TCAD for electronic devices part 3

Microelectronics devices, sensors and MEMS

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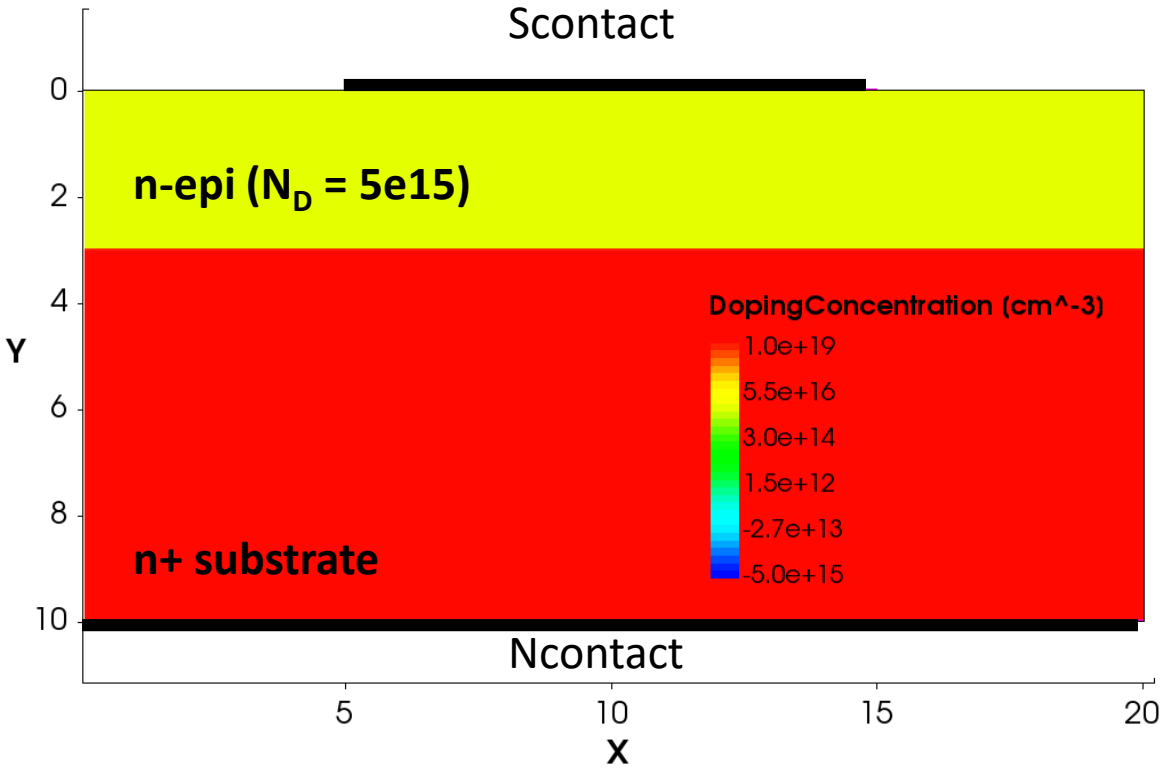
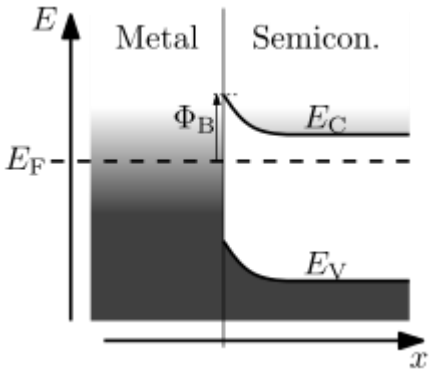
Example 1. Schottky diode



Parameter:
Barrier potential
(**`barrier`** in sdevice command files)

