Contribution ID: **107** Type: **Oral**

FSBB-M and FSBB-A: Two Large Scale CMOS Pixel Sensors Building Blocks Developed for the Upgrade of the Inner Tracking System of the ALICE Experiment

Tuesday 23 September 2014 11:10 (25 minutes)

Two CMOS Pixel Sensors (CPS) flavours: MISTRAL and ASTRAL, dedicated to the upgrade of the Inner Tracking System (ITS) of the ALICE experiment are being designed at IPHC in Strasbourg. Each of two sensors is composed of three identical units called FSBB (Full Scale Building Block), multiplexed towards the external word. This paper will show the design and the laboratory test results of FSBB-M (for MISTRAL) and FSBB-A (for ASTRAL).

Summary

The ALICE-ITS upgrade requires 50 µm thin CPS covering about 10 m^2 detection areas. These CPS should have higher read-out speeds and radiation tolerance than those already achieved in the Pixel Detector (PXL) equipping the STAR experiment at RHIC/BNL. These requirements are the main motivation to migrate from a 0.35 µm process used for the development of MIMOSA28 dedicated to the STAR-PXL detector to a smaller feature size process. A 0.18 µm process, based on a high resistivity epitaxial layer of sizeable thickness, has therefore been chosen for these new devices. [Ref. TWEPP 2013, Id: 62]

After validation of the process, two sensor architectures, called MISTRAL and ASTRAL, are being developed at IPHC. MISTRAL is derived from MIMOSA28 sensor. It is based on a column parallel read-out with amplification and correlated double sampling (CDS) inside each pixel. Each column is terminated with two high precision discriminators in order to read out 2 rows simultaneously. The matrix is read out in a rolling shutter mode (200ns/2-rows). The discriminator outputs are processed through an integrated zero suppression logic (SUZE02). With this mature architecture, MISTRAL, with its ˜1.3x3 cm^2 sensitive area, is currently developed to suit both the inner and outer layers of the ITS. The MISTRAL sensor for the inner layers will provide a single point resolution of ˜5 µm with a power consumption of ˜185 mW/cm^2 and a readout frequency of ˜25 k frame/s. In order to reduce the power density for the outer layers, the MISTRAL sensor for the outer layers will rely on larger pixels to provide a single point resolution of ˜10 µm. The power consumption diminishes to ˜100 mW/cm^2 while the readout frequency increases to 40-50 k frame/s.

ASTRAL provides a further improvement in terms of power consumption and readout speed. It integrates signal discrimination inside each pixel. As a consequence, the analogue signals driving over centimetre long traces are replaced by the digital signals. The ASTRAL sensor is proposed for the innermost layers with a single point resolution of ˜5 µm. Its expected power consumption is ˜85 mW/cm^2 with a read-out frequency of ˜50 k frames/s.

The first prototypes of FSBB-M and FSBB-A were designed and fabricated. Their tests with X-ray and beta sources will start in June 2014.

This contribution will discuss in details the design of both sensors and summarise their laboratory test results.

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Session Classification: ASICs

Track Classification: ASICs