THGEM for Multi-Proposal 2-D Image Detection

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1. Introduction

A GEM (Gas Electron Multiplier) based detector, which consists of the drift area, the electron multiplication area, and the induction area, was proposed by Fabio Sauli in 1977 [1]. A GEM is made of a thin polymer film that is perforated with a periodic array and is coated with a thin metallic film on both sides [2]. Electron multiplication in a GEM based detector is performed by the electron avalanche inside the holes of a GEM [2]. However, the standard GEM has problems of low electron multiplication and a high fabrication cost. The thick GEM-like (THGEM) was developed to compensate for such problem. When compared with a standard GEM, the electron gain is higher and the manufacturing cost is lower due to using a general purpose PCB (printed circuit board) [3,4]. In this study, we describe the signal response of the THGEM based detector that has THGEMs with holes of various sizes.

2. Methods and Results

In this study, we developed a 2-dimensional THGEM based detector consisting of a metallic plate for drift voltage generation, a THGEM, and a signal output circuit under the induction area, as shown in Fig. 1. In addition, a detector chamber was made using aluminum material. The radiation incident window, which is attached to the front side of the detector, was made using a carbon plate of 400 μm thickness because the window must have a low x-ray cross-section [Fig. 2 (a)]. To generate the drift voltage, the thin conductive foil of 40 μm thickness that was coated on the opposite wall of the window was used. Here, one side of the foil was coated with a thin Mylar film for electrical insulation, as shown in Fig. 2 (b). In addition, a THGEM was fabricated by gold plated PCB of 400 μm thickness as shown in Fig. 2 (c). The signal output circuit with a delay line was a fabricated strip type.

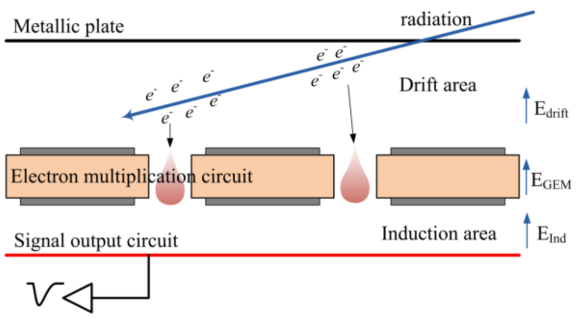

Fig. 1. The progress of radiation signal transmission in the GEM detector; generated electron by reaction between the incident radiation and the inner gas is amplified in the THGEM, and amplified electrons are outputted to outside by signal output circuit.

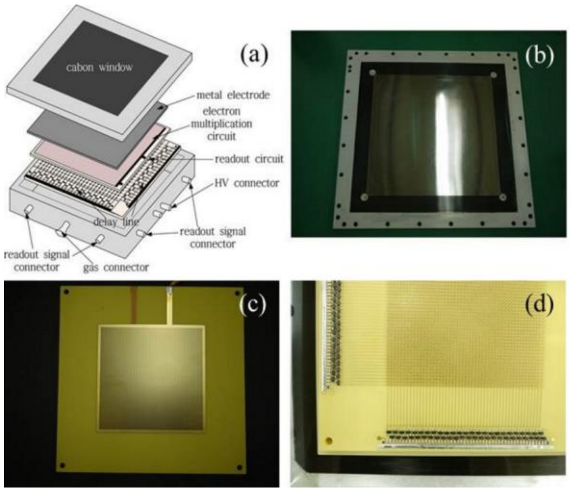

Fig. 2. 2-dimensional THGEM; (1) schematic of THGEM based detector, (b) radiation window with metallic plate, (c) THGEM, (d) signal output circuit with delay line

2.1 Fabrication of THGEM

In a THGEM based detector, a THGEM for electron multiplication is the major component. The hole size of a THGEM and state of the circumferential RIM surrounding a hole affect the electric field related with the electron amplification rate. Therefore, they affect the image quality. Figs. 3 (a) and (b) show the original image and an enlarged image of a THGEM. The hole size of a THGEM is 0.3, 0.4, 0.5 mm as shown in Fig. 3 (c), (d), and (e). The width of a RIM surrounding a hole is about 50 μm.

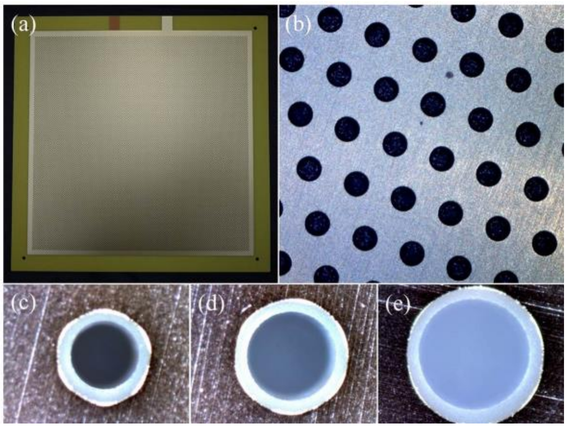

Fig. 3. Fabricated the THGEM: (1) original image, (b) ×100 enlarged image, various holes size (c) 0.3 mm, (d) 0.4 mm, and (e) 0.5 mm

2.2 Signal Output Circuit

A circuit for a signal output has the function of transferring the generated charges to an electric device for the signal conversion and amplification. As shown in Fig. 2 (d), the line strip-shaped circuit is orthogonally connected to the delay line, which consists of 95nH inductors and 39pF capacitors.

