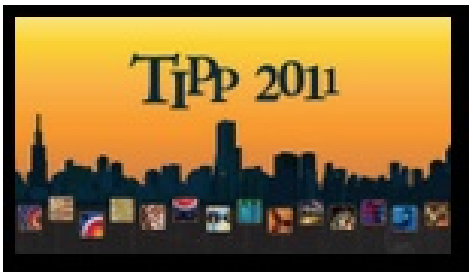

Contribution ID: **349** Type: **Poster Presentation**

Optimum Design of Cq integrated Silicon Photomultipliers for TOF-PET Application

Recently, there has been great interest on the development of Silicon Photomultipliers (SiPM) to use in MR compatible PET detectors as well as high energy physics, neutron physics, and bioluminescence. The characteristics of SiPM such as its compactness, low operating bias, high gain, fast timing characteristics, and non-sensitivity to magnetic field.
Dynamic range and PDE (Photon Detection Efficiency) are trade-off relation because dynamic range is proportional to the number of micro-pixels in a SiPM pixel. So the optimum micro-pixels for PET detectors coupled with LYSO was calculated with TCAD modeling in order to increase the energy resolution at 511 keV while having enough dynamic range at 511keV energy ranges.
To use SiPMs in TOF-PET, timing resolution has to be more improved. Coincidence timing resolution of PET detectors depends on pulse shapes which are the convolution of intrinsic rise and decay time of scintillation crystals and single photon pulse of geiger mode APD in a SiPM pixel. A large fraction of current in the single photon pulse causes poor timing performance, so timing performance can be improved by increasing the fraction of initial current in single photon pulse. To do this, a quenching capacitor (Cq) parallel to the quenching resistor (Rq) was added because Cq is a fast current path in the beginning of avalanche.
In this study, SiPMs were fabricated on 4.5 um thick epitaxial wafers in the NNFC (National Nano Fab Center) CMOS process line. Metal-Insulator-Metal (MIM) capacitors were integrated with 2 metal layers fabrication process.
The single photon pulse shape of Cq integrated SiPMs was analyzed and compared to normal SiPMs. And the timing resolution, energy resolution at 511 keV, and dynamic range were measured with fabricated devices.

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Track Classification: Instrumentation for Medical, Biological and Materials Research