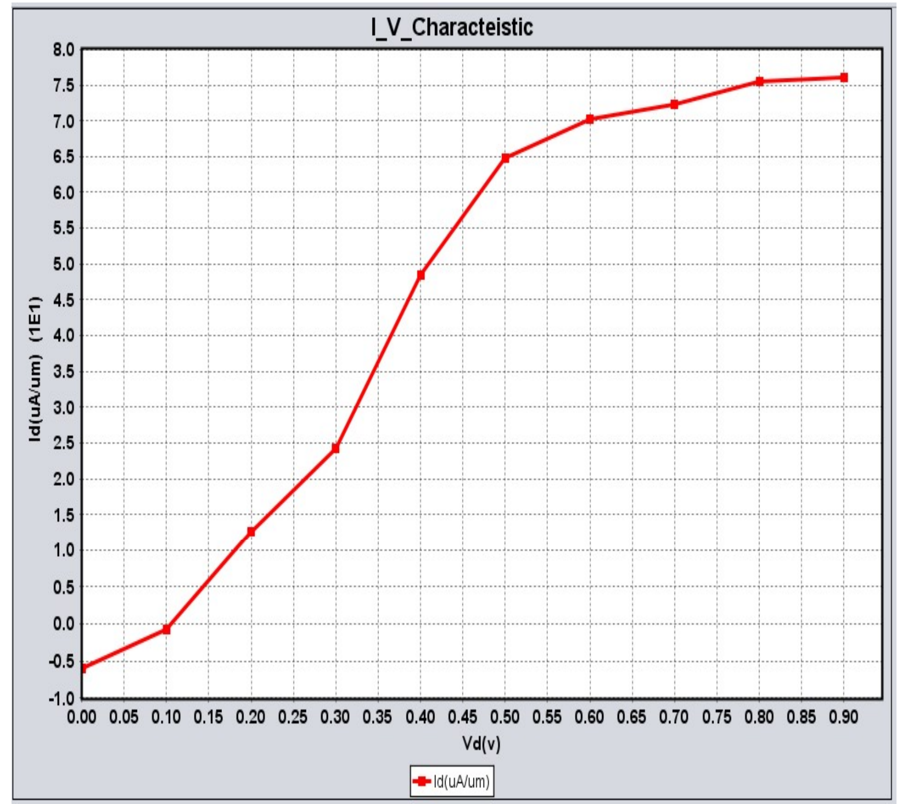


Tunneling FET

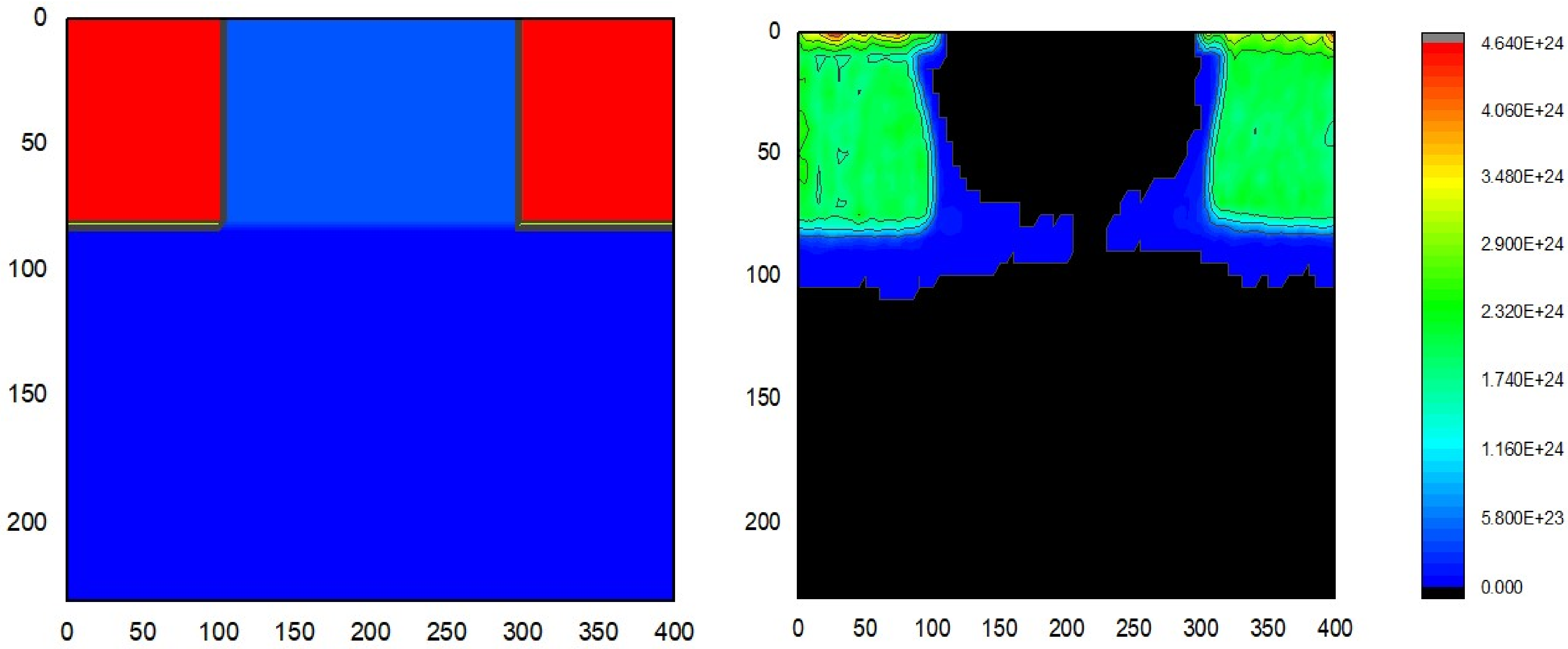


Tunneling FET Transfer Characteristics

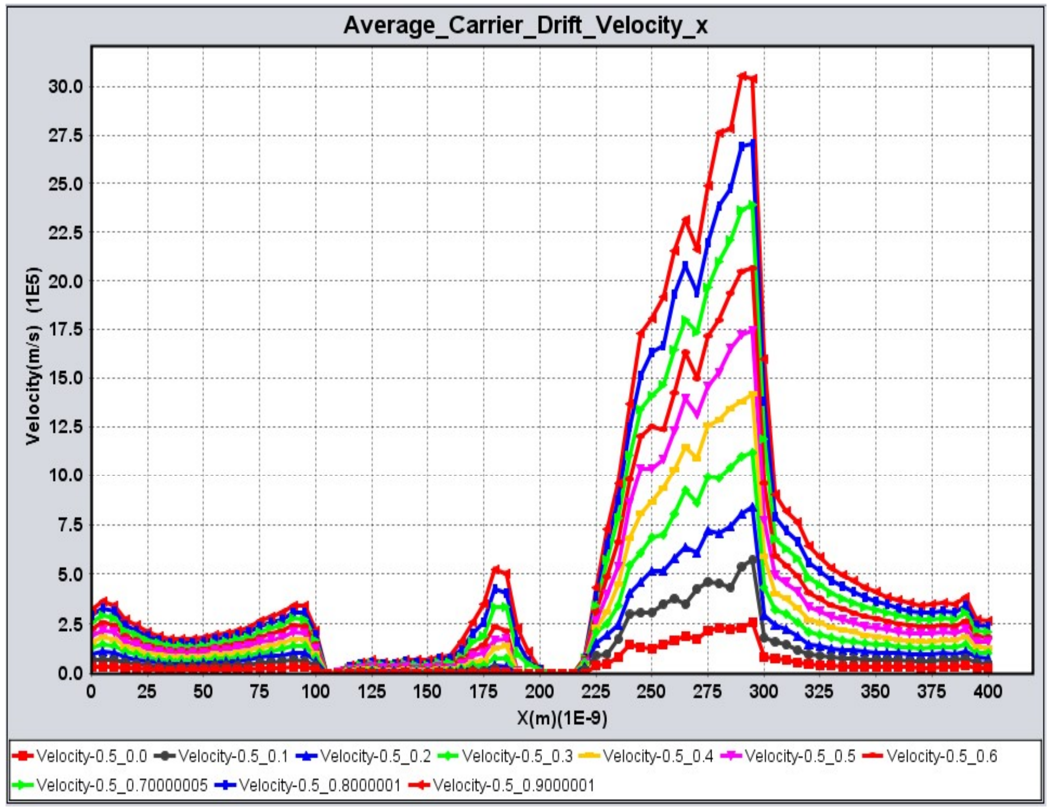




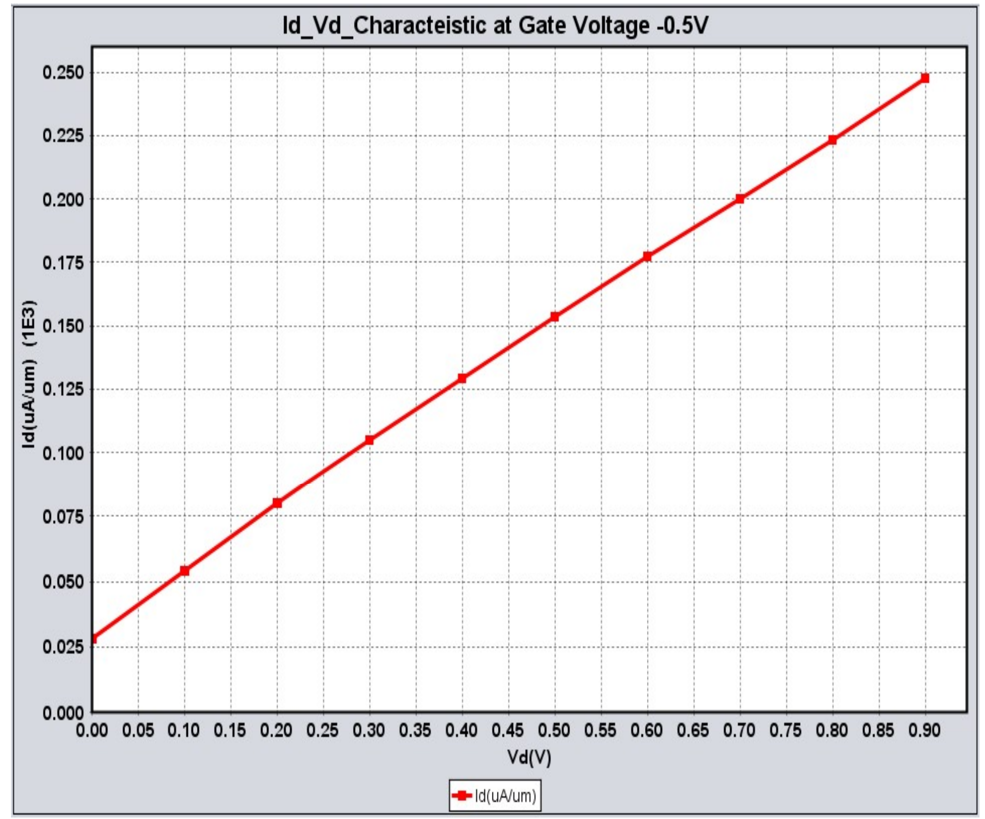
MESFET


0
50
100
150
200
0
50
100
150
200
250
300
350
400
0
50
100
150
200
0
50
100
150
200
250
300
350
400
4.640E+24
4.060E+24
3.480E+24
2.900E+24
2.320E+24
1.740E+24
1.160E+24
5.800E+23
0.000

MESFET



Average_Carrier_Drift_Velocity_x
Velocity(m/s) (1E5)
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400
X(m)(1E-9)
Velocity-0.5_0.0
Velocity-0.5_0.1
Velocity-0.5_0.2
Velocity-0.5_0.3
Velocity-0.5_0.4
Velocity-0.5_0.5
Velocity-0.5_0.6
Velocity-0.5_0.70000005
Velocity-0.5_0.8000001
Velocity-0.5_0.9000001



Id_Vd_Characteistic at Gate Voltage -0.5V
Id(uA/um) (1E3)
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90
Vd(V)
Id(uA/um)

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