In-house development of large area Silicon ΔE-detector for Alpha-particle/heavy-ion detection

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Introduction

Detection, identification and measurement of energy of ionizing radiations are the three important aspects in the research on Nuclear Science and Technology. This task has been fulfilled over the years by using a variety of nuclear detectors. Silicon surface barrier detectors (both E-type and ΔE-type) fall in the category of solid state detectors and offer superior energy resolution. This is due to reduced statistical limit on energy resolution as a result of generation of more number of electron-hole pair per impinging charged particle. Silicon ΔE-detectors are very much useful for heavy-ion/fission spectroscopy and particle identification measurements. The field of particle identification is an extensive subject by itself and is discussed in a number of review articles [1, 2, and 3].

Now-a-days, there is a strong demand from detector users for Silicon based delta E detectors with larger active area (i.e. active area diameters of 10 – 14 mm). Highly fragile nature of thin silicon (20–30 μm) samples, poses a real challenge in preparing larger diameter samples maintaining its thickness uniformity. Preparation of these samples involves multiple etching of each sample. In this article preparation of samples, fabrication of detectors and their characterization is discussed.

Fabrication Process

N-type silicon (mechanically polished) wafers of 16 mm diameter, 60 μm thickness, 1 kΩ-cm resistivity and <111> orientation were taken as starting material. Their thicknesses were reduced to 25-26 μm by doing chemical etching of the wafer. Subsequently, the wafers were fixed on a ceramic mount. A thin layer of gold of 200 ˚A thickness was deposited on the radiation-entry sides of the wafers. On the backside an ohmic contact was prepared by depositing aluminium layer of 2000 ˚A thickness. Both gold and aluminium layers were deposited using vacuum thermal evaporation at 10^{-6} Torr. Subsequently, the ceramic mounts were held in SS transmission assembly having the microdot connector.

About Figures

Fig. 1(a) shows the samples after completion of etching and followed by fixing them in mounts. Fig. 1(b) shows samples after carrying out metallization and Fig. 1(c) shows detectors after carrying out encapsulation.

(a) **(b)**

(c)

Fig.1: (a) After preparing and mounting samples
(b) Samples after metallization
(c) Detectors after encapsulation

Results and Discussions

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The fabricated detectors were having active areas of diameters ~ 13 mm and 13.5 mm respectively. They were tested for I-V characteristics measurement and representative forward bias current-voltage characteristic is shown in Fig.2. The representative reverse bias current-voltage characteristic is shown in Fig. 3. It is evident from the forward and reverse *I-V* characteristics that the detectors exhibit diode behaviour. The detectors were also tested for their alpha particle response. ^{241}Am – ^{239}Pu dual alpha particle source was utilized to carry out this measurement. Representative alpha particle spectrum is shown in Fig. 4. The spectrum shows that two different alpha energies pertaining to ^{241}Am and ^{239}Pu are clearly resolved. Typical value of energy resolution obtained was 110 keV for an applied reverse bias voltage of 4.3 V across the detector and the corresponding leakage current was 0.37 µA.

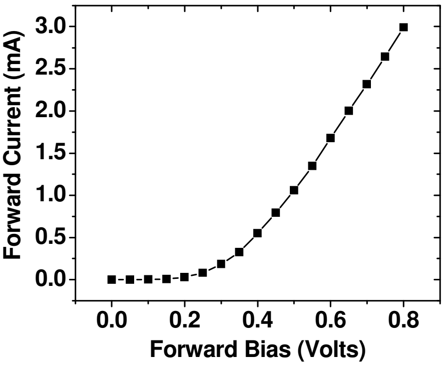

Fig.2. Forward characteristics

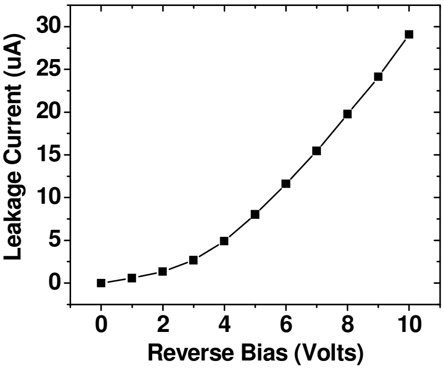

Fig. 3. Reverse characteristics

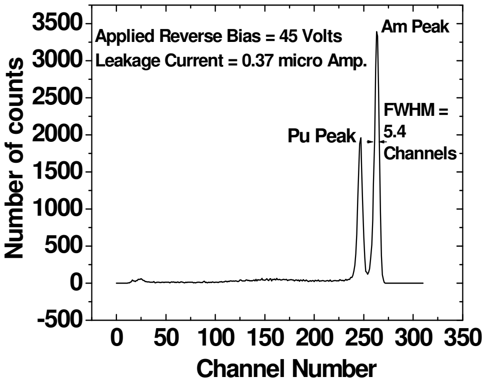

Fig. 4. Representative alpha spectrum

Conclusion

We have received improved performance of our fabricated large area delta E detectors as compared to our previously developed prototype one with regard to their alpha spectra. The present detectors are of lower thicknesses, of larger active area and showed better alpha response with two well separated Am and Pu alpha peaks. However, the leakage behaviour of the device needs to be improved further. Our effort is on to address the issue.

References

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