

TCAD simulation VI

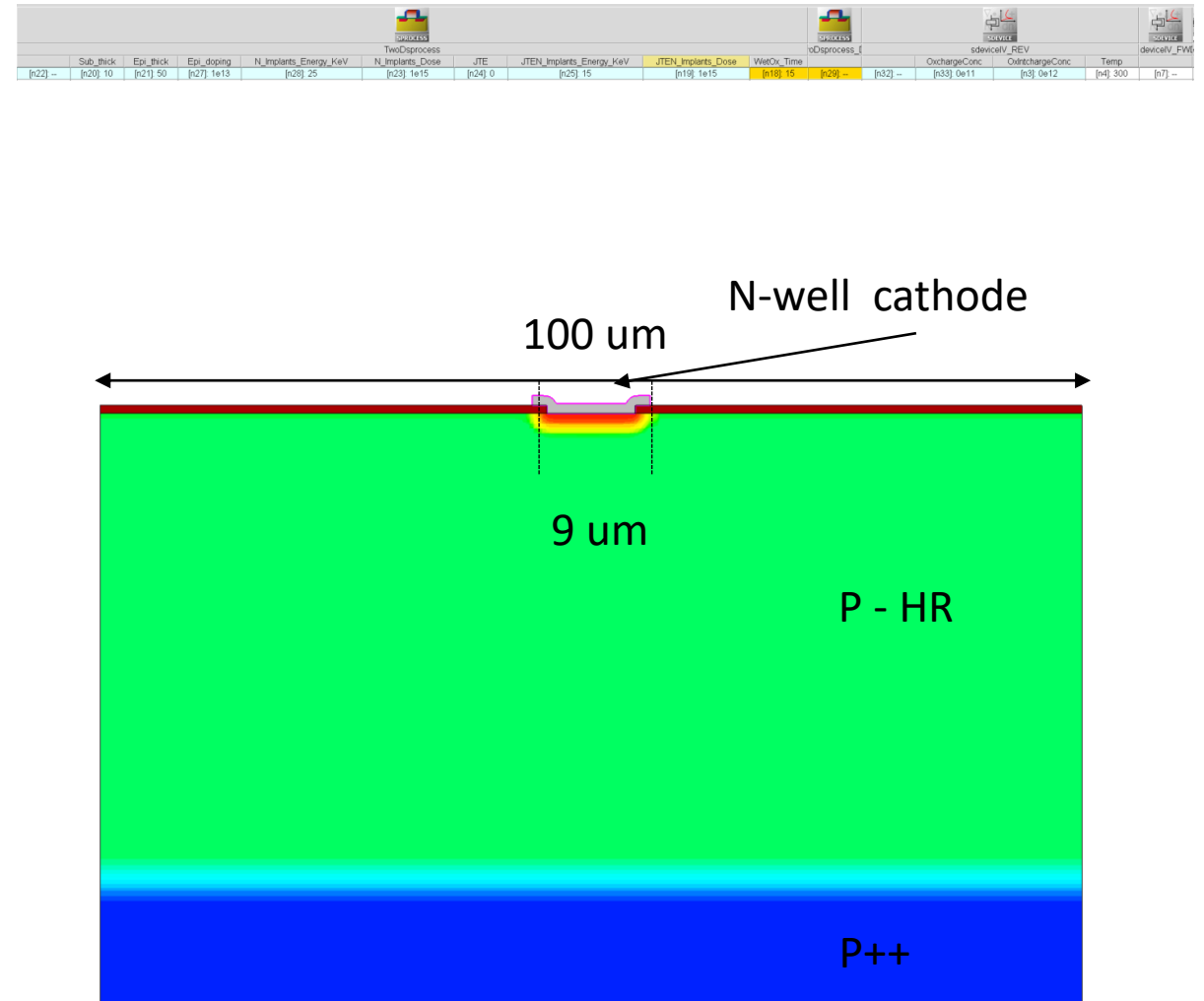
E. Giulio Villani

Overview

- **Simulation example of 2D PN junction using SPROCESS and SDEVICE**
- **IV / BV effects of JTE**
- **IV / BV effects of interface charge**

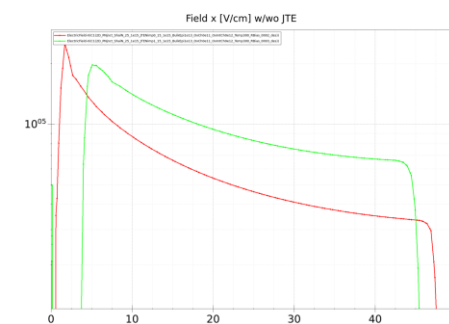
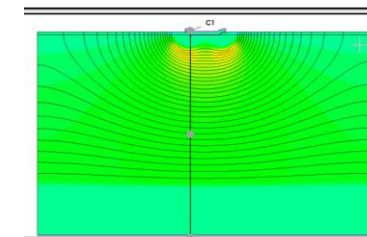
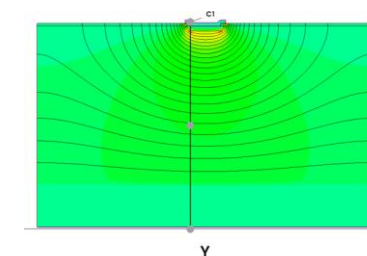
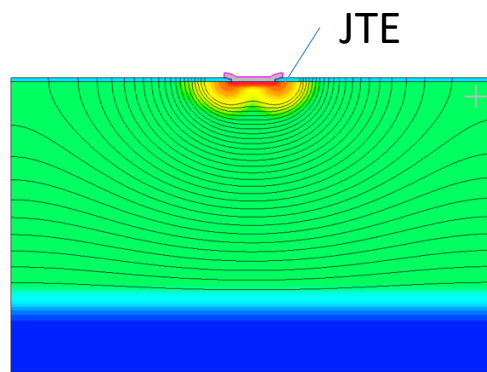
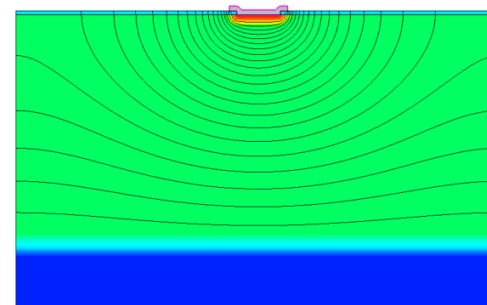
TCAD Synopsys Simulation

