Development of Double Sided Silicon Strip Detectors

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Introduction

Segmented silicon detectors in the form of strips or pixels are being widely used in high energy particle physics and nuclear physics experiment world over. A position resolution of a few microns can be achieved using such detectors. These detectors are realized using well established silicon integrated circuit technology allowing large scale production of detectors with good uniformity at lower costs. We have earlier developed DC-coupled single sided silicon strip and micro strip detectors for international experimental facilities such as LHC, CERN and RHIC, BNL [1,2]. We have established the technology for fabrication of these detectors at Indian industries. Considering the requirement of physics experiments in India and future international facilities (FAIR, SPIRAL2), development of large area (~40cm^2) double sided silicon strip detectors for two dimensional position sensing has been initiated. Such detectors are being developed for the first time in India. The first prototype has been developed and characterized. The summary of the detector design, fabrication process and initial results of detector characterization are presented in this paper.

Detector design and fabrication process

The detector has been designed to have a geometry of 62 mm x 62 mm with 64 P$^+$ strips on the front side and 64 N$^+$ strips on the back side. The pitch of the strips is about 0.9 mm. The detector is enclosed in a number of guard rings to improve the breakdown voltage and to reduce leakage currents. To isolate the N$^+$ strips, implanted P$^+$ layers are used around the N$^+$ strips. Design features suitable for mounting the detector in transmission mount and double sided wire bonding have been incorporated in the design of detector.

The detector has been fabricated using a twelve layer mask process. The main process steps include field oxidation, front P$^+$ screen oxidation and implantation, front N$^+$ implantation, back P+ implantation and back N$^+$ implantation. The implantation steps were followed by annealing and drive-in cycles. Subsequent to all high temperature cycles, contact opening, metallization and passivation were carried out on both sides of the detector.

For packaging of the detector a PCB package was designed to allow detector mounting in transmission mount and wire bonding of 64 front P$^+$ side and 64 back N$^+$ side strips. The front P+ side and back N+ side of the detector are as shown in Figure 1.

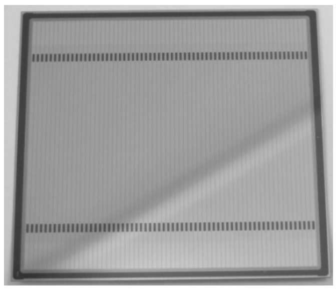

Fig. 1 P side of the double sided silicon strip detector

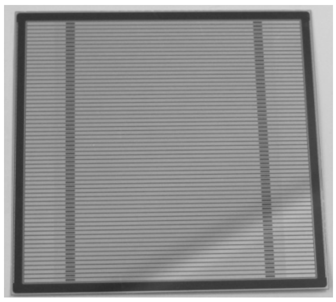

Fig. 2 N side of the double sided silicon strip detector

Characterization of the detector

The detector has been characterized using static tests such as leakage current and capacitance measurements of individual strips. These tests reflect the overall quality of detector in terms of defects (surface and bulk), shorts between the regions, breakdown voltage, etc. A multichannel characterization system and a probe-jig were developed for characterization of double sided detector. The characterization of 64 strips was done on 32 strips at a time as only a 32 channel system was available for measurements. The system incorporated a picoammeter or LCR meter for strip current or capacitance measurement, a programmable bias voltage supply and a multiplexer for switching the measurement channel from one strip to other strip. Individual strip current, total strip current and strip capacitance were measured at different bias voltage using a PC based system. The alpha response of individual strips was also tested by mounting the detector in a vacuum chamber with an alpha source. Standard electronics comprising preamplifier, spectroscopy amplifier and MCA was used for recording pulse height spectrum.

Results

The leakage current of the individual strips at 70V (full deletion voltage) is shown in Fig.3. As can be seen the strip current is quite low, less than 10nA, and is uniform except for a few strips. The individual strip capacitance at full depletion voltage is plotted in Figure 4.

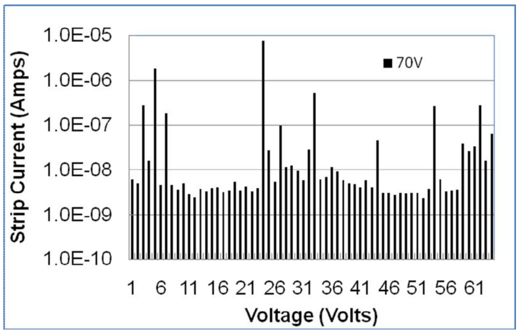

Fig. 3 Leakage current of 64 P side strips of the double sided silicon strip detector at 70V

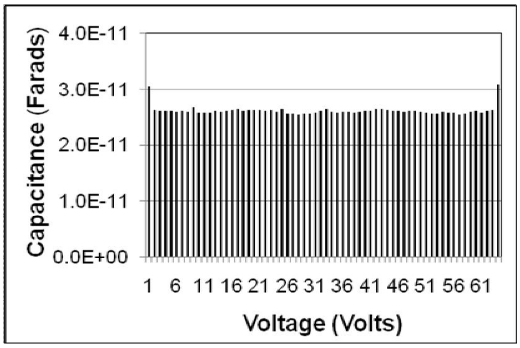

Fig. 4 Capacitance of 64 P side strips of the double sided silicon detector at 70V

The response of detector to charged particles has been verified using an alpha source (^{238}Pu + ^{239}Pu). The pulses from individual P side and N side strips were observed on an oscilloscope using standard electronics. The typical alpha histogram is as shown in Fig.5.

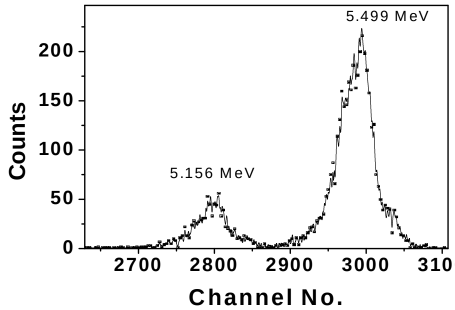

Fig.5 Histogram with alpha particles obtained for a strip of detector

Summary

First prototype of double sided silicon strip detector has been successfully fabricated and packaged. The electrical characterization of the detector shows encouraging results. The characterization of the detector for 2-D position sensing is being carried out.

References

[1] A. Topkar *et al*, Nuclear Instruments and Methods in Physics Research, A, 585, 121 (2008)

[2] A. Topkar *et al*, DAE-BRNS Symposium, NSNI- 2010, 323 (2010)