TCAD simulation III

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Overview

- **Simulation example of 2D PN junction using SDEVICE**
- **CV**

TCAD simulation
SDEVICE

TCAD Synopsys Simulation

- **Sentaurus Device** is a numeric semiconductor device simulator, capable of simulating the electrical, thermal, and optical characteristics of various semiconductor devices.
- It simulates 1D, 2D, and 3D device behaviour over a wide range of operating conditions, including mixed-mode circuit simulation, combining numerically simulated devices with their compact modeling, which is performed on a SPICE-based circuit simulation level.

1 **File Section**: input/output files

2 **Electrode Section**: electrode definition, matching those in the input grid

3 **Physics Section**: physics models to use in the simulation

4 **Plot Section**: variables to plot

5 **Math Section**: solvers

6 **Solve Section**: what to solve (IV,CV, Charge injection)

A typical command file of Sentaurus Device consists of several sections (or statement blocks), with each section executing a relatively independent function. The default extension of the command file is _des.cmd, for example, pp1_des.cmd. To start: **sdevice**

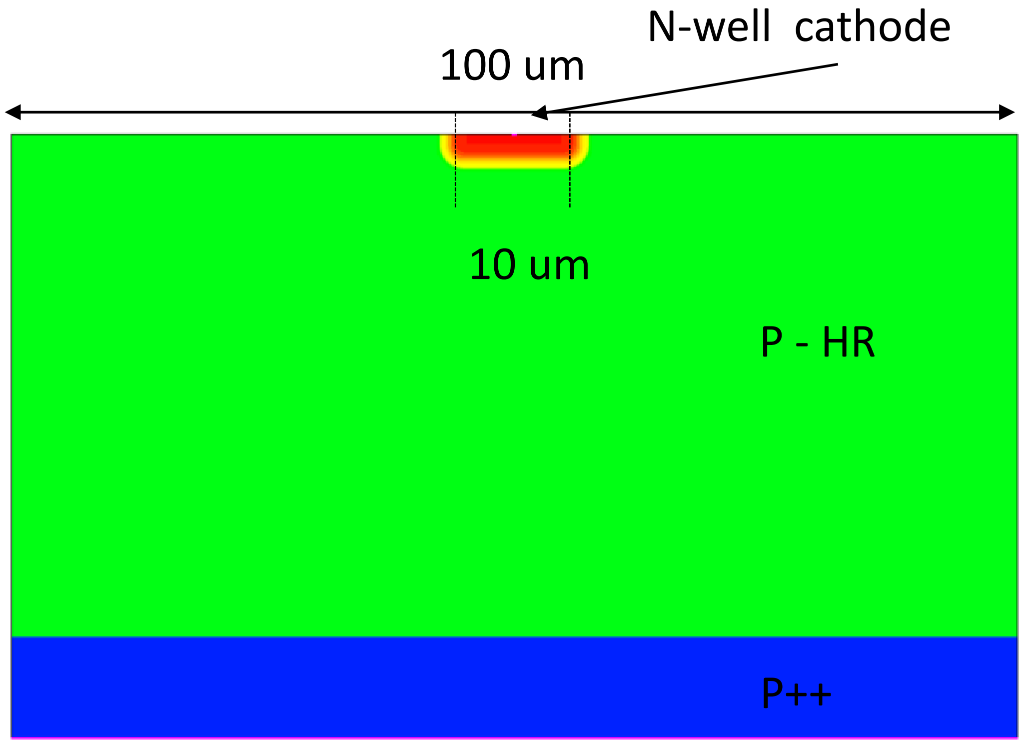
TCAD Synopsys Simulation

- SDEVICE simulation of 2D pn junction
  - **CV**

- **The CV analysis is performed by applying a DC bias to the cathode and injecting a small AC signal into it**

$$\delta I = Y \delta V$$

δI = current vector
δV = voltage vector
Y = admittance matrix
$Y = A + i2\pi\nu C$



TCAD Synopsys Simulation

- SDEVICE command file: almost the same as for the DC analysis
  - **File Section**: input/output files
    Electrode Section: electrode definition, matching those in the input grid
  - **Physics Section**: physics models to use in the simulation
  - **System:** defines a mixed mode setup consisting of the device(s) and sources attached to it
    Plot Section: variables to plot
  - **Math Section**: solvers to use

```
### System definition
System    {
                    PNjnct PNjnctDUTA (
                    "cathode"   =  SENS_CTH
                    "substrate" = SENS_SUB
          )
                Vsource_pset vc ( SENS_CTH 0 ){ dc = 0 }
                Vsource_pset vs ( SENS_SUB 0 ){ dc = 0 }
          }
```

