Fast Timing Monolithic Silicon Pixel Sensor for TOF-PET

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TT-PET Project
- PET is a nuclear medicine method used to observe the metabolic processes in the body, by detecting pairs of back to back gamma-rays produced by the annihilation of positrons emitted by a beta plus tracer
- Thin TOF-PET project is developing a PET based on silicon monolithic sensors with very high time resolution (30 ps) for small animal and meant to be inserted in existed MRI scanner (PET-MRI)

16 cells and 60 layers
Inner radius: 2.02 cm

Fulfill 4 important keys of PET-MRI
1. Time of Flight (TOF)
2. Depth of Interaction (DOI)
3. Thin
4. Insensitive to magnetic field

Design of silicon pixel sensor
Weighting Potential (cross section)

Guard ring
N-well
p-Stop
N-well
HV+

Potential (V)
X [µm]

C-V simulation

- Low capacitance & uniform weighting field
- Technology CAD was used to design sensor and to evaluate the performance of the sensor

ASIC Development
Sensor layout of Monolithic Prototype (September 2016)

- Equivalent Noise Charge on 1 pF: 600 electrons RMS
- Pulse rise time: 1 ns
- Power consumption: 14 mW/cm²

based on SiGe HBT transistors

I-V Measurement
Apply 20, 40, 60, 80, 100 V to First GR

- Successfully controlled the breakdown voltage by applying voltage to the first guard ring

Sensor layout of Monolithic Prototype (April 2017)

- Pixel Matrix with guard ring
- Special guard ring test structures
- Full read-out chain, amplifier, discriminator and TDC

Geant4 Simulation
Pairs of gamma-rays were produced from 5 points in Geant4 simulation and the positions were reconstructed with/without TOF information
- TOF significantly contributes to the reconstruction performance
- DOI contributes to avoiding performance degradation along radius

Testbeam with m.i.p.

1M. Benoit et al., 100 ps time resolution with thin silicon pixel detectors and a SiGe HBT amplifier, JINST 2016

Corresponds to 24 ps with 511 keV photons

11th International HSTD11 in conjunction with 2nd Workshop on SOIPIX2017 (OIST)