Contribution ID: **200** Type: **oral**

Radiation hardness of small-pitch 3D pixel sensors up to HL-LHC fluences

Wednesday, 24 May 2017 17:42 (18 minutes)

3D silicon detectors, with cylindrical electrodes that penetrate the sensor bulk perpendicularly to the surface, present a radiation-hard sensor technology. Due to a reduced electrode distance, trapping at radiation-induced defects is less and the operational voltage and power dissipation after heavy irradiation are significantly lower than for planar devices. During the last years, the 3D technology has matured and 3D pixel detectors are already used in high-energy physics particle detectors where superior radiation hardness is key: in the ATLAS Insertable B-Layer (IBL) and the ATLAS Forward Proton (AFP) detector.

For the High-Luminosity upgrade of the Large Hadron Collider (HL-LHC), the radiation-hardness requirements are even more demanding with expected fluences up to 1-2$\times10^{16}$ n_{eq}/cm^2 for the innermost pixel layer of the ATLAS and CMS experiments at the end of life time after an integrated luminosity of 3,000 fb^{-1}. Moreover, to face the foreseen large particle multiplicities, smaller pixel sizes of 50$\times$50 or 25$\times$100 μm^2 are planned.

In the context of this work, a new generation of 3D pixel sensors with small pixel sizes of 50x50 and 25x100 µm² and reduced electrode distances are developed for the HL-LHC upgrade of the ATLAS pixel detector, and their radiation hardness is tested up to the expected high fluences. Since a readout chip with the desired pixel size is still under development by the RD53 collaboration, first prototype small-pitch pixel sensors were designed to be matched to the existing ATLAS IBL FE-I4 readout chip for testing. Irradiation campaigns with such pixel devices have been carried out at KIT with a uniform irradiation of 23 MeV protons to a fluence of 5$\times10^{15}$ n_{eq}/cm^2, as well as at CERN-PS with a non-uniform irradiation of 23 GeV protons to a peak fluence of 1.4$\times10^{16}$ n_{eq}/cm^2. The hit efficiency has been measured in several beam tests at the CERN-SPS in 2016. The benchmark efficiency of 97% has been reached at remarkably low bias voltages of 40 V at 5$\times10^{15}$ n_{eq}/cm^2 or 100 V at 1.4$\times10^{16}$ n_{eq}/cm^2. Thanks to the low operation voltage, the power dissipation can be kept at low levels of 1.5 mW/cm² at 5$\times10^{15}$ n_{eq}/cm^2 and 13 mW/cm² at 1.4$\times10^{16}$ n_{eq}/cm^2 for -25°C. The performance of these devices is significantly better than for the previous generation of 3D detectors or the current generation of planar silicon pixel detectors, demonstrating the excellent radiation hardness of the new 3D technology.

Primary author: LANGE, Joern (IFAE)

Co-authors: VAZQUEZ FURELOS, David (IFAE Barcelona); FÖRSTER, Fabian (IFAE Barcelona); GRINSTEIN, Sebastian (IFAE Barcelona); TERZO, Stefano (IFAE Barcelona)

Presenter: LANGE, Joern (IFAE)

Session Classification: R4-Semiconductor detectors(4)

Track Classification: Semiconductor detectors