Modelling and reliability study of gamma- and charged particles-irradiated electronic components used in space industry

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nSilition
Smaller, Smarter, Stronger

SYNHERA

FÉDÉRATION WALLONIE-BRUXELLES

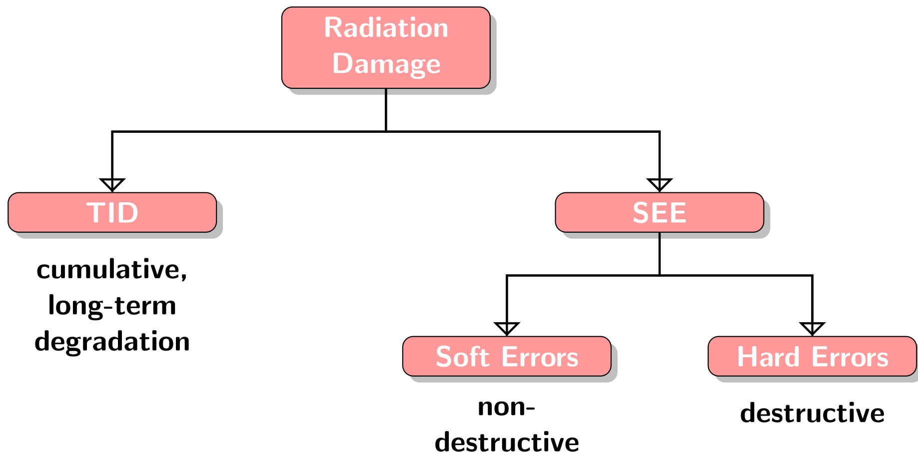
Outline

1. Recap on the Single Event Effects (SEE)
   - Mechanisms and Effects
   - SET analysis - Transient fault model

2. Research Project
   - Aim of the Project
   - Example of the Geant4 model
   - Preliminary results and perspective

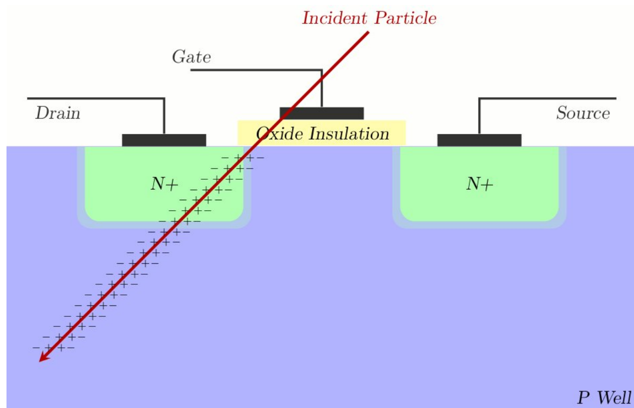
Recap on the Single Event Effects

Radiation damage to on-board components separated in two categories



Mechanisms and Effects

Ionization → What happens with the charges created ?



Mechanisms and Effects

Different kinds of SEE

- SEU : Single Event Upset
- SET : Single Event Transient
- SEL : Single Event Latch-up
- SEGR : Single Event Gate Rupture
- ...

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SET analysis - Transient fault model

Differents models, our partner uses this model

$$I_{\text{inj}}(t) = \frac{Q}{\tau_1 - \tau_2}\left(e^{-\left(\frac{1}{\tau_1}\right)} - e^{-\left(\frac{1}{\tau_2}\right)}\right)[1][2]$$

Where Q is the charge deposited, τ_1 is the collection time constant of the junction and τ_2 is the ion track establishment time constant.

[1] G.C. Messenger, "Collection of charges on junction nodes from ion tracks", IEEE Transactions Nuclear Sciences, 1982.

[2] M. Hosseinabady et al., "Single Event Transients analysis in high speed circuits",

International Symposium on Electronics Design, 2011.

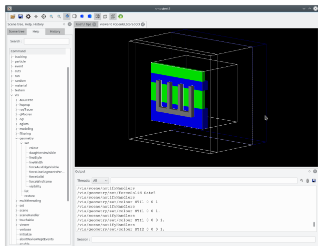
Aim of the Project

Get values of Q depending on the position where the particle hit inside the component and depending on the technology

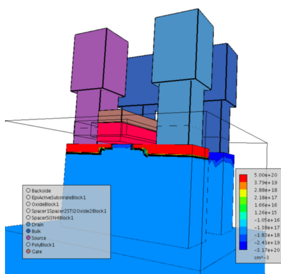
- Modelling and simulate transistors according to the ESA specifications [3] using Geant4.
- Evaluate the reliability of the model and calculate a recombination factor of free carriers created by incident radiation.
- Geant4/TCAD coupling.

[3] ESCC, Single Event Effects Test Method and Guidelines, ESCC Basic Specifications 25100.

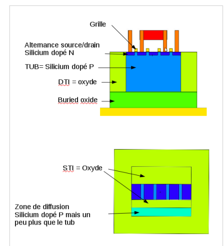
Example of the Geant4 model



G4



TCAD



MCNP

Preliminary results

We ran simulation only for the depletion zone (block of silicon) to help us fix some simulation parameters :

- good approximation physics lists depending on the incident particle
- time-efficient tracking method
- first approximation of the recombination factor

We are at the start of the statistical analysis but there are promising results regarding the reliability of the model !

Thanks to ...

And to you !