2.3 Signal response

The input voltage of a THGEM is divided with the drift voltage and the induction voltage. In this study, we measured the change in signal gain according to the voltage difference between electrodes. Fig. 4 presents the changing curve of a signal gain according to the change of the voltage between each side of the THGEM. As shown in figure, the change ratio of the signal gain according to an increase in the THGEM input voltage has almost a linear relation. And the signal gain per kV of the drift voltage is 1.5-times as shown in figure 5. The relationship between the size of a hole and the signal gain is an inverse proportion. In the case of 0.4 and 0.5 mm hole sizes, the difference in signal gain is 2.2 times as shown in Fig. 6.

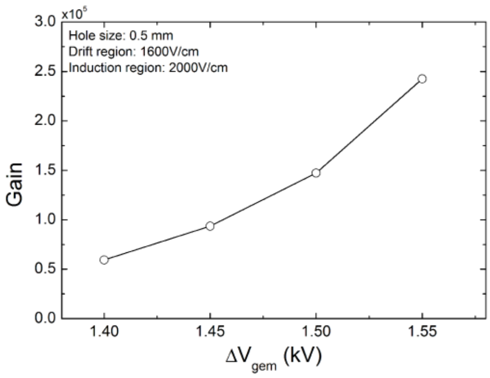

Fig. 4. Changing curve of signal gain according to input voltage in electron multiplication circuit.

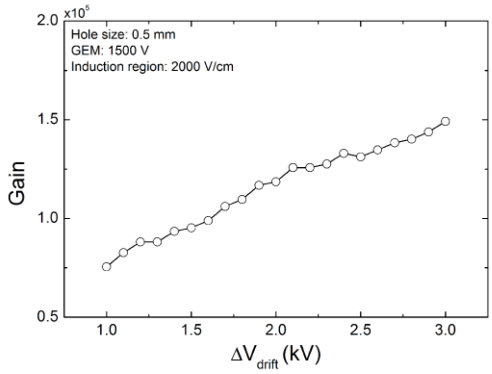

Fig. 5. Changing curve of signal gain according to change drift voltage.

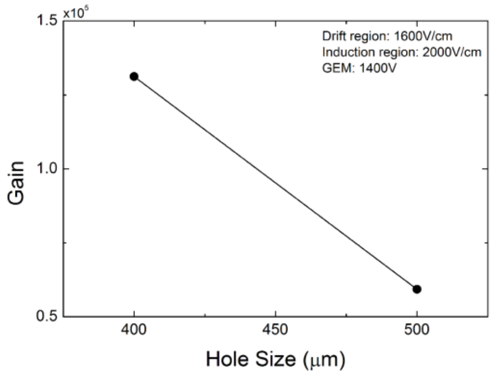

Fig. 6. Changing curve of signal gain according to change hole size.

2.4 2-Dimensional Imaging

To acquire a 2-dimensional transmission image, we used the double layer THGEM with 0.5 mm holes. In addition, ^{241}Am (99 μCi), which generates a 59 keV γ-ray, is used to acquire an image. To measure the performance of a 2-dimensional radiation image, the source of the point beam type was used. The measured image using a point beam can use the calculation of the image resolution. To generate the point beam source, a tungsten plate of 1mm thickness with a 3 mm diameter hole was used. Fig. 7 shows the measured signals from 4 channels at both ends of a low and column delay line. As a result, the acquisition of the image using the developed THGEM was successful, as shown in Fig. 8.

Fig. 7. Output signals from preamplifiers; the signal position is calculated using four signals.

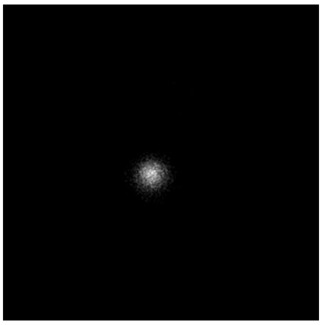

Fig. 8. 2-D point response image

3. Conclusions

In this study, we developed a THGEM based study of another research group. Although this was not the first time the THGEM has been developed, this is the first implementation in Korea. Through the THGEM development process, we tested the properties of a THGEM and measured a 2-dimensional image. Further, we will evaluate the performance based on the image resolution, uniformity, etc. Additionally, we will try to apply a THGEM based detector on various application fields.

ACKNOWLEDGEMENTS

This work was supported by Nuclear Research and Development Program (2012M2A2A6004262) of the National Research Foundation of Korea (NRF) grant funded by the Korean Ministry of Science, ICT and Future Planning (MSIP) and the Research Project “Research on Fundamental Core Technology for Ubiquitous Shipping and Logistics (No. 1615005657)” through the Ministry of Oceans and Fisheries (MOF) of Korea.

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