Radioactive Source and Proton Beam Tests of Silicon Strip Position Detectors

Y.I. Kim[a*], D.H. Kah[a], H.J. Hyun[a], H.D. Kang[b], H.J. Kim[a], S.W. Jung[a,], J.H. So[a], S. Ryu[a] and H. Park[a]
[a]*Basic Atomic Energy Research Institute, Kyungpook National Univ.*
[b]*Radiation Science Research Institute, Kyungpook National Univ..*
email: bluekyi83@.knu.ac.kr

1. Introduction

The silicon strip position detector has been developed and used in various areas due to its intrinsic high position resolution for medical imaging sensor, radiation detector, positioning detectors in space science and experimental particle physics. High technology, modern equipments and deep expertise are needed to design, develop and produce good quality silicon sensor. Only few facilities in the world can develop silicon sensor of required quality as silicon detector. That is why silicon sensor is so expensive and it takes time to purchase silicon sensor once it is ordered. Much more areas will need high resolution silicon sensors in coming years and it is important to have know-how of silicon sensor development with domestic facility.

We designed and fabricated DC- and AC-coupled silicon strip sensors in 5-inch fabrication line with <100> high resistivity (> 5 KΩcm) n-type silicon wafer of 380 μm thick. The front-end electronics and DAQ system were developed for signals readout from silicon strip sensors. We performed silicon strip sensor test with ^{90}Sr radioactive source and measured the signal-to-noise ratio of the developed silicon sensors. We also performed beam test using 35 MeV proton beam from the MC-50 cyclotron at the Korea Institute of Radiological and Medical Science (KIRAMS) in Seoul and present preliminary results of the proton beam test.

2. Concepts of Silicon Strip Detector

The silicon sensor can be fully depleted by applied reverse bias voltage. One of advantages of full depletion is that silicon bulk can be used as the active sensor volume. When charged particles pass through the silicon bulk, electron-hole pairs are produced and electrons are collected in electrodes by electric field.

High position resolution of silicon detector can be achieved by dividing large-area diode into many small strips and read charge signals out separately. The position of passage of the charged particle is then determined by the location of the strip showing signal.

The Silicon sensor is called as DC-coupled and AC-coupled for direct and capacitive coupling of electronics to the silicon detector, respectively. Design and fabrication of DC-coupled and AC-coupled silicon strip sensors are reported in previous [1] and this Korea Nuclear Society (KNS) Meeting [2].

A cross sectional view of DC- and AC-coupled single-sided silicon strip sensor is shown in Fig. 1

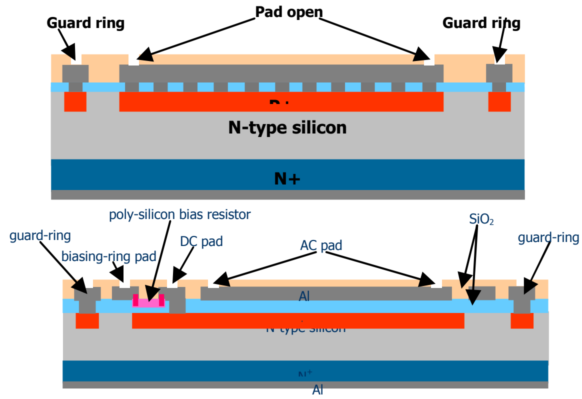

Fig. 1. A cross sectional view of DC- (the upper) and AC-(the lower) coupled single-sided silicon strip sensor.

3. Beta Source Test of Sensors

We used ^{90}Sr beta ray for source test purpose. After silicon sensor is fully depleted by reverse bias voltage [3], the beta source signal is measured on the oscilloscope. We measured noise level of the silicon sensor without beta source and the beta source is then put on the top of the silicon sensor in a dark box. A result of beta source test with DC-typed double-sided silicon strip sensor was reported in previous KNS meeting [4].

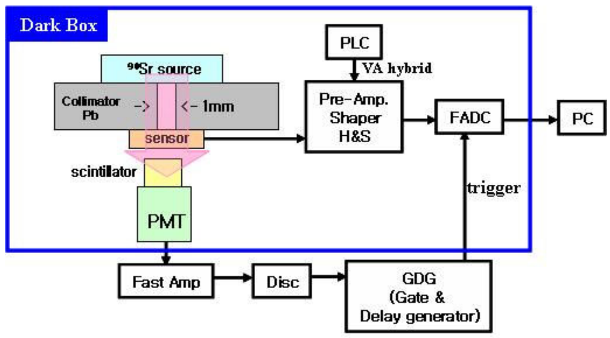

Figure 2. Experiment setup for the signal to noise ratio measurement using ^{90}Sr.

At this time we used our sensor hybrid board, PLC (Power Logic and Control) board and FADC board to read signal out. 17 channel of the DC-coupled single-sided strip detector was used for the beta ray test and signal of each strip was recorded and analyzed. The experimental set up for the signal to noise measurement is sown in Fig. 2. BGO crystal was used for the trigger purpose.

