

# Fine-Pixel Detector FPIX Realizing Sub-micron Spatial Resolution Developed Based on FD-SOI Technology

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Monolithic pixel devices are attractive for various aspects in particle detector application. One of the notable features is that the pixel size can be reduced without constraints from the metal bumps which limit the pixel size of hybrid pixel devices typically to 50 $\mu$ m. We are developing monolithic pixel devices utilizing Lapis 0.20  $\mu$ m FD-SOI (Fully-Depleted Silicon-on-Insulator) technology. FPIX, fine-pixel detector, has been designed to demonstrate the capability of the SOI monolithic pixel in view of excellent spatial resolution achievable. With consisting of eight on-pixel FETs, FPIX realized a pixel size of 8 $\times$ 8 $\mu$ m in a 128 $\times$ 128 matrix, 1 $\times$ 1mm active area, in a chip size of 3 mm square. The signals are extracted in a rolling-shutter mode and digitized by external ADCs. There are eight parallel readout lines; therefore each ADC handles signals out of 16 columns of 128 rows. The 12-bit digitization requires 200 ns, corresponding to a frame readout time of 0.5 ms.

FPIXs have been fabricated on various SOI handle wafer types, single SOIs in Cz and FZ, p- and n-types, also on double SOI (p type Cz). This redundancy is an outstanding feature that we can select the sensor type and resistivity best suited for application. Among them, double SOI has been developed for, among other reasons, radiation resistivity. The second active layer is used to compensate for the threshold shifts caused by holes trapped in the BOX (buried oxide) layer due to radiation.

We have evaluated the tracking performance of a system consisting of four single SOI FPIX devices of FZ p-type (25k $\Omega$ cm, 500 $\mu$ m thickness) in a 120 GeV hadron beam at Fermilab. A double SOI FPIX (1k $\Omega$ cm, 300 $\mu$ m thickness) irradiated to 100 kGy has also been tested for the performance.

We calculated the residual distribution of hit position to the track reconstructed from other three. The residual distribution is well fitted by a Gaussian function with a standard deviation of 0.87 $\mu$ m. Taking into account the uncertainty in the track position, we are confident that sub-micron spatial resolution has been achieved by FPIX.

We have also observed a signal out of 100kGy irradiated FPIX corresponding to the MIP particles. We report the detail of the FPIX design and the performance evaluation.

## Summary

Monolithic pixel device FPIX has been designed based on 0.2  $\mu$ m FD-SOI technology for the purpose of demonstrating the excellent spatial resolution achievable with this technology. With a pixel size of 8 $\mu$ m $\times$ 8 $\mu$ m, a spatial resolution well below 1  $\mu$ m has been achieved.

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