Gas pixel detectors for X-Ray polarimetry applications

R.Bellazzini,G.Spandre and Luca Baldini

INFN sez.Pisa, Largo B. Pontecorvo, 3 I-56127 Pisa, Italy

Abstract

Since 2001 we have been working at INFN Pisa on the concept of Gas Pixel Detectors in which a custom CMOS analog chip is at the same time the pixelized charge collecting electrode and the amplifying, shaping and charge measuring front-end electronics of Micropattern Gas Detectors or other suitable charge multipliers. To this purpose three ASIC generations with increasing size, reduced pitch and improved functionality have been realized. Here we report on the last version of this concept representing a big step forward both in terms of size and performance. The large area CMOS pixel array has the top metal layer patterned in a matrix of 105k, 50 μm pitch, hexagonal pixels, each of them directly connected to the underneath full electronics chain which has been realized in the remaining five metal layers of the 0.18μm VLSI technology. The chip integrates more than 16.5 million transistors and it is organized as a 15mm×15mm active area. It is subdivided in 16 identical clusters, each one with an independent differential analog readout buffer. Each cluster has a customizable internal self-triggering capability with independently adjustable thresholds. An internal wired-OR combination of each cluster self-triggering circuit holds the maximum of the shaped signal on each pixel. The self-triggering function also includes an on-chip signal processing for automatic localization of the event coordinates. In this way it will be possible a significant reduction of readout time and data volume by limiting the signal output only to the pixels belonging to the region of interest. The very small pixel area and the use of a deep sub-micron CMOS technology brings the noise down to 50 electrons ENC.

Results from in depth tests of this device when coupled to a fine pitch (50 micron on a triangular pattern) Gas Electron Multiplier are presented. The matching of readout and gas amplification pitch allows to get optimal results. The application of this detector for Astronomical X-Ray Polarimetry is discussed. The experimental detector response to polarized and unpolarized X-ray radiation is shown. Results from a full MonteCarlo simulation for two astronomical sources, the Crab Nebula and the Hercules X1, are also reported.

Obviously, depending on type of electron multiplier, pixel and die size, electronics shaping time, analog vs. digital read-out, counting vs. integrating mode, many other applications can be envisaged for this class of devices.