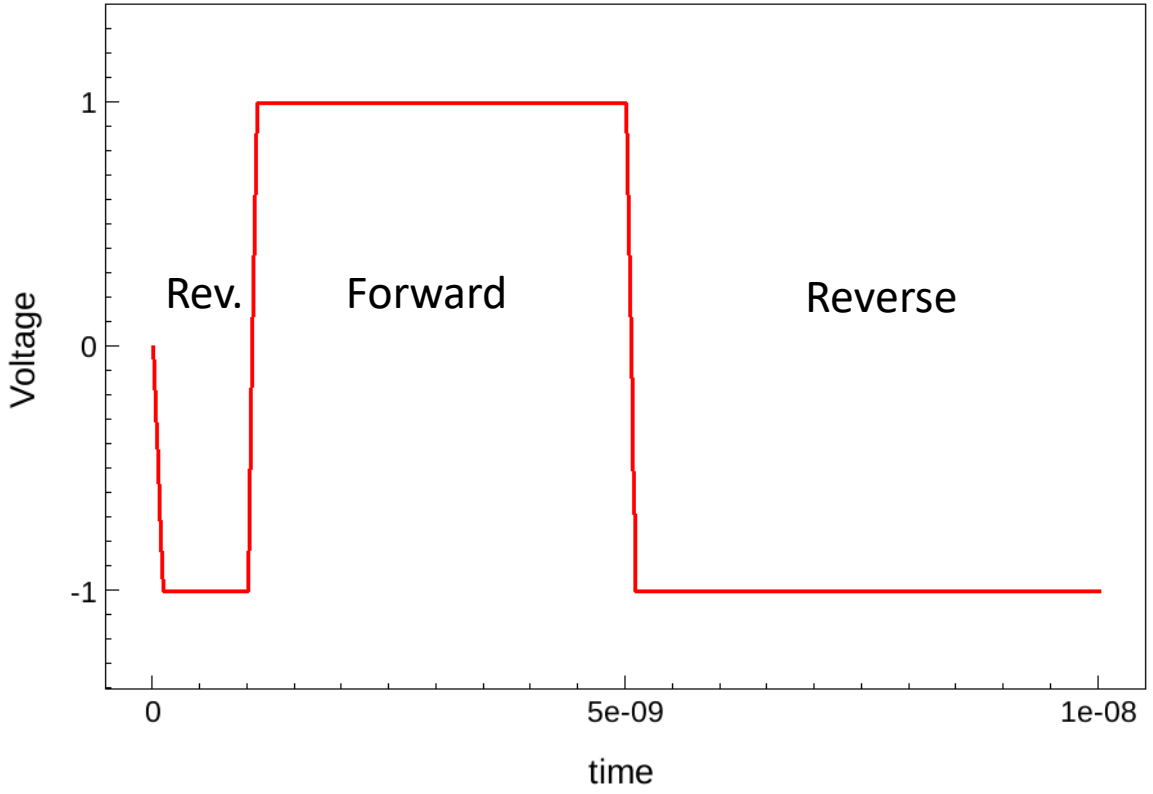


Files:

`P3EX1_SchottkyDiode_sde.txt`	Device structure
`P3EX1_SchottkyDiode_sdevice.txt`	IV curve in forward bias
`P3EX1_SchottkyDiode_sdevice2.txt`	IV curve in reverse bias
`P3EX1_SchottkyDiode_sdevice3.txt`	transient simulation (switching)

