

Shuguang Zou, Xiangming Sun, Ping Yang, Yan Fan, Guangming Huang, Dong Wang, Xiaoting Li, Le Xiao, Hua Pei, Zhen Wang, Mangmang An, Kai Wang, Wei Zhou, Chufeng Chen
 Central China Normal University, Wuhan, Hubei 430079, China

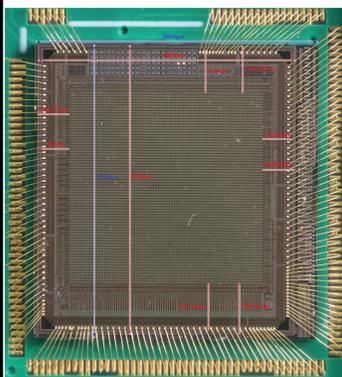
Abstract

We have developed a highly pixelated electrode array named Topmetal-II-. It contains a 72×72 pixel array of 83.2μm pitch size. The key feature of Topmetal-II- is that it can directly collect charge via metal nodes of each pixel to form two-dimensional images of charge cloud distribution. Topmetal-II- sensor is designed with a low power consumption of 104 mW and low RMS noise of 30 e-. From our measurement by injecting pulse signal into each pixel of the top metal, we get the ENC of about 15 e- after trapezoidal shaper. Furthermore, the average noise of normal pixels is 14.741 e- with sigma of 3.523 e-. With such a low noise, we can measure charge particle track without any gas amplification in some applications, achieving high energy and spatial resolution. Thus Topmetal-II- makes a competitive candidate for the next generation of TPC readout node in high energy physics.

Introduction

Topmetal-II- is designed as a low noise sensor with high spatial resolution at room temperature. Low noise chip can be applied in time projection chambers, for experiments like dark matter research. By injecting pulse signal to measure noise, we demonstrate the performance of Topmetal-II-.

Topmetal-II-

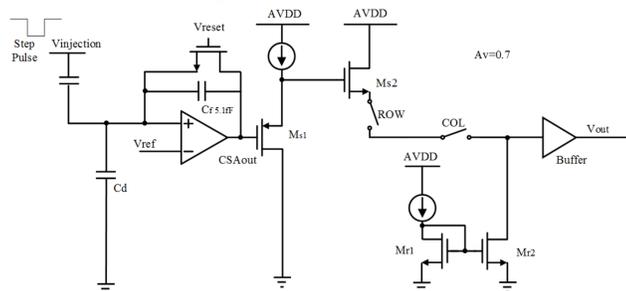


- 72×72 pixel array.
- Pixel Size
 pixel size: 83.2μm×83.2μm.
 Top metal size: 25μm×25μm
 opening window size 15μm×15μm.
- Two modes: Analog and Digital mode.

Noise Test Method

Topmetal-II- can directly collect charges via metal nodes of each pixel. There is a guard ring at the periphery of metal node of each pixel. By injecting pulse signal into guard ring, we can measure the noise of each pixel of Topmetal-II- in analog mode.

Analog Readout:



Experiment Condition & Trapezoidal Shaper

TopMetal-II- :

CSA: Vref= 618mV
 Vreset=800.4mV

DAQ:

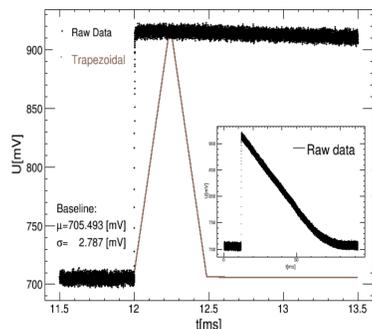
SNR:57.2dB, ENOB:9.1
 Data acquisition clock: 10MHz
 +/-1V with 14-bit resolution

Analysis:

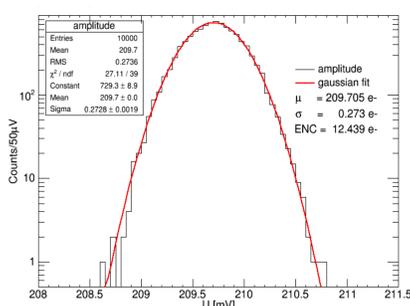
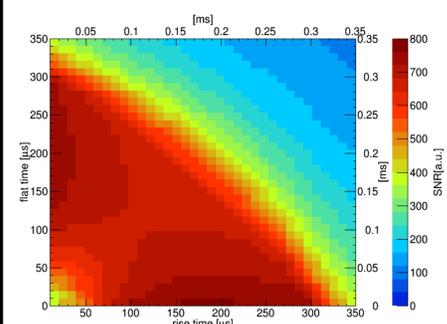
The result of applying trapezoidal filter to events of injection step pulse.

By scanning the parameters of trapezoidal filter, we can get the optimal σ which corresponds to the maximum of μ/σ .

