

Supplementary Material

Nanowire FET based Neural Element for Robotic Tactile Sensing System

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2 Parameters used for Device (Silvaco ATLAS) and Circuit Simulations (Multisim)

Block-iterative carriers = 2

CONSTANTS:

Boltzmann's constant = 1.38066e-023 J/K
 Elementary charge = 1.60219e-019 C
 Permittivity in vacuum = 8.85419e-014 F/cm
 Temperature = 300 K
 Thermal voltage = 0.025852 V

REGIONAL MATERIAL PARAMETERS:

Region	1	2	3	4	5	5	5	6	6	6
Material	SiO2	HfO2	HfO2	Silicon	Nickel	Nickel	Nickel	Nickel	Nickel	Nickel
Type	insulator	insulator	insulator	semicond.	metal	metal	metal	metal	metal	metal

Band Parameters

	3.9	20.0	20.0	11.8
Epsilon				
Eg (eV)				1.08

Chi (eV)	:	4.17
Nc (per cc)	:	2.8e+019
Nv (per cc)	:	1.04e+019
ni (per cc)	:	1.45e+010

Bandgap narrowing parameters

bgn.e (eV)	:	0.009
bgn.n (/cc)	:	1e+017
bgn.c	:	0.5
ubgn.b	:	3.1e+012
ubgn.c	:	3.9e-005
bgn.shnk.me	:	0.321
bgn.shnk.mh	:	0.346
bgn.shnk.eps	:	11.7
bgn.shnk.ge	:	12
bgn.shnk.gh	:	4

Effective Richardson Constants

An**	:	110
Ap**	:	30

Incomplete Ionization Parameters

Gc	:	2
Gv	:	4
Ed (eV)	:	0.044
Ea (eV)	:	0.045

Recombination Parameters

taun0	:	1e-007
taup0	:	1e-007
etrap	:	0
nsrhn	:	5e+016
nsrhp	:	5e+016
ksrhtn	:	0.0025
ksrhtp	:	0.0025
ksrhcn	:	3e-013
ksrhcp	:	1.18e-012
ksrhgn	:	1.77
ksrhgp	:	0.57
nsrhn	:	5e+016
nsrhp	:	5e+016
augn	:	2.8e-031
augp	:	9.9e-032
augkn	:	0
augkp	:	0
kaugcn	:	1.83e-031

kaugcp	:	2.78e-031
kaugdn	:	1.18
kaugdp	:	0.72
aug.cnl	:	2.2e-031
aug.cpl	:	9.2e-032
aug.chi	:	1.66e-030
hns.ae	:	6.7e-032
hns.ah	:	7.2e-032
hns.be	:	2.45e-031
hns.bh	:	4.5e-033
hns.ce	:	-2.2e-032
hns.ch	:	2.63e-032
hns.he	:	3.47
hns.hh	:	8.26
hns.n0e	:	1e+018
hns.p0e	:	1e+018
copt	:	0

Band-to-band tunneling Parameters

mass.tunnel	:	0.25
me.tunnel	:	0.322
mh.tunnel	:	0.549

Thermal Velocities

vn (cm/s)	:	1.08e+007
vp (cm/s)	:	1.3e+007

Saturation Velocities

vsatn (cm/s)	:	1.03e+007
vsatp (cm/s)	:	1.03e+007

REGIONAL MOBILITY MODEL SUMMARY:

Model for Electrons:

Concentration Dependent Mobility

@ Temperature = 300 Kelvin

Using built-in model (refer to manual).

Parallel Field Dependent Mobility

Using parallel field model.

Using built-in Silicon model for Vsat.

alpha = 2.4e+007

theta = 0.8

tnom = 600

beta = 2

Model for Holes:

Concentration Dependent Mobility
 @ Temperature = 300 Kelvin
 Using built-in model (refer to manual).

Parallel Field Dependent Mobility
 Using parallel field model.
 Using built-in Silicon model for Vsat.
 alpha = 2.4e+007
 theta = 0.8
 tnom = 600
 beta = 1

Key Parameters:

Rel. Permittivity of HfO ₂	:	20.0
Work function of Ni (eV)	:	5.01
Fixed Oxide Charge Density (cm ⁻²)	:	10 ¹¹
Si-NW with width (nm)	:	100
height (nm)	:	100
length (μm)	:	15
Channel Doping (cm ⁻³)	:	10 ¹⁴
Source/Drain Doping (cm ⁻³)	:	10 ²⁰

References:

(2015)

Silvaco (2015). Silvaco ATLAS User Manual.