; Structure definition

(sdegeo:set-default-boolean "ABA")

(sdegeo:create-cuboid (position 100 100 0) (position -100 -100 100) "Silicon" "waiweijiti1")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 100)100 "Silicon" "yuanzhujiti2")

(sdegeo:create-cuboid (position 100 100 100) (position -100 -100 100.5) "SiO2" "sbm1umSiO2")

(sdegeo:create-cylinder (position 0 0 100) (position 0 0 101)8.75 "Aluminum" "ayj")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)92.75 "Silicon" "sbmh88")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)84 "Silicon" "sbmh8")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)82.25 "Silicon" "sbmh77")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)73.5 "Silicon" "sbmh7")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)71.75 "Silicon" "sbmh66")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)63"Silicon" "sbmh6")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)61.25 "Silicon" "sbmh55")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)52.5 "Silicon" "sbmh5")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)50.75 "Silicon" "sbmh44")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)42 "Silicon" "sbmh4")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)40.25 "Silicon" "sbmh33")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)31.5 "Silicon" "sbmh3")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)29.75 "Silicon" "sbmh22")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)21 "Silicon" "sbmh2")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)19.25 "Silicon" "sbmh11")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)10.5 "Silicon" "sbmh1")

(sdegeo:create-cylinder (position 0 0 99) (position 0 0 100)8.75 "Silicon" "czyj")

(sdegeo:create-cuboid (position 100 100 0) (position -100 -100 -0.5) "SiO2" "xbm1umSiO2")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 -1)100 "Aluminum" "cyj")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 90)100 "Silicon" "0")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 90)96 "Silicon" "00")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 56.41)94 "Silicon" "1")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 56.41)86 "Silicon" "11")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 40)84 "Silicon" "2")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 40)76"Silicon" "22")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 28.586)74 "Silicon" "3")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 28.586)66 "Silicon" "33")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 20)64 "Silicon" "4")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 20)56 "Silicon" "44")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 13.4)54 "Silicon" "5")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 13.4)46 "Silicon" "55")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 8.35)44 "Silicon" "6")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 8.35)36 "Silicon" "66")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 4.6)34 "Silicon" "7")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 4.6)26 "Silicon" "77")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 2.02)24 "Silicon" "8")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 2.02)16 "Silicon" "88")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 0.512)14 "Silicon" "9")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 0.512)6 "Silicon" "99")

(sdegeo:create-cylinder (position 0 0 0) (position 0 0 1)100 "Silicon" "czxbm")

(sdegeo:define-contact-set "anode" 4.0 (color:rgb 1.0 0.0 0.0 ) "##" )

(sdegeo:set-current-contact-set "anode")

(sdegeo:define-3d-contact (find-face-id (position 0 0 101)) "anode")

(sdegeo:define-contact-set "cathode" 4.0 (color:rgb 0.0 1.0 0.0 ) "##" )

(sdegeo:set-current-contact-set "cathode")

(sdegeo:define-3d-contact (find-face-id (position 0 0 -1)) "cathode")

(sdedr:define-constant-profile "n0" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n0" "n0" "waiweijiti1")

(sdedr:define-constant-profile "n1" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n1" "n1" "yuanzhujiti2")

(sdedr:define-constant-profile "p1" "BoronActiveConcentration" 1e18)

(sdedr:define-constant-profile-region "PlaceCD.p1" "p1" "sbmh88")

(sdedr:define-constant-profile "n3" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n3" "n3" "sbmh8")

(sdedr:define-constant-profile "p2" "BoronActiveConcentration" 1e18)

(sdedr:define-constant-profile-region "PlaceCD.p2" "p2" "sbmh77")

(sdedr:define-constant-profile "n4" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n4" "n4" "sbmh7")

(sdedr:define-constant-profile "p3" "BoronActiveConcentration" 1e18)

(sdedr:define-constant-profile-region "PlaceCD.p3" "p3" "sbmh66")

(sdedr:define-constant-profile "n5" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n5" "n5" "sbmh6")