- SDEVICE simulation of 2D pn junction
 - IV
 - SC/Depletion region visualisation
 - Breakdown voltage
- The Junction Termination Extension (JTE) is added to the edges of the cathode to spread over a wider region the potential drop. This reduces the field and increases the breakdown voltage



TCAD Synopsys Simulation

- **Pics showing the field with/without JTE**
 - The potential drop is extended over a wider region with the JTE, increasing the BV



TCAD Synopsys Simulation

- **Effects due to the oxide trapped and interface charge**

Physics

if Oxide charge not zero it includes effects due to SiO₂ interface surface states

```
#if @OxchargeConc@ != "0"
```

```
#include "OXIDE_TRAPS"
```

```
#endif
```

TCAD Synopsys Simulation

- **Effects due to oxide trapped and interface charge**

```
Physics(Material="Oxide")
{
  ### Nox: SiO2 fixed trapped charge definition
  ### Nox: fixed

  Charge(Conc=@OxchargeConc@)
}
Physics(MaterialInterface="Silicon/Oxide")
{
  ### Nint: 0.8 - 0.9 of Nox
  ### it just uses Gaussian distribution for interface traps
  ### donor-like Si-SiO2 interface traps Gaussian, Ev+0.7eV,sigma= 70meV
  ### acceptor-like Si-SiO2 interface traps Gaussian,[ Ec-0.4eV,0.4 of Nint; Ec-0.6eV, 0.6 of Nint], sigma = 70meV
  ### Reference [1]

  Traps((hNeutral Conc=@OxIntchargeConc@ Gaussian EnergyMid=0.70 EnergySig=0.07
fromValBand eXsection=1e-15 hXsection=1e-15 )

      (eNeutral Conc=@<0.4*@OxIntchargeConc@>@ Gaussian EnergyMid=0.40 EnergySig=0.07
fromCondBand eXsection=1e-15 hXsection=1e-15 )

      (eNeutral Conc=@<0.6*@OxIntchargeConc@>@ Gaussian EnergyMid=0.60 EnergySig=0.07
fromCondBand eXsection=1e-15 hXsection=1e-15 ))

}

TrappedCarDistrPlot {
  ### plots the interface traps distribution vs. E at some 'typical' location near the Si/SiO2 interface

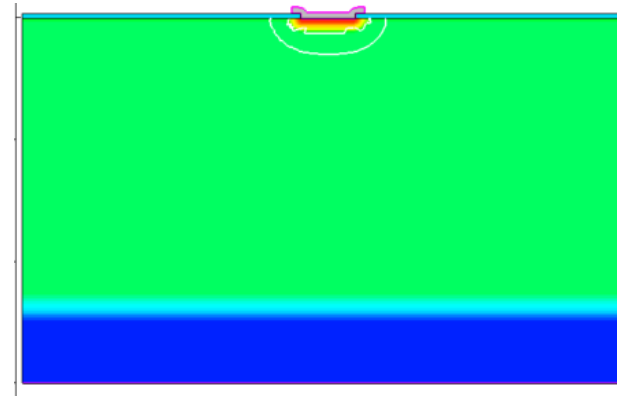
  MaterialInterface="Silicon/Oxide" {(0.132 -260 )}
  ### plots the silicon region traps

}
```

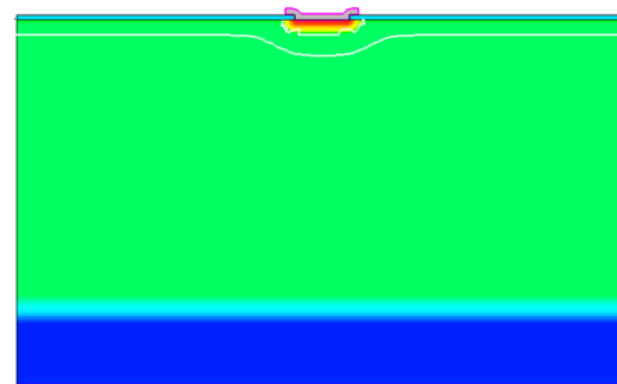
[1] F. Moscatelli et al., *Measurements and TCAD simulations of bulk and surface radiation damage effects in silicon detectors*, IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC), San Diego, CA, USA, 2015, p. 1-6, doi: 10.1109/NSS-MIC.2015.7581944, 2015

TCAD Synopsys Simulation

- **Effects due to oxide trapped and interface charge**
 - Effects on depletion, leakage current



No oxide charge



$1e11 \text{ cm}^{-2}$ oxide charge

Thank you

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- Simulation example : 2D pn using SPROCESS
- IV (FWD/REV), SC, Depletion region
- JTE effects
- Oxide charge