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Tri-axis 5µm hexagon pixel-strip matrix combining 3*852 current comparator in a 180nm node

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We present a new kind of sensors made of 5µm pixels using 6-metal TJ 180 nm technology. The pixels are interconnected among themselves to conducting lines with three directions 0°, 120° and -120°. Two neighbouring pixels are connected to different lines with different directions. The lines are connected to readout cells hosting current amplifier with its current comparator, together with the digital readout circuitry. In a 400 ns frame, the circuit can output the address position of up to 16 hits. The sensor of 0.5cm2 is intended to reduce the number of electronic channels while preserving the spatial resolution.

Summary (500 words)

The PICMIC project proposes a new detection system allowing the exploitation of the excellent time (˜ps) and spatial (˜µm) resolutions that a MicroChannel Plate (MCP) can provide. This presentation will focus on the position measurement of the PICMIC detection system using a new sensor of 5µm hexagonal pixels that occupy the top metal layer (TML) of a circuit for collecting charge from MCP [Fig.1]. Those collection pixels are interconnected through vias to conducting lines of different orientations in an original way and hence reduce drastically the number of readout channel. In this new scheme, two neighbouring pixels are connected to two different lines of different orientations. The conducting lines of the same orientation are placed in one of the next three metal layers (TML-1, -2, -3). The three orientations are 120°, -120° and 0°. Under the interconnection layers, a readout matrix (RM) is overlayed in the rest available metal layers. To cover a MCP surface of $50mm^2$, the demonstrator, fabricated in TJ180nm technology, features a RM of 53*128 readout-cell of 140µm x 50µm size, but only 3*852 places are needed to grab the corresponding lines. The Analog part is made of an optional current mirror to reduce the input impedance, followed by a current comparator. The threshold of the current mirror is selectable with an 8-bit common current-DAC from 80nA to 20.48µA. An additional inner-place 3-bit system adjust locally the fixed pattern offset of the array.

The digital array is read by a priority encoder mechanism. Every cell that records a hit, raise a flag. The flag is released once its address position is recorded. This sequencing permits to read 16 positions in a frame of 400ns. The data are sent out in parallel at 40MHz.

A robust i2c protocol is used to set the ASIC's configurations. The maximum overall power consumption of the circuit is 256mA*1.8V. The application expects triangle-shaped current signals in the range of [13uA x 2ns] and [1.8mA x 0.4ns].

Injecting current pulses through a thin probe on top of the die. Several lines are fired. By crossing we were able to successfully determine the injection position. We repeated the injection using two different at the same time and we were able to find the two positions with a resolution of 5 µm confirming that the new device will be able to efficiently separate nearby particles.

Ongoing study are evaluated to decrease the pitch to 2.5µm, together with the increase of the size of the sensor to $1cm^2$. Additional feature will be implemented to timestamp and memorize more event, as well as increasing the readout speed. In an even further step, changing to a smaller technology node is envisaged.

Meanwhile, the detector setup for the proof of concept of the PICMIC project is almost ready, to take full benefit of the MicroChannel Plate sensors.

Succesfully, this amazing Tri-axis pixel-strip circuit had been invented, developed, produced and tested in less than 3 years.

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