(sdedr:define-constant-profile "p4" "BoronActiveConcentration" 1e18)

(sdedr:define-constant-profile-region "PlaceCD.p4" "p4" "sbmh55")

(sdedr:define-constant-profile "n6" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n6" "n6" "sbmh5")

(sdedr:define-constant-profile "p5" "BoronActiveConcentration" 1e18)

(sdedr:define-constant-profile-region "PlaceCD.p5" "p5" "sbmh44")

(sdedr:define-constant-profile "n7" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n7" "n7" "sbmh4")

(sdedr:define-constant-profile "p6" "BoronActiveConcentration" 1e18)

(sdedr:define-constant-profile-region "PlaceCD.p6" "p6" "sbmh33")

(sdedr:define-constant-profile "n8" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n8" "n8" "sbmh3")

(sdedr:define-constant-profile "p7" "BoronActiveConcentration" 1e18)

(sdedr:define-constant-profile-region "PlaceCD.p7" "p7" "sbmh22")

(sdedr:define-constant-profile "n9" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n9" "n9" "sbmh2")

(sdedr:define-constant-profile "p8" "BoronActiveConcentration" 1e18)

(sdedr:define-constant-profile-region "PlaceCD.p8" "p8" "sbmh11")

(sdedr:define-constant-profile "n10" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n10" "n10" "sbmh1")

(sdedr:define-constant-profile "n2" "PhosphorusActiveConcentration" 1e18)

(sdedr:define-constant-profile-region "PlaceCD.n2" "n2" "czyj")

(sdedr:define-constant-profile "p+0" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+0" "p+0" "0")

(sdedr:define-constant-profile "n-0" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-0" "n-0" "00")

(sdedr:define-constant-profile "p+1" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+1" "p+1" "1")

(sdedr:define-constant-profile "n-1" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-1" "n-1" "11")

(sdedr:define-constant-profile "p+2" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+2" "p+2" "2")

(sdedr:define-constant-profile "n-2" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-2" "n-2" "22")

(sdedr:define-constant-profile "p+2" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+2" "p+2" "2")

(sdedr:define-constant-profile "n-2" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-2" "n-2" "22")

(sdedr:define-constant-profile "p+3" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+3" "p+3" "3")

(sdedr:define-constant-profile "n-3" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-3" "n-3" "33")

(sdedr:define-constant-profile "p+4" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+4" "p+4" "4")

(sdedr:define-constant-profile "n-4" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-4" "n-4" "44")

(sdedr:define-constant-profile "p+5" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+5" "p+5" "5")

(sdedr:define-constant-profile "n-5" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-5" "n-5" "55")

(sdedr:define-constant-profile "p+6" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+6" "p+6" "6")

(sdedr:define-constant-profile "n-6" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-6" "n-6" "66")

(sdedr:define-constant-profile "p+7" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+7" "p+7" "7")

(sdedr:define-constant-profile "n-7" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-7" "n-7" "77")

(sdedr:define-constant-profile "p+8" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+8" "p+8" "8")

(sdedr:define-constant-profile "n-8" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-8" "n-8" "88")

(sdedr:define-constant-profile "p+9" "BoronActiveConcentration" 1e19)

(sdedr:define-constant-profile-region "PlaceCD.p+9" "p+9" "9")

(sdedr:define-constant-profile "n-9" "PhosphorusActiveConcentration" 1e12)

(sdedr:define-constant-profile-region "PlaceCD.n-9" "n-9" "99")

(sdedr:define-constant-profile "pxbm" "BoronActiveConcentration" 1e18)

(sdedr:define-constant-profile-region "PlaceCD.pxbm" "pxbm" "czxbm")

(sdedr:define-refeval-window "world" "Cuboid" (position 100 100 -1) (position -100 -100 101))

(sdedr:define-refinement-size "RefDef.world" 20 20 20 16 16 16)

(sdedr:define-refinement-placement "RefPlace.world" "RefDef.world" "world")

(sdedr:define-refinement-function "RefDef.Channel" "DopingConcentration" "MaxTransDiff" 1)