A 25MHz USB2 based home-made Flash Analog to Digital Converter (FADC) board has one analog input, one trigger input and one output. An analog signal from the double-sided silicon sensor was connected into the analog input of the FADC board via a preamplifier and an amplifier. A signal from the reference sensor was connected into the trigger input of the FADC board via a preamplifier, an amplifier and a discriminator. An FADC output was recorded into the personal computer and data was analyzed with C++ based data analysis program.

Fig. 3 shows the measurement result of one of strip channel and the signal to noise ratio is estimated to be around 10. Further analysis is on-going.

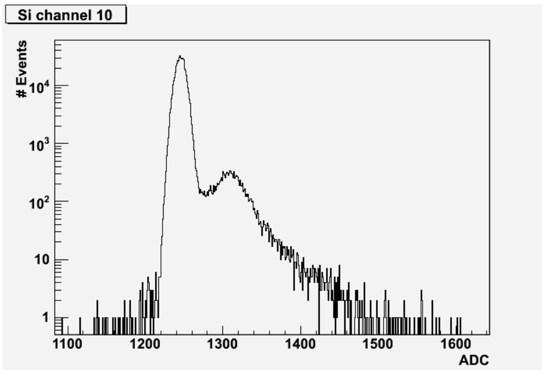

Fig.3. ADC distribution of single strip measure with ^{90}Sr.

4. Proton beam test of the Strip Sensor

This experiment was performed using a 45 MeV proton beam at the KIRAMS in the Seoul. We measured signal to noise ratio of the sensor.

The experimental setup is similar as the radioactive source test. The schematic of set up for measurement and detectors and electronics for data acquisition in a dark box is shown Fig 4.

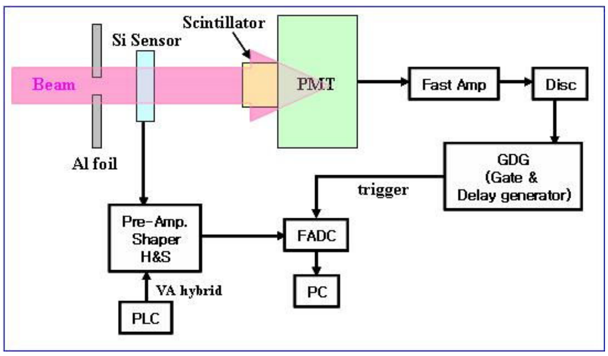

Figure 4. Experimental setup for proton beam test of silicon sensor.

A data analysis is in progress but preliminary result showed that there must be misalign problem between the proton beam and active strip sensor areas. We used 1mm collimator, a size of sensor is 1.8 x 30 mm^2 and distance between the collimator and a sensor is about 20 cm. To make sure our understanding we performed simulation study and could reproduce similar distribution as data. The results of the simulation and data analysis are shown in Fig 5. We are planning to do the proton beam test again in coming month with understanding of this problem and expect better measurement results.

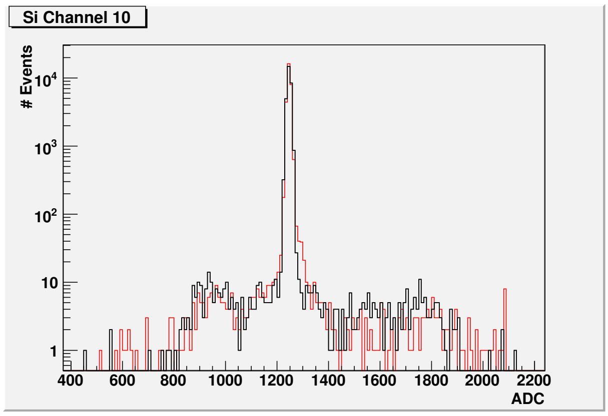

Figure 5. ADC distribution of single strip channel (red for real data and black for simulation).

5. Conclusion

DC- and AC-coupled single-sided strip sensor were designed, developed and fabricated on the 5-inch fabrication line for first time in Korea. With various measurements and tests [2] showed that qualities of the fabricated sensor are as good as Hamamatsu's.

We presented signal to noise ratio of each strip channel with ^{90}Sr. And we also performed beam test, sensors were irradiated in 45 MeV proton beam. We measured signal to noise level of the sensor and detail analysis is still on progress.

REFERENCES

[1] D. H. Shin et al., Design and Development of Double-sided Silicon Strip Sensor, Korean Nuclear Society Meeting, October 2004.

[2] J. Bae et al., Electirc characteristic Measurement of AC-coupled silicon strip position sensor, Korean Nuclear Society Meeting, November 2006.

[3] G. Lutz, Semiconductor Radiation Detector, Springer, New York, pp 101-102, 1999.

[4] D. H. Kah et al., Signal-to-noise Ratio Measurements of Double-sided Silicon Strip Position Sensor with a Radioactive Source and Proton Beam, Korean Nuclear Society Meeting, May 2006.