Contribution ID: **24** Type: **Oral**

Development of a small-scale prototype of the GOSSIP chip in the 0.13um CMOS technology.

Wednesday 5 September 2007 10:55 (25 minutes)

Abstract.
The GOSSIP (Gas On Slimmed Silicon Pixel) detector is a candidate to be a good alternative for silicon based pixel detectors. The Gossip chip is being developed to serve as a read-out array for such a gas-filled detector. Thanks to the very low capacitance at the preamplifier input, the front-end of the chip demonstrates low-noise performance in combination with a fast peaking time and low analog power dissipation. Measurement of the drift time of every primary electron enables 3D reconstruction of the particle's track. For this purpose Time-to-Digital converter must be placed in each pixel.
A small-scale prototype of the GOSSIP chip has been developed in the 0.13μm CMOS technology. The prototype includes a 16 by 16 pixel array. Each pixel is equipped with the front-end circuit, threshold DAC, and a high resolution 4-bit TDC.
The chip will be available for testing in May 2007 and after initial tests it will be processed to build a prototype detector.

Summary

Summary.
The GOSSIP (Gas On Slimmed Silicon Pixel) chip is a CMOS pixel array with a fine grid (e.g. micromegas) placed at a distance of 50μm on top of it by means of wafer post-processing technology. One mm above this grid the cathode foil is placed. The cathode foil and the grid are put at -800V and -400V, respectively, and the pixel array surface is at ground potential. The volume between the drift foil and the pixel array is filled with a suitable gas mixture. When a minimum ionizing (MIP) particle passes the drift gap, about 10-50 electron-ion pairs will be created along the track. Driven by the electric field the electrons will drift towards the pixels. In the grid-to-pixel gap an avalanche multiplication occurs making the sufficient charge to activate an on-pixel integrated circuit. The activated pixels are a projection of the track on the array surface. Moreover, the drift time measurements at the activated pixels will allow 3D track reconstruction.
A number of features make the GOSSIP chip advantageous for future particle detectors. It has no thick silicon sensor bulk, but a gas volume instead. Therefore it has a low material budget and it is free from the radiation damage effects in the depletion layer of the silicon sensor. The on-pixel circuitry will be radiation hard due to the internal properties of the up-to-date deep-submicron CMOS technology.
In the first prototype [1] we designed a front-end for a pixel as small as 55μm by 55μm. The low value of the parasitic capacitance at the input of the preamplifier let us design a low-noise (ENC=60e rms) and the same time very fast (40 ns peaking time) and low power (2μW per channel) front-end circuit including a CMOS comparator. The low power aspect is of primary importance since any additional cooling system involves an increase of the material budget. The chip demonstrated low sensitivity for digital crosstalk and the new design with a TDC in each pixel cell should validate this. This requires careful layout of the input traces in combination with common usage of the isolated NFETs and an increased amount of substrate contacts throughout in the circuit.
The main goal of the present prototype of the GOSSIP chip is to build a real small-scale detector capable of the particle track reconstruction. For this purpose we have designed a 16 by 16 pixels array. The total sensitive area is 0.88 mm2 with a pixel size of 55μm by 55μm. To compensate the channel-to-channel threshold spread a

4-bit DAC is added in each pixel cell.
In order to measure drift time each pixel cell contains a TDC. Its function is to digitize the time interval between the moment when the pixel has been hit and the end of the 40 MHz clock signal (LHC bunch cycle). This value gives the time that a particle has passed through the detector. The TDC is made of a pulse controlled local oscillator on the basis of a 2-input NAND gate with a chain of inverters in feedback. The circuit starts oscillating on the positive edge of the output signal of the comparator (hit signal) and stops at the positive edge of the clock signal. The oscillator is followed by a 4-bit pulse counter in the form of a linear feedback shift register. This circuit counts the number of pulses at the output of the oscillator. The resulting value is the digital code of the drift time. Time resolution of the TDC (1.6 ns) is determined by the delay in the feedback of the oscillator. Quality of this type of TDC is set by the temperature stability of the chain of inverters together with its sensitivity to the drift of the power supply voltage. Simulations show that the error is lower than LSB when the TDC operates within the temperature range 30 degrees and the power supply range 60 mV.
In a test situation the trigger signal comes much later than the particle. The hit time slice will be defined with the help of a 4-bit latency counter. It gives a number of full 40 MHz clock cycles between the hit signal and the trigger signal. If the trigger signal does not show up within 15 clock cycles both the latency counter and the drift time counter will be reset.
After receiving the trigger signal all 256 pixels of the array will be sequentially read-out.
For better testability we are able to feed the test signal to each pixel separately and mask bad pixels. A serial link is used to load the data to the registers controlling the corresponding analog switches of the threshold DAC, the pixel mask circuit and the test signal circuit.
[1] V.Gromov, R.Kluit, H. van der Graaf, "Prototype of the Front-end Circuit for the GOSSIP (Gas On Slimmed Silicon Pixel) Chip in 0.13 µm CMOS Technology ", 12th Workshop on Electronics for LHC and Future Experiments, pp. 253-257, Valencia, Spain, 25-29 September 2007.

Authors: Mr KLUIT, Ruud (NIKHEF); Mr GROMOV, Vladimir (NIKHEF)

Co-author: Mr GRAAF, Harry van der (NIKHEF)

Presenter: Mr KLUIT, Ruud (NIKHEF)

Session Classification: Parallel session B4 - ASICs 1 FE chips