A Prototype of Radiation Imaging Detector Using Double-sided Silicon Strip Sensor

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1. Introduction

We have the experience developing radiation imaging detector using single-sided silicon strip sensor[1]. Based on that, in this time, we developed an imaging detector to study the feasibility of our double-sided silicon strip sensor for imaging applications.

2. Silicon Sensor

A double-sided silicon strip sensor provides two coordinates of high granularity with small strip pitches on its both sides. Our double-sided silicon strip sensor[2] is made of a 380μm thick n-type silicon wafer, with 512 p-type strips implanted at 100μm pitch on the junction side as X coordinate of incoming particle. 512 n^+-type strips, orthogonal to those, are implanted with 50μm pitch on the ohmic side as Y coordinate. On the ohmic side, a p blocking strip(p-stop) is added between n strips to increase the inter-strip resistance. For the prototype imaing device, 64 strips(a strip per eight) on each side are coupled to low-noise electronics.

Electrical characteristics test resulted in the full depletion of 70V and the leakage current of 1 nA a strip at 70V. The 80V bias is supplied for operation. The discrete resistors and capacitors are placed nearby the silicon sensor for biasing and AC coupling in the sensor board.

3. Front-end Electronics

The front-end electronics is based upon the VA1TA[3] chip, which consists of 128 charge sensitive preamplifier-shapers, simultaneous sample-and-hold and multiplexed analog readout with self trigger. The four boards with a VA1TA chip, which is connected with only 32 strips of the silicon sensor, are used to process the signals from the sensor board. The analog signal then is digitized by 12bit-FADC.

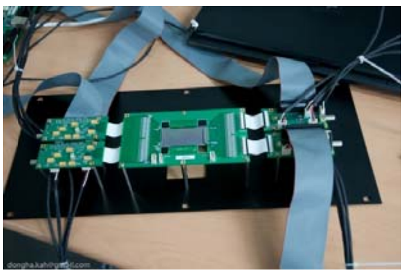

Fig. 1. Four boards with a VA1TA are connected via thin flat cables to the sensor board with double-sided silicon sensor.

The Equivalent Noise Charge(ENC) was ~1200e^- per strip channel which are overall ENC of the sensor and readout electronics. The Signal to Noise Ratio(SNR) by the Minimum Ionization Particle(MIP) was measured to ~23 as expected from the ENC.

4. Imaging Test

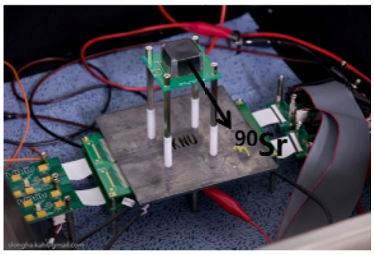

Fig. 2. The setup for imaging test

In the setup for imaging, the sensor board is placed under the 'KNU' phantom that is a lead plate on which 'KNU' characters with the area of 3.2cm x 1.5cm are engraved. Over the phantom is the collimated β source of ^{90}Sr as MIP. With the setup put in a dark box, two dimensional position data are taken by DAQ board with Xilinx chip when the signals of p and n strip channels coincide. To suppress noise background, the threshold of VATA1TA is set to 5 ENC so that the hit pattern of 'KNU' appear gradually when electrons are bombed to the phantom. The accumulated hits reconstructs the same image as the shape of the phantom.

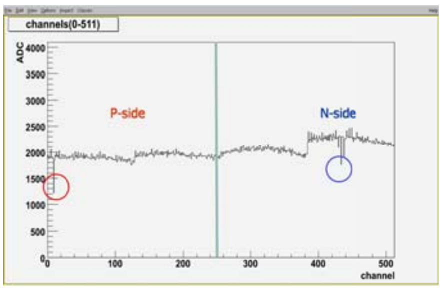

Fig. 3. The ADC values of p and n strip channels when they coincide. The ADC values of signals are relative to baseline of ~2000 which are measured through pedestal test. The peaks indicated by the circles are strip channel hit on the both sides.

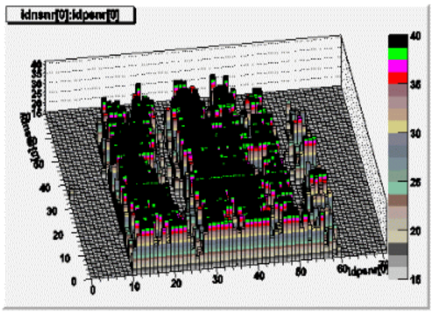

Fig. 4. The hit pattern in the double-sided silicon strip detector when electrons are bombed to the phantom. 'U' wasn't clear due to the alignment of imaging setup that electrons rarely reach it.

5. Conclusion

We fabricated a double-sided silicon strip detector that consist of a DC-coupled double-sided silicon strip sensor and readout electronics. Its SNR of ~23 was high enough for imaging test so that we constructed simple imaging test setup adding a phantom and a collimated β source. Then we could obtain the image of the phantom from the silicon detector.

REFERENCES

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[2] D.H. Son, et al, "Signal-to-Noise Ratio Measurement of a Double-Sided Silicon Strip Detector by Using 45-MeV Proton Beam", Journal of the Korean Physical Society, Vol. 52, No. 3, pp.949-953, 2008.
[3]IDEAS,"VA1TA",http://www.ideas.no/products/ASICs/pdf/Va1Ta.pdf