# Simulation study on the radiation tolerance of microstrip detectors for the CBM Silicon Tracking System

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We are using the three-dimensional TCAD simulation package from Synopsys [1] to simulate double-sided silicon strip detectors (DSSDs) for the CBM Silicon Tracking System (STS). The STS will consist of eight stations of DSSDs at a distance of 30-100 cm from the target. The expected neutron fluence will vary from $1\times10^{13}$ $n_{eq}cm^{-2}$ to $1\times10^{15}$ $n_{eq}cm^{-2}$ depending on the location of the sensors. Hence we performed detailed simulations to understand the expected radiation damage in DSSDs and to foresee if these DSSDs will be able to survive the expected lifetime of the CBM experiment. We have simulated two types of DSSDs, one having orthogonal strips and other having a stereo angle of $\pm7.5$ °. Fig. 1 shows a zoom on the n-side of the simulated detector.

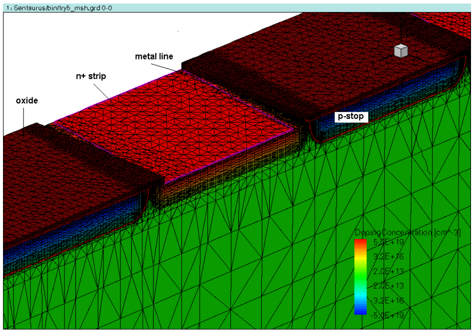


Figure 1: Zoomed frontal view of the simulated DSSD

We simulated the impact of irradiation by varying the effective doping concentration ($N_{eff}$) and minority carrier lifetime ($\tau$) with fluence ($\phi$) using the Hamburg model [3]. The effect of surface damage was also studied by varying the oxide charge density ($Q_F$) at the Si-$SiO_2$ interface. The values of integrated fluence and the corresponding values of $N_{eff}$ and $\tau$ are listed in Table 1. The University of Perugia trap model [2] was applied. The time line assumes CBM operating at highest interaction rates ($10^7$/s).

Fig. 2 shows the simulated versus the measured current-voltage (I-V) and backplance capacitance-voltage (C-V) behaviour before irradiation for a DSSD with orthogonal strips of size $1.5\times1.5$ cm$^2$. The simulation results are comparable with the measurements. Fig. 3 shows the leakage current density versus the fluence for DSSDs with a stereo angle of $\pm7.5°$. The simulated values of the damage constant ($\alpha$) for DSSDs with orthogonal strips and with stereo angle of $\pm7.5$ ° are $3.6\times10^{-17}$ A/cm and $4.0\times10^{-17}$ A/cm, respectively, while the experimental value is $\alpha$ = $(3.99\pm 0.03)\times10^{-17}$ A/cm [4]. We will compare the simulated $\alpha$ with our detectors after irradiations in 2011.

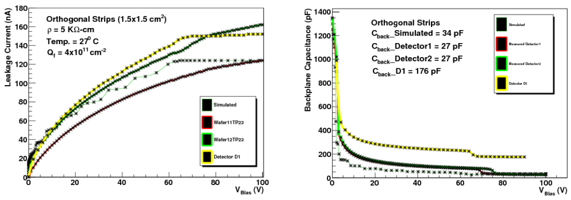


Figure 2: Simulated I-V and C-V curves compared with measurements of several CBM01/02 prototype detectors

Table 1: Fluence profile of neutrons as expected for CBM

| Year | Int. Fluence [$10^{14}$ n/cm$^{-2}$] | $N_{eff}$*$10^{11}$ [cm$^{-3}$] | $\tau_{electron}$ [$\mu$sec] | $\tau_{hole}$ [$\mu$sec] |
|---|---|---|---|---|
| 0 | 0 | 9 | 1000 | 300 |
| 0.05 | 0.05 | 7.41 | 4.98 | 4.92 |
| 0.3 | 0.3 | -1.72 | 0.833 | 0.831 |
| 1 | 1.0 | -34.3 | 0.250 | 0.250 |
| 2 | 2.0 | -89.9 | 0.125 | 0.125 |
| 3 | 3.0 | -150 | 0.083 | 0.083 |
| 4 | 4.0 | -214 | 0.062 | 0.062 |
| 5 | 5.0 | -278 | 0.05 | 0.05 |
| 6 | 6.0 | -343 | 0.041 | 0.041 |

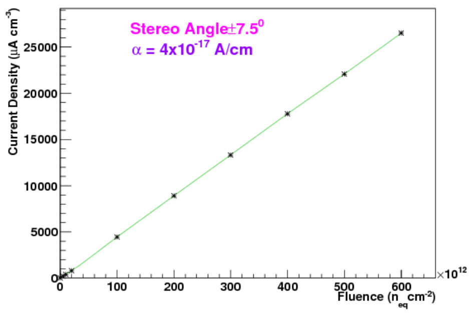


Figure 3: Variation of leakage current density with neutron fluence for the silicon microstrip detector with stereo angle

## References

[1] http://www.synopsys.com/home.aspx

[2] M. Petasecca *et al.*, IEEE Trans. Nucl. Sci. **53** (2006) 2971

[3] M. Moll, E. Fretwurst and G. Lindström, Nucl. Instrum. Meth. Phys. Res. **A 439** (2000) 282

[4] M. Moll, *Radiation damage in silicon particle detectors-microscopic defects and macroscopic properties*, Dissertation, Universität Hamburg 1999