

# Analysis of Neutron Responses with a Thin-film Coated Semiconductor Radiation Detector

Han Soo KIM<sup>1)\*</sup>, Jang Ho HA<sup>1)</sup>, Se-Hwan PARK<sup>1)</sup>, Kyu Hong LEE<sup>1)</sup>, Cheol Ho LEE<sup>2)</sup>

<sup>1)</sup> Korea Atomic Energy Research Institute

<sup>2)</sup> Department of Nuclear Engineering, Hanyang University

E-mail: khsoo@kaeri.re.kr

Key words :  $^6\text{LiF}$ , Neutron, semiconductor, Detector, Linearity

## Introduction

McGregor et al. showed thermal neutron detection efficiency with respect to the thickness of neutron converter films. And for thermal neutron flux measurements, a thin film of  $^6\text{LiF}$  was used up to 25  $\mu\text{m}$  thickness<sup>1)</sup>.

In this study, two PIN-type SiC semiconductor neutron detectors, which are for thermal neutron detection by charged particle emissions of  $^6\text{LiF}$  reaction and for fast neutron detection by elastic and inelastic scattering SiC atoms, were designed and fabricated for comparison of two neutron detector's responses. Neutron responses were measured at ENF (Ex-core Neutron irradiation facility) in HANARO research reactor.

## Materials and Methods

The neutron probability for thermal neutron reaction is  $^6\text{Li}(n, \alpha)\text{T}$  neutron absorption and  $^{28}\text{Si}(n, n')^{28}\text{Si}$  elastic scattering for fast neutron reaction. By using MCMPx code, thermal neutrons reacted with a SiC and  $^6\text{LiF}$  thin film from  $10^{-2} \sim 1$  eV range. Above 1 eV neutron energies, two neutron detectors showed the same reaction probabilities.

Two PIN-type SiC neutron detectors were designed for thermal and fast neutron detection. Figure 1 and 2 show the design schematic of two SiC neutron detectors. For a thermal neutron detector, 9  $\mu\text{m}$ -thick  $^6\text{LiF}$  was designed. Depletion depth of the designed SiC was 29.7  $\mu\text{m}$  with no biasing. Thickness and doping profiles can be found in figure 1.

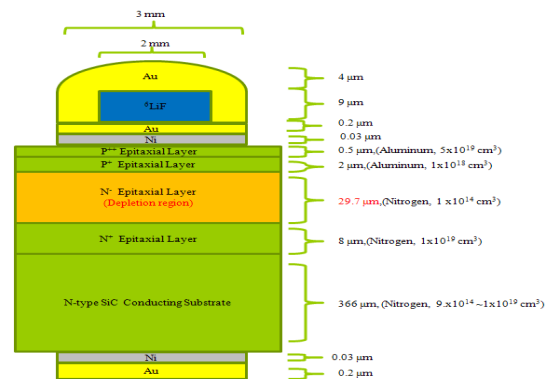


Fig. 1. A schematic of a thermal neutron detector.

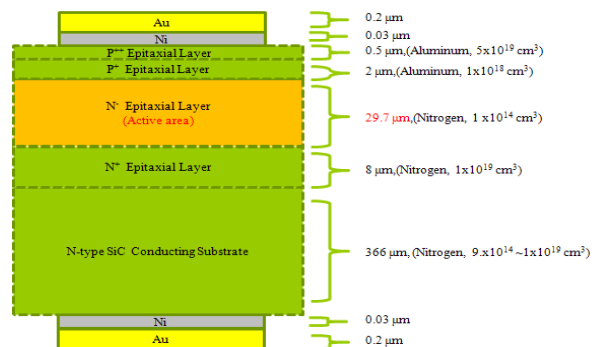


Fig. 2. A schematic of a fast neutron detector.

## Results and Discussion

Figure 3 and 4 show experimentally observed energy spectra, which were detected by a fast and thermal neutron detectors, respectively. SP technology® SP-100 charge sensitive preamplifier, SP-200 shaping amplifier, and ORTEC® 919 MCA were used in measurements.

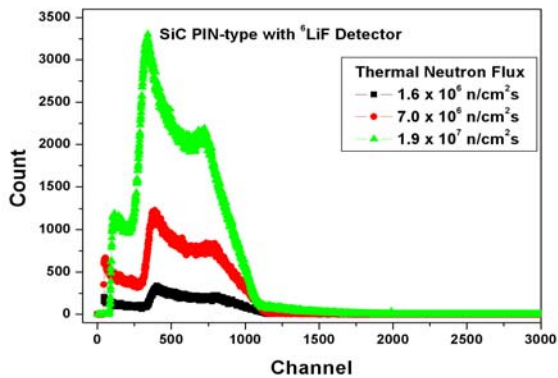


Fig. 3. Experimentally observed energy spectrum by using a thermal neutron detector. The measuring time was 5 min.

The observed total counts at each neutron flux were calculated by the peaks of tritium with Gaussian function because tritium and alpha are oppositely directed. When the neutron flux was  $1.9 \times 10^7$  n/cm<sup>2</sup>·s, the detected neutron count was approximately 600,000. The neutron detection was about 3.3 % using the measuring time and active area of the detector.

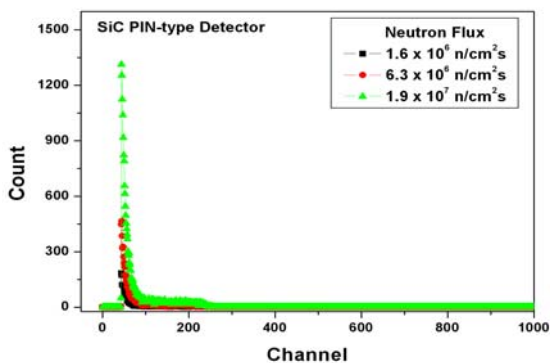


Fig. 4. Experimentally observed energy spectrum by using a fast neutron detector. The measuring time was 5 min.

In fast neutron detection, continuum energies from the elastic and inelastic scattering of SiC atom were observed. The linear response for fast neutron was also obtained (99%) by using the neutron flux and their observed counts. Fig. 6 shows a linear response of thermal neutron detectors.

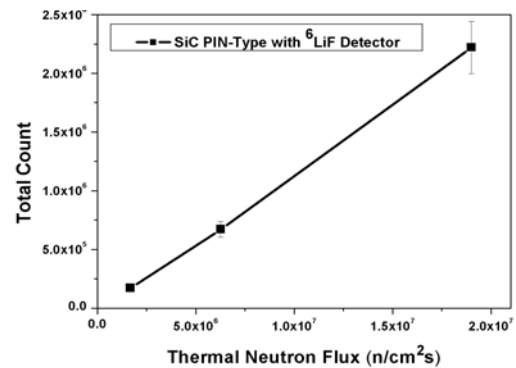


Fig. 6. A linear response is observed with a thermal neutron detector..

## Conclusion

For thermal neutron detection, a PIN-type SiC semiconductor was fabricated with <sup>6</sup>LiF neutron converter and the responses are compared with a SiC fast neutron detector. We can successfully observed thermal neutron detection with a thin-film coated semiconductor detector and obtained a linear response for varied neutron fluxes.

## \* ACKNOWLEDGMENTS

This work has been carried out under the nuclear R&D program of Ministry of Education, Science, and Technology (MEST).

## Reference

1. D. S. McGregor et. al, Designs for Thin-film-coated Semiconductor Thermal Neutron Detectors, IEEE Trans. Nucl. Sci, 2454, (2000)