(sdedr:define-refeval-window "world" "Cuboid" (position 100 100 -1) (position -100 -100 1))

(sdedr:define-refinement-size "RefDef.world" 8 8 8 4 4 4)

(sdedr:define-refinement-placement "RefPlace.world" "RefDef.world" "world")

(sdedr:define-refinement-function "RefinementDefinition\_1" "MaxLenInt" "All" "All"1 4 "DoubleSide")

(sde:build-mesh "n@node@\_msh")

File{

 Grid= "@tdr@"

 Current= "@plot@"

 Plot= "@tdrdat@"

}

Electrode{

{ Name="anode" Voltage=0.0 }

{ Name="cathode" Voltage=0.0 }

}

Physics{

Mobility(DopingDep CarrierCarrierScattering

#eHighFieldSaturation( GradQuasiFermi )

#hHighFieldSaturation( GradQuasiFermi )

Enormal

)

eQCvanDort

EffectiveIntrinsicDensity( OldSlotboom )

Recombination(SRH( DopingDep ))

}

physics (MaterialInterface="SiO2/Silicon") {

Charge(Conc=4e11)

}

Plot {

eDensity hDensity

Current eCurrent hCurrent

ElectricField/vector eEparallel hEparallel

eQuasiFermi hQuasiFermi

Potential Doping SpaceCharge

eMobility hMobility eVelocity hVelocity

Potential SpaceCharge ElectricField

Doping DonorConcentration AcceptorConcentration

}

Math {

RHSMax= 1e40

RHSMin= 1e-10

RHSFactor= 1e40

Digits= 5

Method = Blocked

SubMethod = ILS

Number\_Of\_Threads= 12

Number\_of\_Solver\_Threads = 12

DirectCurrent

Extrapolate

RelErrControl

Notdamped=50

Iterations=20

WallClock

}

Solve {

Coupled ( Iterations=100 LineSearchDamping=1e-8 ){ Poisson }

 Coupled { Poisson Electron Hole }

 Save ( FilePrefix="n@node@\_init" )

# ramp 0 cathode and save solutions:

Quasistationary

(InitialStep=0.01 Increment=1

 Minstep= 0.0001 Maxstep=1.2

Goal { name="cathode" voltage= @V@ }

)

{ Coupled (Iterations=20 LineSearchDamping=1e-8){ Poisson Electron Hole } }

}

File{

 Grid ="@tdr@"

 \*Parameter ="@parameter@"

 Plot ="@tdrdat@"

 Current ="@plot@"

 Output ="@log@"

}

Physics {

 Fermi

 \*InCompleteIonization

 Hydrodynamic( eTemperature )

 Mobility ( DopingDependence HighFieldSaturation Enormal )

 EffectiveIntrinsicDensity(BandGapNarrowing (OldSlotboom))

 Recombination (

 Auger

 SRH(DopingDependence)

 Avalanche(Okuto)

 )

}

Physics (

MaterialInterface="SiliconCarbide/Oxide" ) {Traps (FixedCharge Conc=4e11) }

Plot {

 eDensity hDensity eCurrent hCurrent

 TotalCurrent/Vector eCurrent/Vector hCurrent/Vector

 eMobility hMobility

 eVelocity hVelocity

 ElectricField/Vector eEparallel hEparallel SpaceCharge

 eQuasiFermi hQuasiFermi

 Potential Doping SpaceCharge

 DonorConcentration AcceptorConcentration

 DonorPlusConcentration AccepMinusConcentration

}

Math {

 NumberofThreads = maximum

 RelErrControl

 eDrForceRefDens= 1e8

 hDrForceRefDens= 1e8

 Notdamped= 100

 Iterations= 15

 ErrRef(electron)= 1e10

 ErrRef(hole) = 1e10

 ExitOnFailure

}

Electrode {

 { Name="anode" Voltage=0.0 }

 { Name="cathode" Voltage=0.0 }

}

Math {

 ImplicitACSystem \* build implicit AC system

 Method= Blocked

 SubMethod= ILS(set=1)

