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Prototype of the front-end circuit for the GOSSIP (Gas On Slimmed Silicon Pixel) chip in the 0.13um CMOS technology.

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Abstract.
Owing to a novel concept of the detection of the single electrons in gas, the GOSSIP chip will hold certain advantages over an ordinary silicon pixel readout chip. Of these, no need for silicon sensor at all, low detector parasitic capacitance and none of the bias current at the pixel are the attractive features to design a compact low-noise and low-power integrated front-end circuit.
A prototype of the integrated circuit has been developed in the 0.13um CMOS technology. The prototype includes a few channels equipped with the preamplifier, the discriminator and the digital circuit to study the feasibility of the TDC-per-pixel concept.
The measurements demonstrate very low input referred noise (70e RMS) in combination with a fast peaking time (≈40ns) and low analog power dissipation (2uW per channel for 1.2V supply). High frequency switching activity on the clock bus (up to 100MHz) in the close vicinity of the sensitive analog inputs does not cause noticeable extra noise.

Summary

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The foreseen GOSSIP (Gas On Slimmed Silicon Pixel) chip will consist of a CMOS pixel array with a Micromegas grid placed at the distance of 50um on top of it by means of wafer post-processing technology. One mm above this grid a cathode foil is built. 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, some 10-50 electron-ion pairs will be created along the track. Driven by an electric field the electrons will drift towards the pixels. In the Micromegas-pixel gap an avalanche multiplication occurs making the charge sufficient to activate an on-pixel integrated circuit.
The activated pixels will show the projection of the track on the array surface. Moreover the drift time measurements at the activated pixels will indicate the polar angle of the track.
A number of features make the GOSSIP chip advantageous for future particle detectors. It has no thick silicon sensor bulk (slimmed pixel chip). Therefore it has a low material budget and is free from the radiation damage effects taking place in the depletion layer of the silicon sensor. The on-pixel circuit will be radiation hard due to the internal properties of the up-to-date deep-submicron CMOS technology.
The value of the parasitic capacitance at the input of the front-end circuit is determined by the area of the pixel pad and consequently could be very low (5fF⋯30fF). This feature enables to design a low-noise (less than 70e RMS) and at the same time very low power circuit. The low power aspect is of primary importance since any additional cooling system involves an increase of the material budget. We expect the GOSSIP chip will dissipate ≈100mW/cmˆ2.
In this work we have developed and tested a prototype of the front-end circuit in the 0.13um CMOS technology.
The front-end circuit consists of the preamplifier and the discriminator. The circuit operates at the low threshold (400e) to provide low single electron inefficiency and

good time resolution. The magnitude of the input signal is in the wide dynamic range (1e···20000e) due to the low ion-electron production statistics and the avalanche multiplication mechanism in gas. A fast rise time of the circuit's pulse response (≈40ns) is needed to minimize the time jitter related to the variation of the magnitude of the input signals. The circuit does not need to be linear while the value of the channel-to-channel threshold spread is important to keep low (input referred 160e RMS). The charge-sensitive preamplifier follows the scheme proposed by F.Krummenacher. It comprises an extreme low feedback capacitance (1fF) and low input parasitic capacitance (30fF for 40umˆ2 input pad area). This solution provides the input signal charge-to-voltage conversion factor as high as 0.6V/fC. The signal at the output of the preamplifier does not need any additional amplification for the discrimination. The discriminator is based on the current comparator topology and generates CMOS signals at the output. Altogether the front-end circuit dissipates 2uW/channel for 1.2V power supply.
For the drift time measurement each channel of the GOSSIP chip will be equipped with a high resolution Time-to-Digital converter (one bin is 1.6ns). To implement such a TDC a high frequency clock signal needs to be delivered to each pixel. Through the parasitic coupling to the sensitive analog inputs the clock signals may ruin the low-noise performance of the circuit. We have developed a simple high frequency (100MHz) switching digital block on some pixels to characterize this effect.
As far as we have measured the switching noise is hardly noticeable. This accounts for the careful layout of the input traces in combination with the common usage of the isolated NFETs and an increased amount of the substrate contacts throughout in the circuit.

Author: GROMOV, Vladimir (NIKHEF)

Co-author: KLUIT, Ruud (NIKHEF)

Presenter: GROMOV, Vladimir (NIKHEF)

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