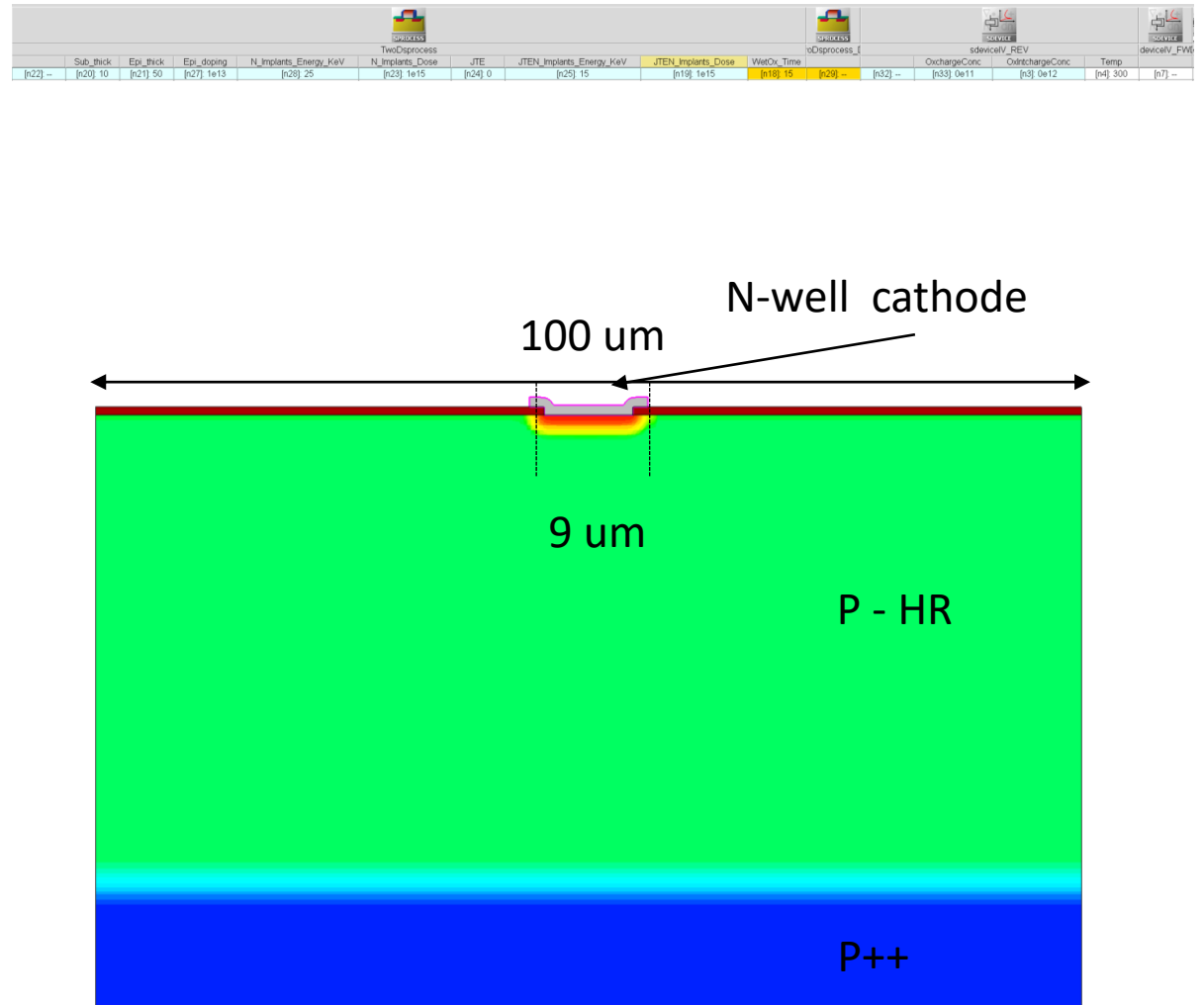# TCAD simulation VI

E. Giulio Villani

Overview

- **Simulation example of 2D PN junction using SPROCESS and SDEVICE**

- **IV / BV effects of JTE**
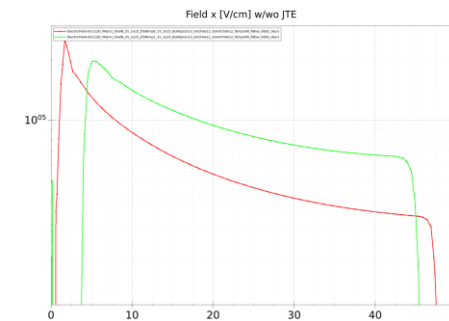- **IV / BV effects of interface charge**

