

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

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

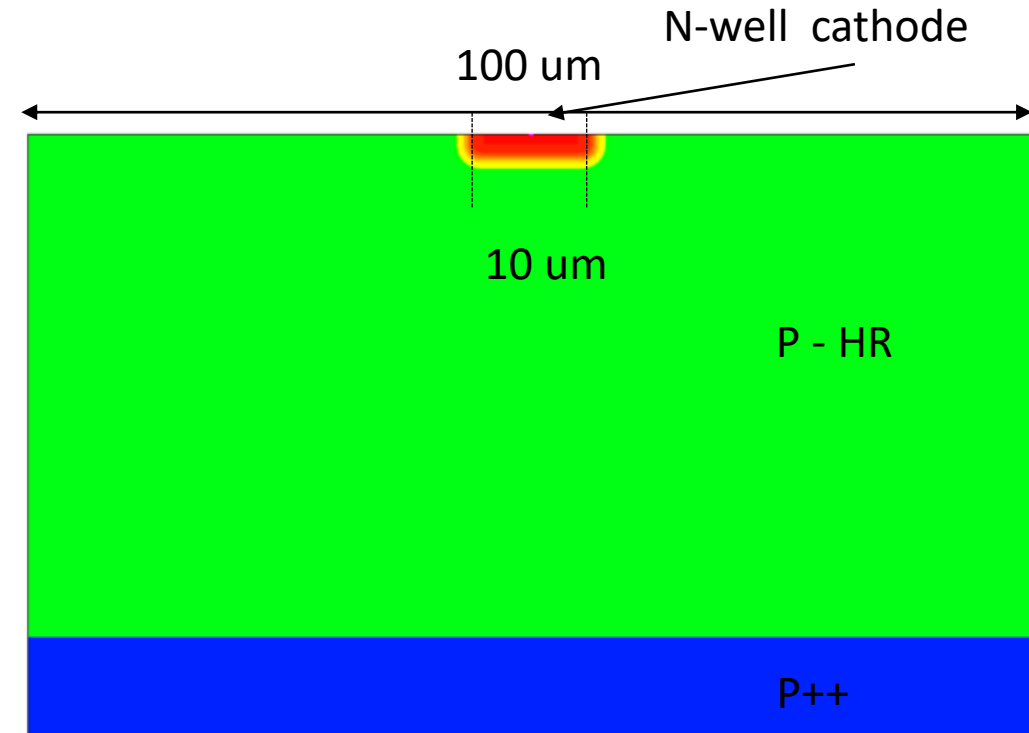
δI = current vector

δV = voltage vector

Y = admittance matrix

$$Y = A + i2\pi\nu C$$

				
TwoDsde	sdeviceV_REV	deviceV_FWL	deviceCV_RE	sdeviceCCE
	Temp			Vbias
	[n2] 280	[n6] --	[n9] --	[n15] --
				[n12] 100



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 {  
  
    PNjct PNjctDUTA (  
  
        "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_PNjct_Temp@Temp@_bias_0V")

    NewCurrentPrefix="2D_PNjct_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 }
        }
    }

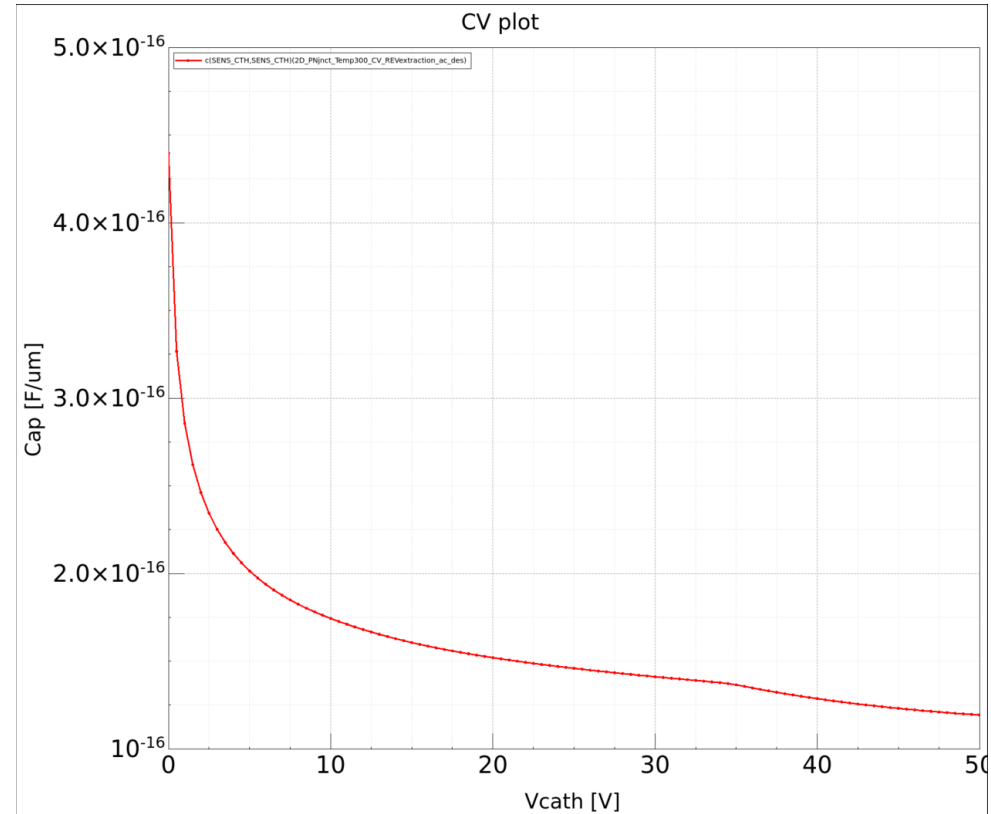
```

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

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

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



CV plot example – doping $1e13$

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

Thank you

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