5 - 6 Fabrication of New p-type Silicon Strip Detectors with Deep p^+ Diffusion Structure

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Junction engineering has been proposed[1] and demonstrated[2] to be a promising route to radiation-hardness segmented silicon sensors and a tool for better understanding the mechanism of charge multiplication in severely irradiated silicon detectors. We have been developing new p-type strip detectors with deep p^+ diffusion structure to enhance the charge multiplication effect in the p-type electrodes. The detectors were processed on 4-inch diameter, FZ, 300-μm thick, < 111 > - oriented, n-type silicon wafers, with nominal resistivity of 6 kΩ·cm. The fabrication process required 5 mask steps, plus an extra step for window opening in the p^+ implanted layer to form a graded p-doping structure. The detector's sensitive area is 10 mm × 10 mm with 60 p^+ implant strips (64 μm wide and 160 μm pitch). A 10 μm deep p-diffusion has been done at the center of the strip to form a graded junction.

The main process sequence can be outlined as follows:

(a) field-oxide growth (700 nm);

(b) p^+ deep p-diffusion (p-side) strip definition and field-oxide wet etching;

(c) p^+ deep p-diffusion (p-side) implantation (with an implantation energy of 100 keV and a dose of 2×10^{14} ions/cm^2) and annealing;

(d) field-oxide growth, p^+ (p-side) strip definition and field-oxide, wet etching;

(e) p^+ (p-side) strip implantation (with an implantation energy of 40 keV and a dose of 2×10^{14} ions/cm^2) and annealing;

(f) n^+ (n-side) implantation (with implantation energy of 60keV and a dose of 1×10^{15} ions/cm^2) and annealing;

(g) contact opening, metallization.

Fig. 1 shows the schematic description of a microstrip detector with deep p-diffusion(10 μm wide) to form a graded junction; Fig. 2 shows the photograph of the deep p-diffusion silicon strip detector.

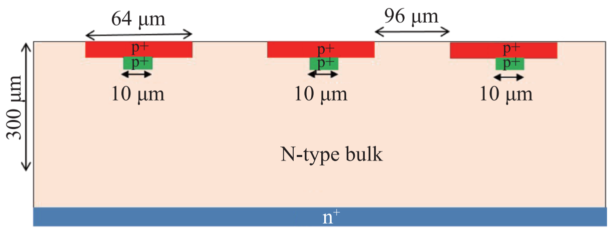

Fig. 1 (color online) Schematic description of a microstrip sensor with deep p-diffusion (10 μm wide) to form a graded junction.

Electrical characteristics were obtained from the current-voltage (I-V) and C-V measurements with a Keithley 487 High Voltage Source Measuring Unit and a Hewlett Packard 4 263 A Impedance Analyser operating at 100 kHz. The full depletion voltage is deduced to be −45 V from the measurement of C-V curve and normalised to a 300 μm diode thickness. As shown in Figs. 3 and 4, when the detector was biased at full deplation voltage (−45 V), the

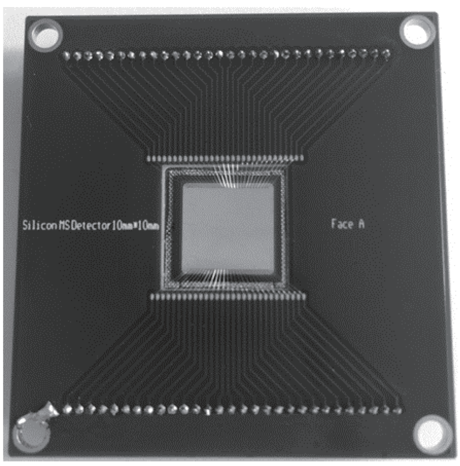

Fig. 2 Photograph of the packaged deep p-diffusion silicon strip detector.

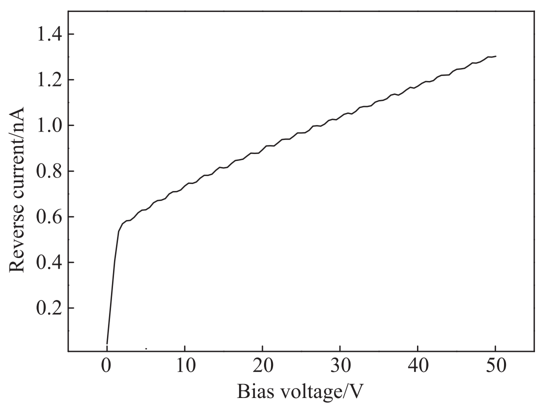

Fig. 3 I-V characteristics measured at 20 ℃ for deep diffused detector

reverse 1eakage current of each strip is less than 1.2 nA. Performances in terms of energy resolution was measured with a ^{241}Am source. Results are presented in Fig. 5. It is shown that the p^{+} implant strips have an energy resolution of 2.6 % for 5.486 MeV of ^{241}Am α particles. Further in-beam experiments will be carried out at HIRFL to measure the radiation-hardness effect of this kind of detector.

