11th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors (HSTD11) in conjunction with 2nd Workshop on SOI Pixel Detectors (SOIPIX2017) at OIST, Okinawa, Japan

Contribution ID: **22** Type: **POSTER**

Development of highly compact digital pixels for the vertex detector of the future e+e- collider

Sunday, 10 December 2017 20:12 (1 minute)

Precise determination of the charged particle tracks and reconstruction of the primary and displaced decay vertices always drive the need for a high precision vertex detector for future electron-positron collider experiments. Such vertex detector should be constructed with pixel detectors with high spatial resolution and low material budget, and fast readout to keep the detector occupancy low. CMOS pixel sensor (CPS) with pixel level discrimination represents one of the most promising candidates. However, the complexity of in-pixel digital circuit always leads to increased pixel size, which is disfavored to obtain high spatial resolution.
Recent developments have demonstrated that depleted Monolithic Active Pixel Sensors (MAPS) could bring in more advantages to charged particle tracking compared to conventional MAPS, such as lower sensing point equivalent capacitance and higher signal collection efficiency. In this context, we propose two highly compact digital pixel structures, based on the advantageous depleted MAPS concept, which shall lead to improved spatial resolution.
The two structures with balance between high precision and circuit simplicity guarantee compact pixels, yet with satisfying high signal over noise ratio. Prototype with these two highly compact structures, with a pixel pitch size of 22 μm, has been designed with a 0.18 μm CMOS Image Sensor process. It contains 112×96 pixels, covering an area of 3 mm×3.3 mm. The prototype will operate in the rolling-shutter mode, with expected processing speeds of 100ns/row and 80ns/row, respectively, for the two proposed structures.

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Session Classification: POSTER

Track Classification: Pixel sensors for tracking