Example 1. Transient simulation

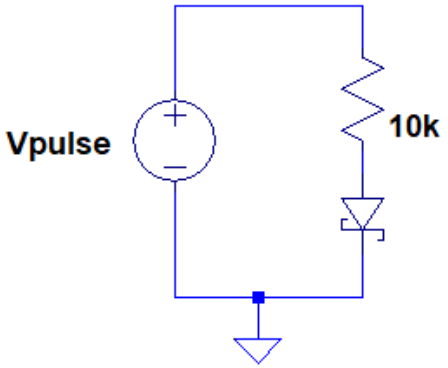
Applied Anode voltage vs. time



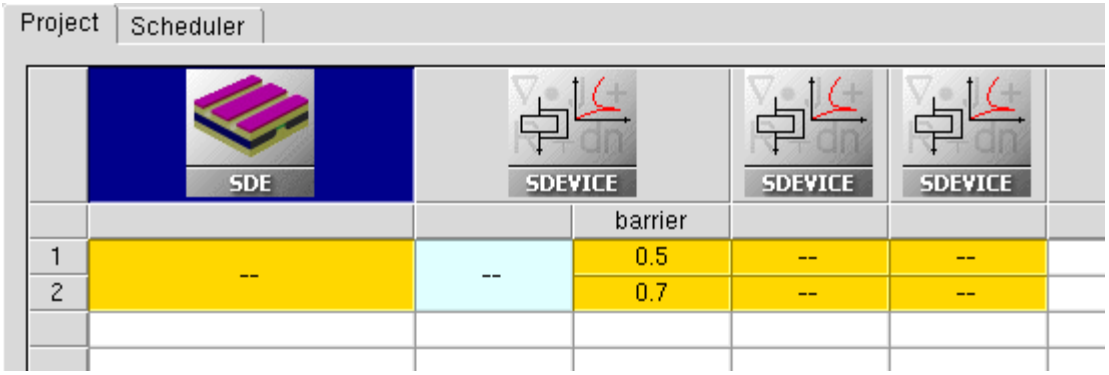
Series resistance:
10 kOhm

Equilibrium cap.
< 40 fF

RC time constant < 0.4ns



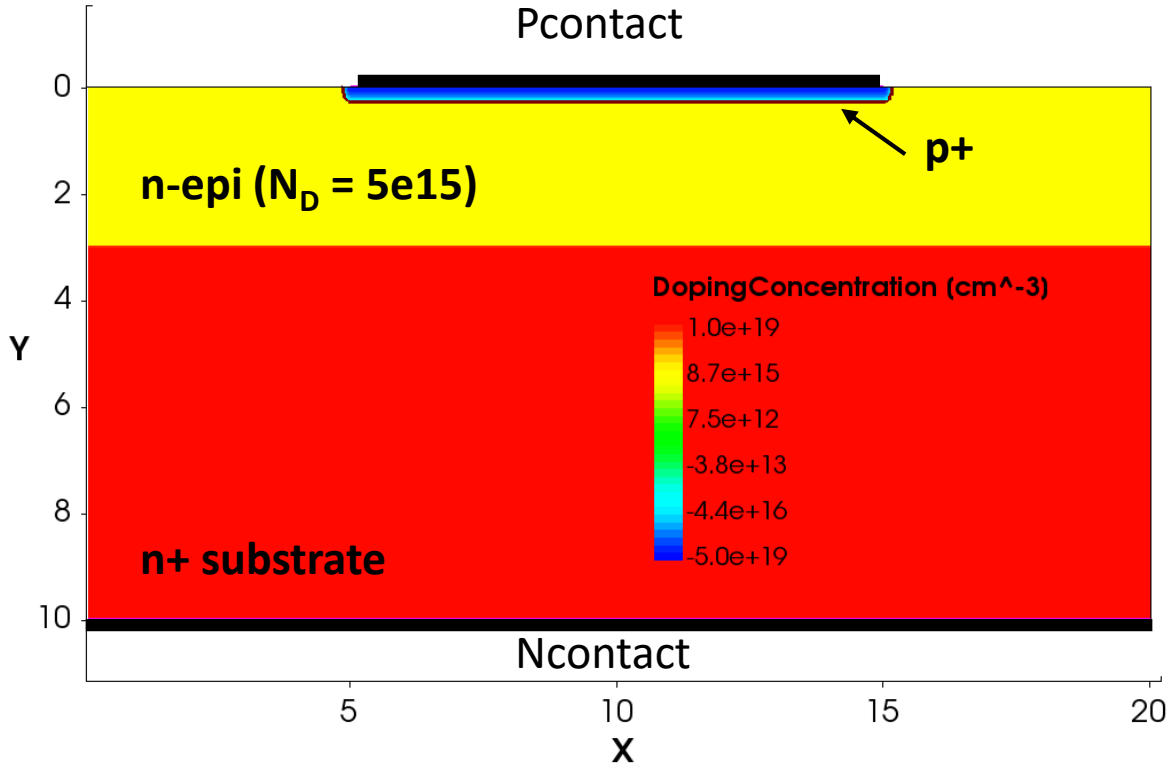
Example 1. Simulation setup



Parameters: barrier – only 2 values.
0.5V: metal = Titanium
0.7V: metal = Aluminum

