RD50 funding request

Date: *13/04/202*

Production at CiS of planar pixel sensors and diodes with n-in-p technology and characterization of main radiation-induced defects

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Request to RD50: 30000 CHF
Total project cost: 58175 CHF

Project description

This proposal is focused on a common sensor production and defect characterization, within the RD50 Collaboration, of diodes and pixel devices on high resistivity p-type FZ material.

The n-in-p sensor technology offers a cost-effective single sided process together with the benefits of electron collection, allowing for operations without full depletion and a high charge collection efficiency, thanks to the fast electron carriers in the strong electric field on the junction side. Several studies on charge collection for p-type segmented detectors performed in the last few years have demonstrated that a significant amount of charge can be measured after irradiation at very high hadron fluences (of the order of 10^{16} n_{eq}/cm^2) [1], indicating that planar p-type detectors technology can be considered as an option for the

inner layers of HL-LHC detectors. It has also been observed that the collected charge for these devices at those fluences is higher than expected from the extrapolation of radiation damage parameters, like full depletion voltage and trapping times, measured at fluences up to 10^{15} n_{eq}/cm^2. Moreover, some of the CCE measurements on highly irradiated sensors at very high bias voltages show a higher collected charge with respect to unirradiated devices. This result has been explained in terms of multiplication effects on the generated charge in high field regions inside the silicon bulk, probably correlated to radiation-induced defects [2].

Defects involved in such processes are still matter of investigation. In fact, although some studies on radiation-induced defects in p-type material have been developed in the past by our community [3,4], a systematic investigation on these important issues has not been performed yet due to the unavailability of samples with on-purpose tailored characteristics. This proposal is aimed at performing such systematic study through the production of a significant batch of dedicated p-type Si samples.

This production will be the first n-in-p run at CiS on 6" wafers and it will also serve as qualification for the upgraded production line. The foreseen bulk material is Boron doped FZ silicon with a resistivity in the range of 13-15 KOhm cm and a thickness of 300 um.
The diodes are designed to have a total area of 5x5 mm^2 (with an active area of 2.5x2.5 mm^2) and 10x10 mm^2 (active area of 5x5 mm^2), with circular openings in the front and back-side metal layers, to allow for laser tests.
Diodes and pixels will be implemented with a multi-guard ring structure on the front-side, that was proven to provide a good breakdown behaviour in past p-type productions before and after irradiation.
The inter-pixel isolation method was also tuned in past productions at CiS and it employs a homogeneous p-spray with a low implantation dose. Pixel detectors previously produced at CiS with this technology, compatible with the ATLAS FE-I3 chip, have resulted in a very good performance up to an irradiation fluence of 5e15 n_{eq} / cm^2 with a tracking efficiency of 98-99%, measured in a beam-test at CERN SPS [5,6].
In the new production, pixel sensors compatible with the ATLAS FE-I4 chip will be implemented. The main research goals are to explore new guard-ring geometries to further improve the breakdown voltages and the implementation of narrower inactive edges, down to a width of 250-300 um, to reduce geometrical inefficiencies.
In addition pixels with a reduced pitch in r-phi of 25 um will be investigated, to demonstrate the feasibility of producing such sensors that can help in track reconstruction with the high occupancy expected in the inner layers of the pixel system at HL-LHC.

After the production the R&D activities will follow two main directions:

Study of Macroscopic Radiation Damage

- Electrical characterization of the pixel devices. Comparison of the breakdown voltages of standard structures and of devices with slimmer edges before irradiation.
- Single Chip Module assembly to FE-I4 chips

- Irradiation with protons (26 MeV in Karlsruhe, 800 MeV in Los Alamos) and reactor neutrons in Ljubljana up to fluences of (1-2)x10^{16} n_{eq} cm^{-2}, γ ray irradiation with ^{60}Co (BNL), 4 MeV electron irradiation at RT and LNT(Minsk).
- Study of the pixel modules performance after irradiation in beam tests at DESY and SLAC.

Study of Microscopic Radiation Damage

- Characterization of trap parameters of main radiation induced defects with spectroscopic methods as DLTS (Deep Level Transient Spectroscopy), TSC (Thermally Stimulated Currents), HRPITS (High Resolution Photo Induced Spectroscopy), EPR (Electron Paramagnetic resonance), FTIR (Fourier Transform InfraRed), PL (PhotoLuminescence).
- understanding of their charge state under operation as well as on electric field profile with TCT (Transient Current Technique), Edge TCT, Photoconductivity decay.
- Cross-correlation of results got with different techniques and cross-links with simulation to get a detailed knowledge on radiation hardness of n-on-p devices and understanding of charge multiplication effects.

Timescale: Start of the production : June-July 2012
End of the production: February 2013
Irradiations: March 2013 - September 2013
Evaluation of the irradiated structures: 2013-2014

Project costs, contributions from participating institutes and request to the RD50 common fund (costs are in Euro, conversion 1 Euro=1.20 CHF):

Preliminary estimation of project costs:

Wafer procurement	4450 EUR	5365 CHF
Wafer polish	2000 EUR	2410 CHF
Processing of 12 Wafers at CiS	41800 EUR	50400CHF

Total 58175 CHF

Request to RD50: 30000 CHF

Contributions from participating institutes: 28175 CHF

References

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