UK HEP Instrumentation Summer School, *Oxford 1-12 July 2024*
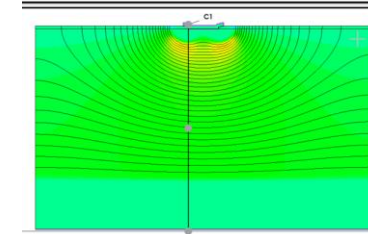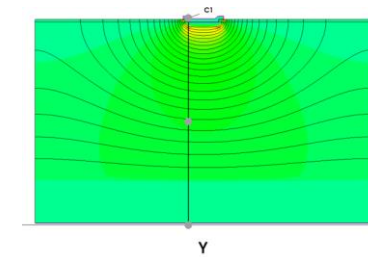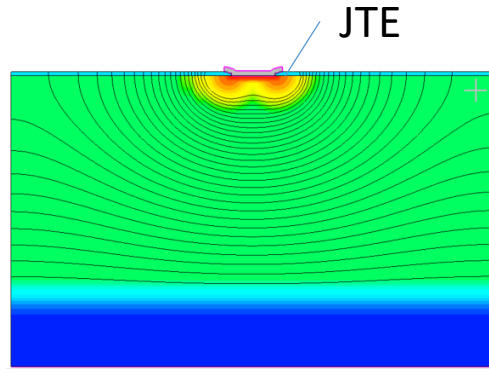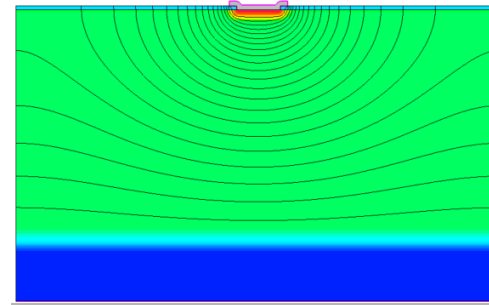
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TCAD Synopsys Simulation

- 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

JTE

Field x [V/cm] w/wo JTE

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


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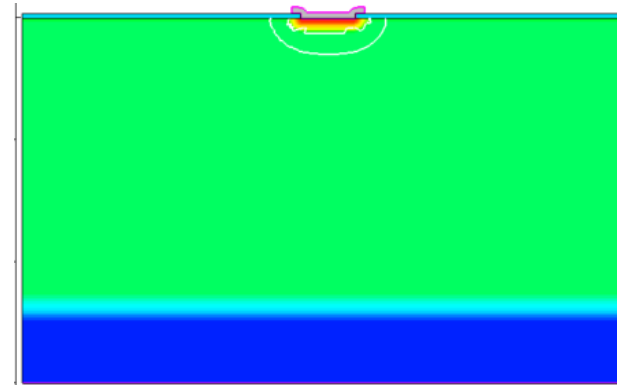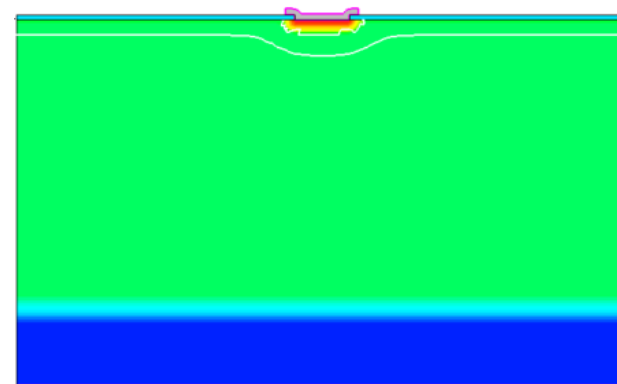
[1] F. Moscatelli et al., *Measurements and TCAD simulations of bulk and surface radia-tion damage effects in silicon detectors*, IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC), San Diego, CA, USA, 2015, p. 1-6, doi: 10.1109/NSS-MIC.2015.7581944, 2015

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TCAD Synopsys Simulation

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

No oxide charge

1e11 cm-2 oxide charge

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Thank you

giulio.villani@stfc.ac.uk

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