TCAD Synopsys Simulation

- SDEVICE command file
  - **Solve Section**: what to solve (IV,CV, Charge injection…)
    - For the CV, a small-signal analysis is performed, i.e. response of the device to small sinusoidal signals superimposed onto the DC bias
    - The Exclude list is used to remove a set of circuit or physical devices from the AC analysis (usually the power supply, to avoid short-circuit the AC analysis)

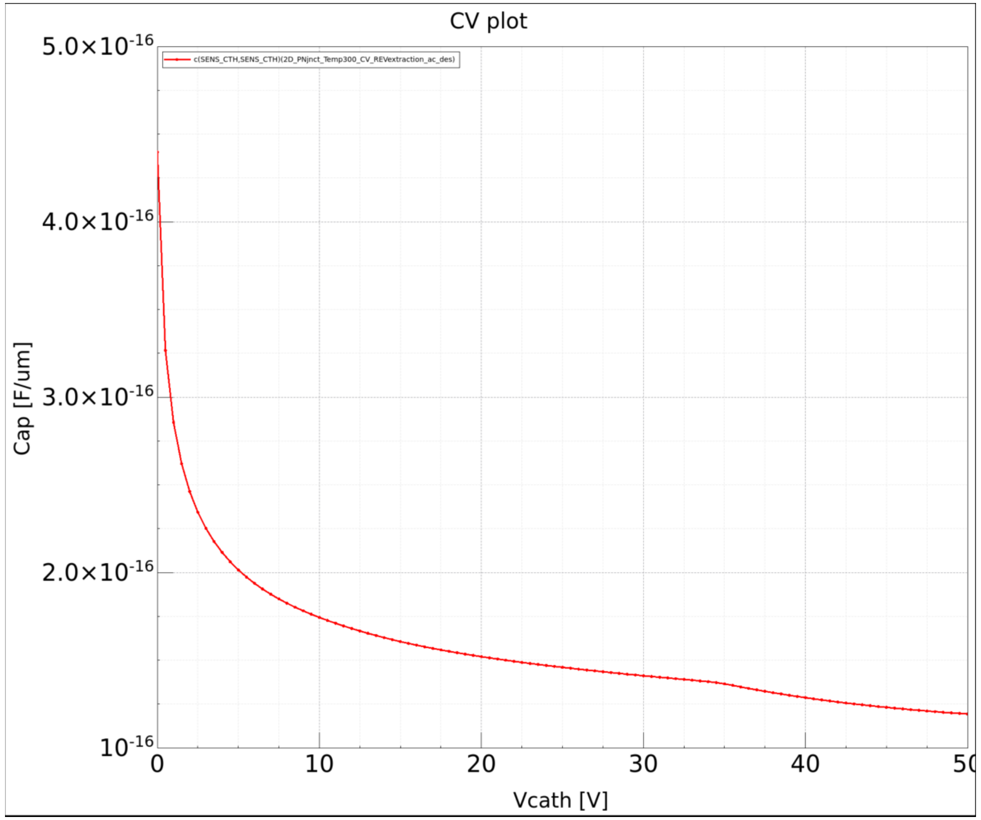
```
### Solve procedure

Solve {
        Coupled(Iterations= 500 LineSearchDamping= 1e-4){ Poisson }

        Coupled(Iterations= 50 LineSearchDamping= 1e-4){ Poisson Electron Hole }

        Plot (FilePrefix = "2D_PNjnct_Temp@Temp@_bias_0V")

          NewCurrentPrefix="2D_PNjnct_Temp@Temp@_CV_REV"

### ramps up the cathode voltage up to the maximum set value
          Quasistationary (
                                    InitialStep=0.01 Increment=1.3
                                    MaxStep=0.025 Minstep=1.e-5
                                    Goal { Parameter=vc.dc
Voltage=Vdd}
                              ) {
                                        ACCoupled (

StartFrequency=1e4 EndFrequency=1e4 NumberOfPoints=1 Decade

Node(SENS_CTH SENS_SUB) Exclude(vc vs)
                                          ACCompute
(Time = (Range = (0 1)  Intervals = 100))
                                               )
          { Poisson Electron Hole  }
                              }

}
```

TCAD Synopsys Simulation

- Visualize the resulting mesh using **SVISUAL**
  - **Re-mesh the structure changing the p – doping**
  - **Visualise the meshing**
  - **CV vs. bias/ cmp with formula**
  - **Doping from CV profile**

$$C_j = \frac{\varepsilon_s}{w} = \sqrt{\frac{e(N_A N_D)}{2\varepsilon_s(N_A + N_D)(V_{bi} - V)}}$$

$$n_0(x) = -\frac{C^3}{q\epsilon}(dC/dV)^{-1}.$$



CV plot example – doping 1e13

TCAD and simulation I

Thank you

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- Simulation example : 2D pn using SDEVICE
- CV / doping from CV