The 3 different simulations (IV forward, IV reverse and transient switching) are included in the same project

Example 2. PN diode



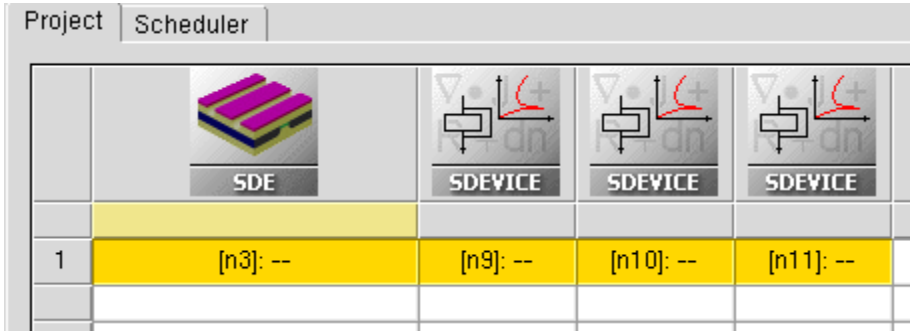
Goal: compare PN junction diode with Schottky diode

Files:

`P3EX2_PNDiode_sde.txt`	Device structure
`P3EX2_PNDiode_sdevice.txt`	IV curve in forward bias
`P3EX2_PNDiode_sdevice2.txt`	IV curve in reverse bias
`P3EX2_PNDiode_sdevice3.txt`	transient simulation (switching)

Example 2. Simulation setup

Create a new project! (Both Schottky and pn junction projects are needed for the comparison)

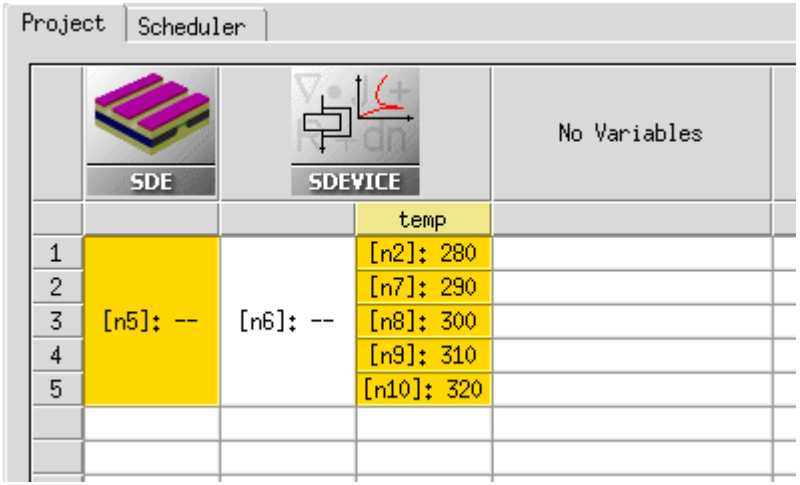


The 3 different simulations (IV forward, IV reverse and transient switching) are included in the same project

Plot PNDiode IV curves in the same graph with Schottky diode IV curves

Example 3: PN diode as temperature sensor

Sentaurus Workbench setup



Define parameter @temp@ in command file

```
Physics{
        Temperature = @temp@
        Recombination(SRH( DopingDep ) )
}
```