Trapezoidal Shaper:



Injection step pulse: 200mV



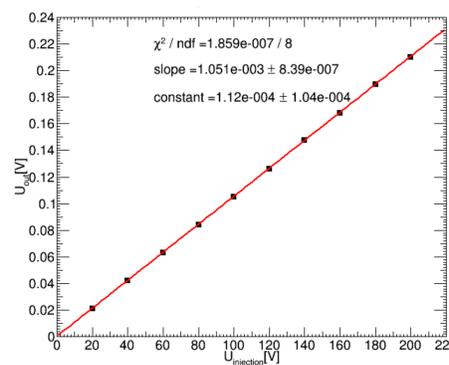
Single Channel Noise

ENC Calculation:

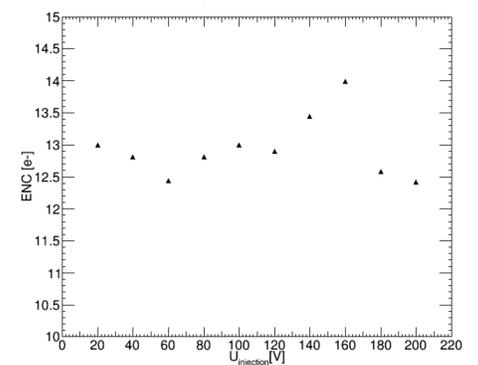
The amplitude of voltage is obtained by trapezoidal filter. We calculate the mean(μ) and sigma(σ) of amplitude among events.

$$ENC = \frac{\sigma}{\mu} * Q_{injection} = \frac{\sigma}{\mu} * \frac{C_f}{V_{out}} * \frac{V_{out}}{A_v} \quad A_v \sim \text{CSA and source follower gain}$$

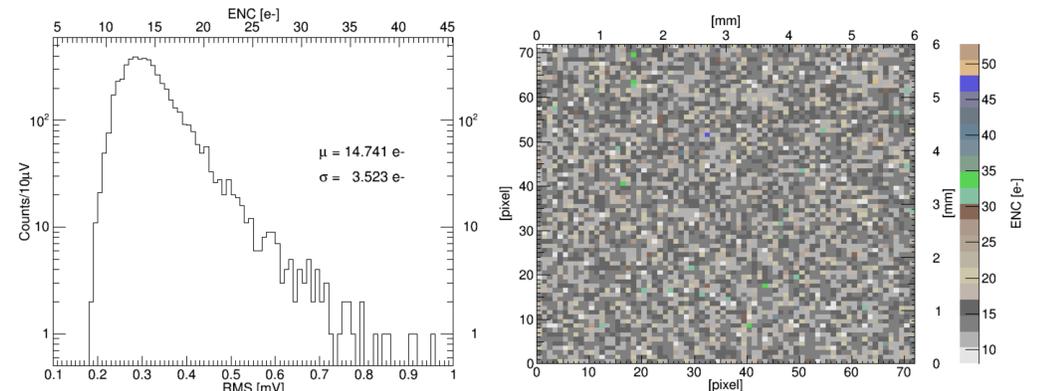
Amplitude vs injection voltage



ENC vs injection voltage

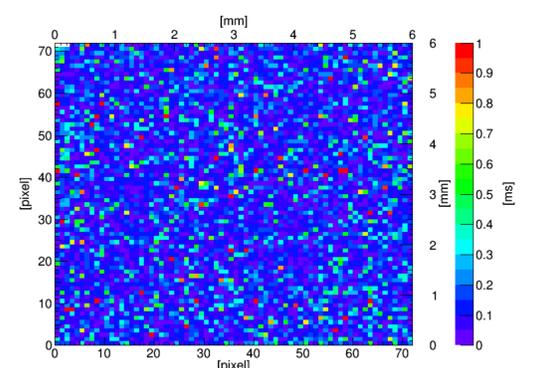
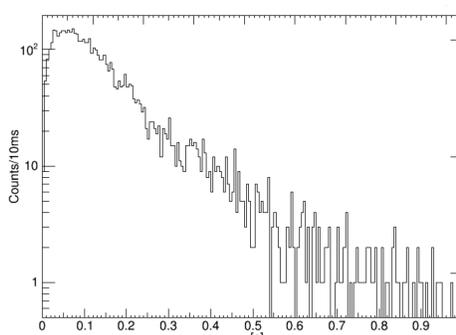


ENC Distribution of Total array



We get the ENC values of normal pixels by the same method described previously. From the picture above, we see that the noise distribution of the whole sensor is almost uniform among pixel matrix.

Decay Constant



Fit each channel with exponential function. Most of decay constants are around 30~300 milliseconds.

Conclusion

A low noise CMOS sensor named Topmetal-II- has been presented. We measured the electronic noise of Topmetal-II- sensor working in analog mode at room temperature and achieved the mean ENC value of 14.741 e- with sigma of 3.523 e-.