Development and Test of Silicon Strip Detector for International Linear Collider

D.H. Kah[a], J.B. Bae[a], J.H. Choi[c], H.J. Hyun[a], S.W Jung[a], H.D. Kang[a], H.J. Kim[a], Y.I. Kim[a], Jik Lee[b], S.S Ryu[a], H. Park*[a] and E. Won[c]

[a]*Department of Physics, Kyungpook National Univ., Daegu 702-701, Korea*

[b]*School of Physics,Seoul National Univ., Seoul 151-747, Korea*

[c]*Department of Physics, Korea Univ., Seoul 136-713, Korea*

email: sunshine@knu.ac.kr

We have been designing and developing of DC/AC-coupled double-sided and single-sided silicon strip detectors for the intermediate tracker in the international linear collider (ILC). We used high resistivity (100) n-type double-sided polished silicon wafer of 380 μm thickness. Five and six masks were used for the fabrication of the n-side and p-side of the double-sided silicon strip sensor, respectively. The p-stops in an atoll pattern to prevent electrical shortening due to the electron accumulation layer on the n-side are designed and fabricated. The direction of the p-strips is orthogonal to that of the n-strips but the direction of the signal readout strips are the same to make material budget and electronics space less. This requires a double-metal structure on the p-side. A very thick oxidation layer is deposited between the first metal and second metal to ensure electrical insulation. The first metal and the second metal are electrically connected by via-hole process.

Since the leakage current is a direct check of the fabrication quality, the leakage currents of the developed double-sided silicon strip sensor are measured with Keithley 6517 picoammeter. The capacitances as a function of the reverse bias voltages are measured with HP 4277A LCZ meter. The results showed that the leakage currents were measured to be less than 10 nA/strip and the capacitances were measured as expected from the resistivity and thickness of the silicon sensors.

With respect to radiation damage with the prototype we used 35 MeV proton beam of a cyclotron in Korea Institute of Radiological and Medical Science in Seoul, Korea. The irradiation was performed at the room temperature, and bias was applied to the sensor during the irradiation. The range of the proton beam fluxes are from 10^{12} to 10^{15} number of proton/cm^2. The prototypes have been operated up to a few times of 10^{12} number of proton/cm^2 with negligible effect of increase of leakage current. From the test results of proton beam irradiation, we concluded that developed sensors have an excellent safety margin of radiation hardness appropriate for the ILC.

We also measured the signal-to-noise ratio (SNR) of the silicon strip sensor with the ^{90}Sr radioactive source. A photodiode sensor of Hamamatsu Photonics was used for the trigger purpose. An analog signal from the silicon sensor was connected into the analog input of the FADC board via a preamplifier and an amplifier. A signal from the trigger 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. The result showed that the SNR of the strip sensor is as good as 25.0. The S/N ratio measurement with the proton beam in KIRAMS is scheduled in this summer.

We designed and are now in process of fabricating AC-coupled silicon strip sensors. In the AC-coupled silicon strip sensor we integrated high ohmic resistors and large capacitors into the silicon sensor. The strip sensors are scheduled to be fab-out in July and we will present the electrical characteristics of the fabricated sensors such as capacitances and leakage currents as function of bias voltages, etc.

ACKNOWLEDGMENT

We acknowledge the support by the Korea Science and Engineering Foundation under a Basic Atomic Energy Research Institute (BAERI) program, the Korea Research Foundation Grant funded by the Korean Government (KRF-2005-070-C00032) and the user program of the Proton Engineering Frontier Project.