Performance study of indigenously developed double sided silicon strip detector with charged particles

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Introduction

Position sensitive segmented silicon detectors in the form of strips or pixels are being widely used in high energy particle physics and nuclear physics experiments. Considering the requirement of nuclear physics experiments in India and the GASPARD Experiment at the upcoming SPIRAL2 facility at GANIL, France, Electronics Division (ED), BARC initiated the indigenous development of large area (~40 cm^2) double sided silicon strip detectors (DSSD). As per the specifications provided by Nuclear Physics Division (NPD), BARC, the detectors were designed (64 strips with a pitch of 0.9 mm) and fabricated. The design, fabrication and static characterization details of the indigenously developed DSSDs have been earlier presented [1]. The performance of the DSSDs has been recently studied with charged particles in collaboration with NPD, BARC. The results of this performance study are presented in this paper.

Experimental

The fabricated detector was packaged on a PCB frame in transmission mount with two 68 pin connectors for taking the P^+ and N^+ strips signals (Fig.1). Prior to conducting experiments with charged particles, the leakage current of all strips was measured up to the bias voltage of 100 V. The total leakage current of the detector was less than 500 nA at 100 V. The full depletion voltage was estimated by Capacitance-Voltage (C-V) measurement and was observed to about 75 V. The detector performance with charged particles was studied using a ^{239}Pu + ^{241}Am alpha source (5.156 MeV + 5.486 MeV alpha particles). The experimental setup comprised of a scattering chamber for mounting the detector along with the alpha source and a 128 channel readout electronics consisting of multi-channel charge sensitive amplifiers and multi-channel shaping amplifiers (Mesytec, Germany). A four channel detector bias supply (Mesytec, Germany) was used to negatively bias the P^+ strips at 100 V. All N^+ strips were grounded. Eight 16-channel ADCs were used for acquisition of energy signal from the amplifier. A multi-parameter software was used for plotting the 1D, 2D spectra.

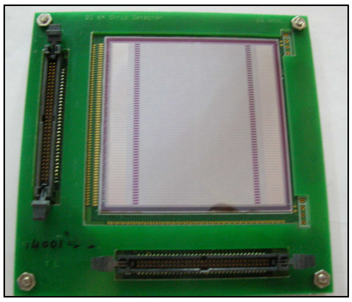


Fig.1 Fabricated and packaged DSSD.

For evaluating the performance of the detector for 2D position sensing, the detector was exposed to alpha particles through a metal mask having a pattern of a diagonal slit of 1 mm and 0.7 mm dia. holes. The energy resolution of the P^+ and N^+ strips for 5.5 MeV alphas incident from the P^+ side was measured from the acquired 1D spectra. Also the data recorded along with the metal mask was analyzed for verifying the position sensing performance of the detector. Subsequently, charged particle beams were used for studying the detector performance at pelletron, TIFR. The results of various measurements are presented in the next section.

Results and Discussion

The typical alpha spectra for P^+ and N^+ strips acquired using a ^{241}Am alpha source are shown in Fig. 2 (a) and (b) respectively. An energy resolution of ~50 keV and ~60 keV respectively for the P^+ and N^+ strips was estimated from the FWHM obtained by fitting the alpha peaks.

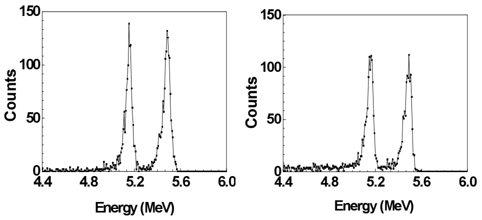
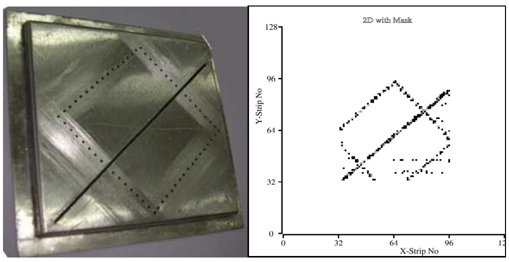


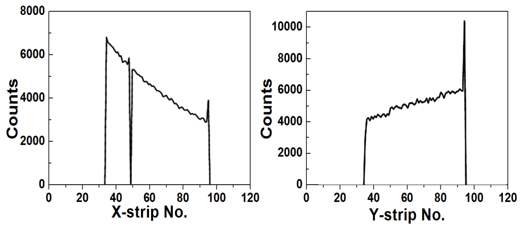
Fig. 2 Alpha spectra for P^+ and N^+ strips

The position resolution of the DSSD was studied by measuring the alpha counts in the strips through a metal mask (Fig. 3(a)). The 2D position image obtained by plotting the counts from P^+ and N^+ strips showed the expected image of the mask confirming the 2D position measurement by DSSD (Fig. 3(b)). The detector was further characterized using 70 MeV ^{7}Li beam incident on 500 mg/cm^2 thick ^{197}Au target. The DSSD was placed at 70^o in the forward direction. The DSSD was observed to show expected behavior (Fig. 4). Fig. 5 shows the strip numbers (i, j), which have given coincident signals for two hit events. The diagonal box represents the events which have got signals from adjacent strips (i, i+1). These events are



(a) **(b)**

Fig. 3 (a) Metal mask and (b) 2D position image of the mask obtained after plotting counts from P^+ and N^+ strips on X-Y axis.



(a) **(b)**

Fig. 4 The counts recorded in (a) P^+ front side strips and (b) N^+ back side strips with 70 MeV ^{7}Li beam on a gold target.

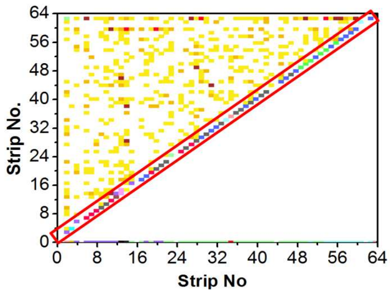


Fig. 5 The two hit events showing hits in the neighboring strips and random hits.

about 8 % of the total events, which matches with the ratio of area of the inter-strip gap to the total active area. This implies that these events correspond to inter-strip events. The sum of all off-diagonal events (~500 counts) corresponds to random coincidences, that agrees well with the estimated random rate. Thus it can be concluded that there are no cross-talks present for the events, when particle are entering one of the strip.

Conclusions

The performance of indigenously developed DSSD was investigated for energy resolution, 2D position sensing and cross talk. The results presented demonstrate the suitability of the DSSD is for nuclear physics experiments.

References

[1] Anita Topkar *et al*, Nucl. Instr. and Meth. A, 834, 205-210 (2016).