2011년도 추계학술발표회 논문요약집
대한방사선방어학회

Radiation Damage Effect on Si and SiC Detectors

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중심어 : Neutron, Gamma-ray, Si, SiC

Introduction

Silicon is an extraordinary semiconductor suited for the fabrication of radiation detector. Charge carrier lifetime and mobility are high, which is very important to make the radiation detector with low noise and good time behavior. Since the fabrication technology of the silicon was mature, one could easily make a radiation detector with a sophisticated structure. Therefore, silicon detector could be the best choice for the various application areas. The depletion layers of the reverse bias rectifying barriers are used to make the silicon radiation detector with low noise. The depletion layer could be made by a silicon surface barrier (SSB) structure or a PIN junction structure. SSB detector was made by depositing the metal electrode on the n or p type silicon wafer. The p-n junction could be made with the semiconductor fabrication process, and the X-ray or α particles could be measured with the detector.

The radiation tolerance of the radiation detector is also very important for the application of the detector to the harsh environment. A study on the effect of the structure of the depletion layer on the radiation tolerance was rare in most of the previous works In the present work, the silicon detectors with two types were fabricated, and their operation characteristics are compared. The dependency of the radiation damage on the detector type was studied. We also fabricated SiC detector and the neutron and gamma irradiation effect on the detector was studied.

Experiment and Results

After neutrons or gamma-rays was irradiated on the detectors, the operating properties of the detectors (leakage current and energy resolution) were re-measured to study the radiation damage effect.

Gamma-rays from ^{60}Cosource were irradiated on the detector at high dose gamma-ray irradiation facility of Korea Atomic Energy Research Institute(KAERI).The total radiation doses on the detector were 300 and 1kGy. The thermal neutron was irradiated on the detector at Ex-core Neutron irradiation Facility(ENF) facility at KAERI. The neutron beam flux was 10^9n/cm^2/s, and the irradiation time was 10h, 10h and 48h. The sequence of the radiation irradiation in this work was as follows. At first, the gamma-rays were irradiated on the detectors with gamma-ray dose of 300Gy, and the gamma rays were irradiated with gamma-ray dose of 700Gy. After the gamma-ray irradiation, neutron was irradiated on the same detectors. The total neutron irradiation time was10, 20, and 68h.

The leakage current and the energy resolution of each detector were measured after the irradiation, and they were compared to the leakage current and the energy resolution measured before the irradiation.

The leakage current of the SSB detector was obtained at 60V, and the leakage current of the PIN diode detector was determined at 40 V.

The leakage current of the PIN diode detector was not changed after the irradiation. The leakage current of the SSB detector was changed after the irradiation. One could also see that the energy resolution of the SSB detector became worse after the neutron irradiation (10^9n/cm^2/s for 68h.).

The SiC detectors with various electrodes were fabricated, and the nuetron and gamma radiation effects were studied with neutron radiation of 7.2 X 10^{14} n/cm^2, and 5.4 X 10 17 n/cm^2, and gamma radiation of 300, 1000 Gy.

Conclusion

The radiation tolerance of the detector was studied. One could see the change of the leakage current and the energy resolution in SSB detector, and the operating performance of the Si PIN detector was more stable than Si Schottky detector.

Acknowledgements

It is also supported by nuclear R&D program of the Ministry of Education, Science and Technology (MEST) of Korea.

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