Response of Neutron Detector Using ^{6}Li and ^{10}B Converters

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1. Introduction

Thermal neutrons can be detected with a ^{3}He gas tube. The semiconductors coated with neutron converter films, such as ^{6}Li and ^{10}B, were also studied as a neutron detector [1]. The nuclear interactions of ^{6}Li and ^{10}B for the thermal neutron detection are

$$n + {}^{6}Li \rightarrow {}^{4}He + {}^{3}H + 4.79\ MeV,$$
$$n + {}^{10}B \rightarrow {}^{7}Li + \alpha + 0.48MeV\ \gamma + 2.3MeV\ (93\%)$$
$$\rightarrow {}^{7}Li + \alpha + 2.8\ MeV\ (7\%).$$

Recently the Gas Electron Multiplier (GEM) is being studied in various application fields [2]. We have developed a GEM for thermal neutron detector. Since a GEM coated with neutron converter can be designed with multi-layer structure, the neutron efficiency of the GEM-based detector can be increased significantly [3].

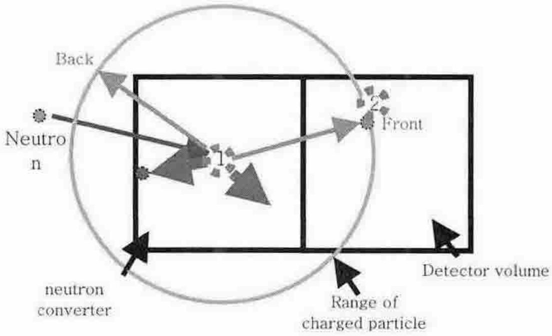

Figure 1. The cross sectional view of a typical neutron detector. 'Front' means the same direction to the incident neutron, 'Back' means the opposite direction. Neutron conversion occurs at the point 1 and the produced charged particle stops at the point 2.

2. Methods and Results

2.1 Optimized Thickness of the Thin Film

The optimized thickness of the thin film for neutron detection was calculated using the MCNP and SRIM codes. Thermal neutrons assumed to incident on the thin film, and the probability of the neutron conversion into the charged particle inside the film was calculated with MCNP (Fig. 1). The escape probability of the generated charged particle from the thin film was calculated with SRIM. The neutron efficiency was calculated changing the chemical components of the thin film, and the thickness of the thin film. The optimum thickness of the thin film for each chemical compound was obtained from the calculation. The neutron efficiency of GEM's coated with the solid converter was also calculated with changing the number of GEM foils. Fig. 2 shows the result of the calculation. Also the effect of the threshold of the charged particle on the neutron efficiency was calculated. The neutron efficiency of the detector for high energy neutron was also calculated.

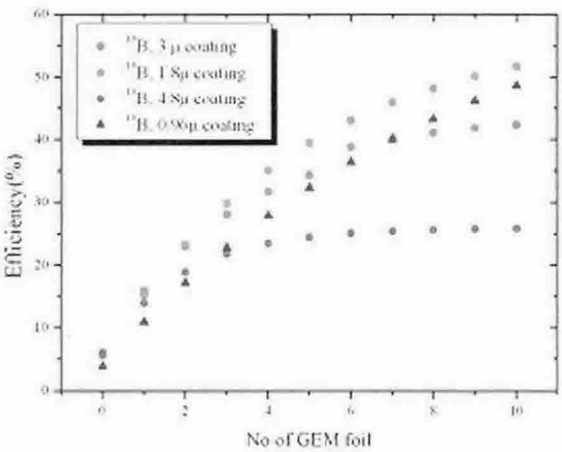

Figure 2. Result of the efficiency calculation of multi GEM neutron detectors. A high efficiency of more than 50% can be attained at the 1.8μ ^{10}B thin films coated on the each side of the ten GEM foils.

2.2 Deposition of the Thin Film Neutron Converter

Thin films such as ^{6}LiF, ^{10}B, and $^{10}B_2O_3$ were deposited with high vacuum evaporator. ^{6}LiF and $^{10}B_2O_3$ films were suitable to use the thermal evaporation method. But an e-beam evaporator was used to deposit ^{10}B thin converter.

The response of the thin film to the neutron was measured using the ionization chamber. We designed and fabricated the ionization chamber for neutron detection. The collecting volume of the chamber is 1500 cc, and the thin film can be placed inside the chamber. Neutrons from ^{252}Cf were measured with the ionization chamber, and the 1-cm thick neutron moderators were placed between the neutron source and the ionization chamber to thermalize the neutrons. The neutron efficiency was increased as the number of neutron moderator was increased.

2.3 Neutron Spectrum Measurement

The thermalized neutron was measured with a drift plate coated with a neutron converter thin film, and the neutron efficiency was estimated. We used a double GEM [4, 5] and the neutron converter was coated only on the drift plate. A ^{252}Cf neutron source was used and the neutron moderator was placed between the source and the detector. The measured spectrum is shown in Fig. 3.

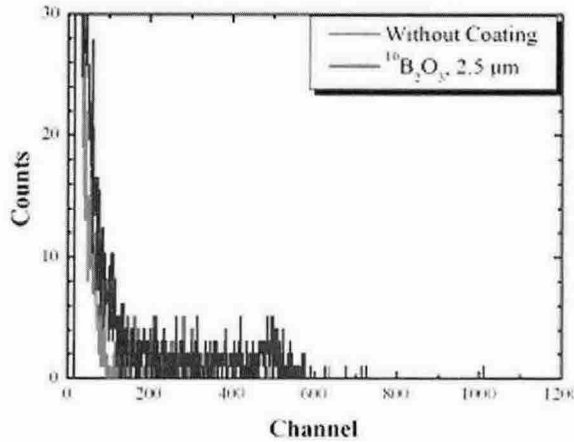

Figure 3. The measured neutron spectrum using GEM.

3. Conclusion

We have designed a high efficiency neutron detector using a multi GEM detector. The optimized thickness of the converter was obtained from the MCNP and TRIM calculation. A thin film such as ^{6}Li and ^{10}B compounds was deposited by a high vacuum evaporator. The efficiency of the converter was measured by placing the thin film inside the ionization chamber. Thin film neutron converter techniques are essential tools for fabricating neutron detectors. The high efficiency position sensitive neutron detector is useful for the neutron radiography.

Acknowledgement

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