Development of SiC Neutron Detector Assembly to Measure the Neutron Flux of the Reactor Core

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1. Introduction

At present, the conventional detector to measure the neutron at harsh environment is a Self Powered Neutron Detector (SPND). Rhodium(Rh)-103 is in the SPND. When neutron is incident on the Rhodium, the neutron capture reaction occurs, and the Rh-103 is converted to Rh-104. The Rh-104 is decayed to Pd-104 by β-decay, and electrons are generated as the decay products. Because of the half life of Rh-104, approximately 5 minutes are required for the SPND output to reach the equilibrium condition. Therefore the on-line monitoring of the nuclear reactor state is limited if the neutron flux in the reactor core is monitored with the SPND.

Silicon carbide (SiC) has the possibility to be developed as neutron detector at harsh environment, because the SiC can be operative at high temperature and high neutron flux conditions. Previously, the basic operation properties of the SiC detector were studied. Also, the radiation response of the SiC detector was studied at high neutron and gamma dose rate. The measurement results for an ex-core neutron flux monitor or a neutron flux monitor of the spent fuel were published. The SiC detector was also developed as neutron detector to measure the fissile material with active interrogation method. However, the studies about the development of SiC detector are still limited.

In the present work, the radiation damage effect of the SiC detector was studied. The detector structure was determined based on the study, and a neutron detector assembly was made with the SiC detectors. The neutron and gamma-ray response of the detector assembly is presented in this paper. The detector assembly was positioned in the HANARO research reactor core, the performance test was done. The preliminary results are also included in this paper.

2. Methods and Results

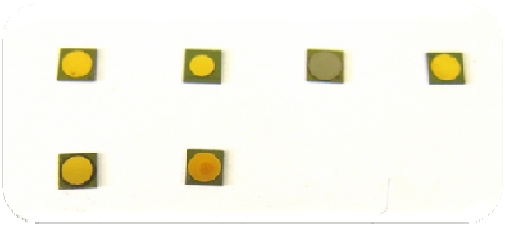

Fig. 1. SiC detectors fabricated in the present work

Effect of metal electrode on the radiation tolerance of the SiC detector was studied. SiC detectors with four different electrodes were fabricated. The detectors were made with 4H SiC crystals, and the detectors had PIN diode structure. The thickness of the crystal was 200 μm. The crystal was cut into square shape with size of 5×5 mm^2. The electrode structures were Cr/Au, Ni/Au, Ti/Cr and Ti/Au, and metal electrode was deposited with sputtering and thermal evaporation method.

The leakage current of each detector was measured with an electrometer (Keithley 4200). The leakage current is less than 25 nA. Energy spectrum of αs were measured with the SiC detector in air conditions.

SiC detectors with four different types were inserted into HANARO reactor core, and the neutron flux was irradiated on the detectors two times. The total neutron irradiation on the detectors were 2.2×10^{15} n/cm^2, and 5.4×10^{17} n/cm^2.

Figure 2 shows the α counts of the spectrum at various bias voltages. One could see that SiC detector with Ti/Au electrode shows the most radiation resistant characteristics.

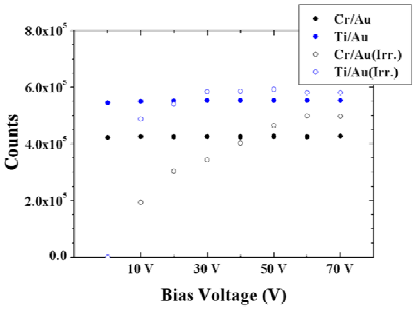

Fig. 2. αcounts at various bias voltages

An SiC detector assembly was made. Two SiC detectors were inserted in the cylindrical tube, and aluminum oxide was filled in the tube. Mylar cables were used to obtain the current from the detectors. The cable length was 13 m. The detector response was measured at ENF of HANARO reactor, and the detector shows linear response to neutron flux up to 10^9 n/cm^2/s.

The detector assembly was positioned in the HANARO reactor core, and the detector signal was measured as the reactor power was increased.

Fig. 2. SiC Detector Assembly

Fig. 1. Decay chain of Ra-226

3. Conclusions

SiC neutron detector has possibility to be developed as in-core or ex-core neutron monitor. The radiation damage effect on the SiC detector was studied. The detector assembly was made, the signal could be measured as the detector assembly was placed in the reactor core. The following experiment is planned to measure the neutron flux in the reactor core.

Acknowledgements

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