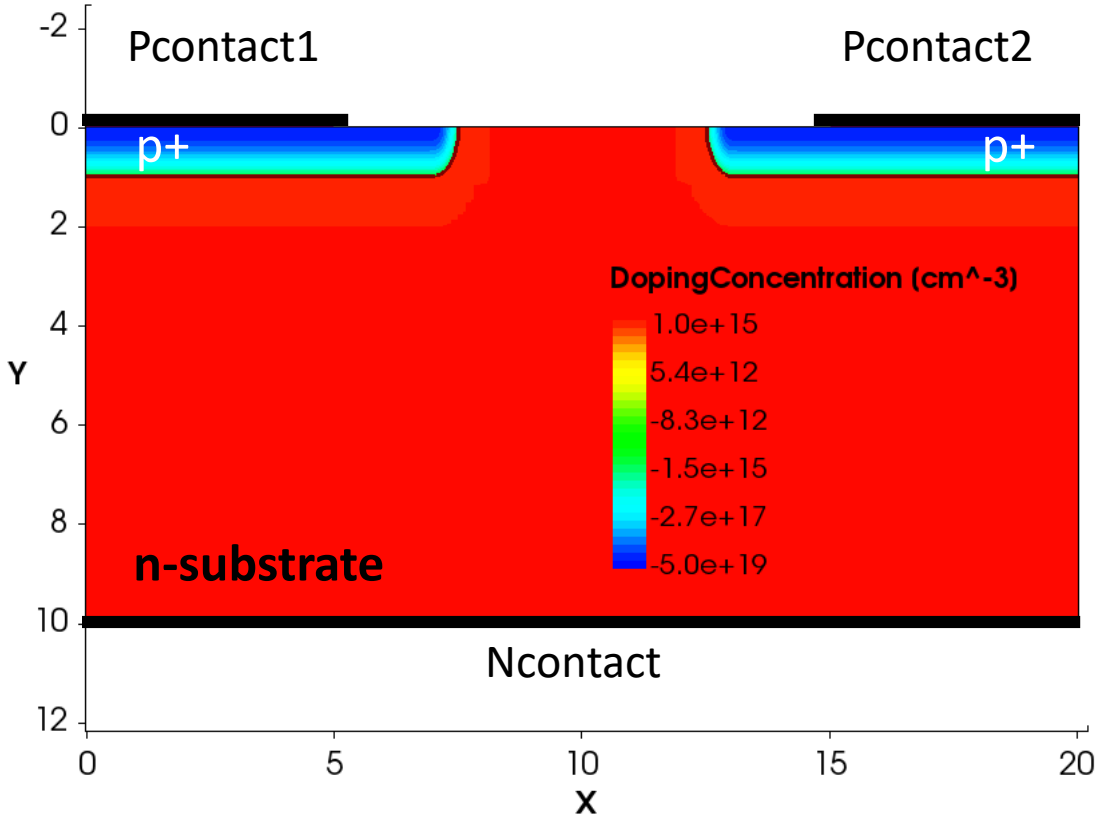
Plot the 5 IV curves in the same File and observe the temperature dependence

$$I_D \cong I_S e^{V_D/kT} \quad \Rightarrow \quad V_D \cong kT ln\left(\frac{I_D}{I_S}\right)$$

Files: **P3EX2_PNDiode_sde.txt** Device structure

P3EX2_PNDiode_sdevice.txt IV curve in forward bias

Example 4. Punch Through



Simulate I-V curves with:
V(Ncontact) = 0
V(Pcontact1) = 0
V(Pcontact2) = 0 → -100

Check the potential profile at the cutline Y = 0.2um for different applied voltages: -10, -20 and -40V

Files: **P3EX4_PunchThrough_sde.txt**
P3EX4_PunchThrough_sdevice.txt

Data extraction and comparison

Shared spreadsheet:

https://docs.google.com/spreadsheets/d/1mpnvX-uLPZhbd6l7KkV_IFlfQcToHZGJy-TUE8eNlYM/edit?usp=sharing

Insert in the shared spreadsheet the following values, estimated from the simulations (alone or in groups of 2 students):

- Ex. 1 and 2: **Forward voltage** for a current of 1µA
- Ex. 1 and 2: **Reverse current** at V_R=5V
- Ex. 1 and 2: **Negative current peak** at switch off
- Ex. 3: **Forward voltage** for a current of 1nA at the 5 different temperatures
- Ex. 4: **Pcontact1 current** at -20V and -40V