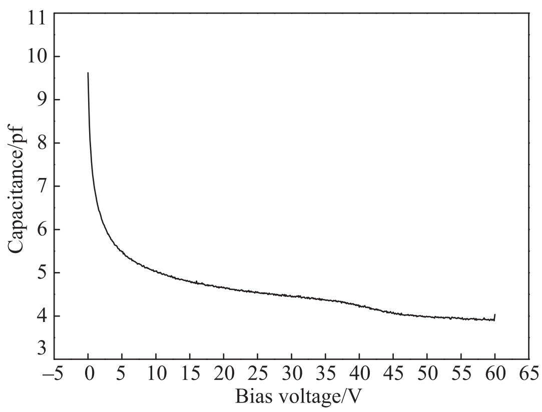

Fig. 4 C-V characteristics measured at 20 ℃ for deep diffused detector

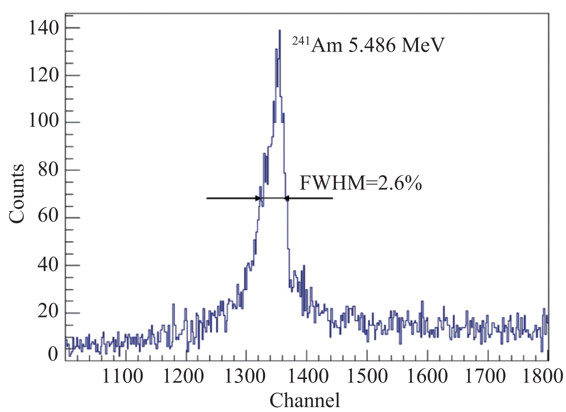

Fig. 5 (color online) Energy resolution of 2.6 % for 5.486 MeV ^{241}Am α particles.

References

[1] I. Mandic, V. Cindro, G. Kramberger, et al., Nucl. Instr. and Meth. A, 612(2010)474.

[2] G Casse, D Forshaw, T. Huse, et al., Nucl. Instr. and Meth. A, 699(2013)9

5 - 7 Progress on Study of the CsI(Tl) Crystal Array

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The CsI(Tl) crystal is regarded as all-important material for its excellent characters in high-energy physics experiments and used as the electro-magnetic calorimeters(EMC) to measure the energy and position of high-energy γ-ray and electron[1−3]. It has higher detection efficiency and sensitivity for X- and γ-ray with the advantage of higher density, higher light yield, not to be easily deliquesced, and without vacuum packaging.

In recent years, the Crystal Detector Group in IMP has improved the processing technology and produced the CsI(Tl) crystals with different size in order to meet requirements from more and more new fields. Now we are able to develop the CsI(Tl) crystal array with the different size.

In the present work, we focus on measuring position resolution of the CsI(Tl) crystal array with the IQSP518 measuring system. The PhotoniQ Model IQSP518 is an economical multi-channel data acquisition system designed for scientists, engineers, and developers as an off-the-shelf solution for data collection from multiple charge-based sensors. Implemented as a stand-alone laboratory instrument with a PC interface, the PhotoniQ is used for charge integration and data acquisition from individual photomultiplier tubes, avalanche photodiodes, and silicon photo-multipliers (SiPM). Available in a standard configuration of two input channels, the IQSP518 can be expanded in the factory or field up to eight parallel channels. Flexible, intelligent triggering and acquisition modes allow the unit to reliably capture event or image data using sophisticated data acquisition techniques. The IQSP518 is fully configurable through its USB 2.0 port using an included graphical user interface. Continuous high speed data transfers to the PC are handled through this interface, and for custom applications through the provided Windows DLL set.

In summary, the results of the CsI(Tl) crystal array(Block:23×23, Pixel：1 mm×1 mm×7.5 mm) are obtained coupled with Hamamatsu H8500 photomultiplier tube (PMT) in the IQSP518 measuring system, including one-dimensional position resolution spectrum and two-dimensional scatter spectrum, details are shown in Figs. 1, 2, and 3. Fig. 2 shows the position resolution, in which X direction is 0.58 mm and Y direction is 0.63 mm. Fig. 3 shows the two-dimensional scatter spectrum of the CsI(Tl) crystal array.