 ACMethod= Blocked

 ACSubMethod= ILS(set=2)

}

Solve {

 Coupled(Iterations=100){ Poisson }

 Coupled { Poisson Electron Hole }

 Save ( FilePrefix = "Equil" )

 NewCurrentPrefix="init\_"

 Quasistationary(

 InitialStep=1e-5 Increment=1.75

 MinStep=1e-8 MaxStep=0.2

 Goal{ Name="cathode" Voltage= -2.8 } )

 {Coupled { Poisson Electron Hole }

 \*Plot ( FilePrefix = "Stationary" Time = (0.00 ; 0.333 ; 0.5; 0.667 ; 1.00) NoOverwrite)

 }

 Load ( FilePrefix = "Equil" )

 NewCurrentPrefix="ac"

 Quasistationary (

 InitialStep= 1.0e-2 Increment= 1.5

 Minstep= 1e-6 MaxStep= 0.05

 Goal{ Name="cathode" Voltage= -2.8 )

{ ACCoupled(

 StartFrequency= 1e6 EndFrequency= 1e6

 \* NumberOfPoints= points\_Per\_Decade\*number\_Of\_Decades + 1

 NumberOfPoints= 1 Decade

 Node(N\_cathode N\_anode ) Exclude(V\_cathode V\_anode )

 ObservationNode(N\_cathode N\_anode )

 ACExtract="@acplot@"

 ACCompute ( Time = (Range = (0 1) Intervals= 40 ) )

 ){ Poisson Electron Hole }

 }

}

File {

 Grid= "@tdr@"

 Parameter= "@parameter@"

 Current= "@plot@"

 Plot= "@tdrdat@"

 Output= "@log@"

}

Electrode {

 { Name= "anode" Voltage= 0.0 }

 { Name= "cathode" Voltage= 0.0 }

}

Physics {

Mobility (

DopingDependence

eHighFieldSaturation

hHighFieldSaturation

Enormal

CarrierCarrierScattering

)

Recombination (

SRH (DopingDependence)

)

HeavyIon (

Direction = (0,0,1)

Location = (-37,17,100)

Time =0.01e-10

Length = [0 0.001 100 100.001]

Wt\_hi = [1.0 1.0 1.0 1.0]

LET\_f =[0 1.28e-5 1.28e-5 0]

Gaussian

PicoCoulomb

)

}

Plot {

eDensity hDensity ElectricField HeavyIonChargeDensity

}

Math {

 Extrapolate

 Notdamped=50

 Iterations=15

 ExitOnFailure

 Digits=5

 ErrEff(electron)=1e10

 ErrEff(hole)=1e10

 \*- Single Device:

 #Method= Super \* Single device < 10k node/single processor

 Method= ParDiSo \* Single device < 100k node/multi processor

 # Method= ILS \* > 8k node/multi processor

 # Number\_of\_Threads= <int> # | maximum

 # Number\_of\_Assembly\_Threads= <int>

 # Number\_of\_Solver\_Threads= <int>

 \*- Multi-Device/Mixed Mode

 # Method=Blocked

 # SubMethod= Super # | ParDiSo | ILS

 RecBoxIntegr(5e-3 50 5000)

}

Solve {

Coupled {Poisson}

Coupled {Hole Poisson}

Coupled {Electron Hole Poisson}

QuasiStationary (

InitialStep = 1e-6

MaxStep = 0.001

MinStep = 1e-9

Goal {Name="cathode" voltage=-3}

) {Coupled {Hole Electron Poisson}}

NewCurrentPrefix = "trans\_"

Transient (

InitialTime = 0

FinalTime =1e-9

MinStep = 1e-13

MaxStep = 1e-11

Increment = 1.1

Decrement = 1.5

){Coupled (iterations=8 notdamped= 15){ Poisson Electron Hole}

#Plot (FilePrefix="TransHI\_" Time=(1e-11;1e-10;5e-10;1e-9;5e-9;1e-8) NoOverwrite)

}

}