Observations on the Electron Multiplication Using of Thick GEM

Kwon-Pyo Hong [a*], Sang-Bok Ahn [a], Woo-Seog Ryu [a], J. Li [b], A. White [b], J. Yu [b]
[a]*Korea Atomic Energy Research Institute, 150 Deogjin-dong, Yuseong-gu, Daejeon 305-353*
[b]*Dept. of Physics, University of Texas at Arlington, Arlington, TX 76019*
[*]*kphong@kaeri.re.kr*

1. Introduction

Electrons under the high electric field (~ 5 kV/mm) are rapidly accelerated and ionize circumstance gas molecules, so that electron avalanche could be took place by chain interactions [1]. Gas Electron Multiplier (GEM) which was invented at CERN in 1997 has many high electric field holes enabling electron multiplication. Meanwhile, Thick GEM was introduced a few years ago [2], which was derived from standard GEM. Thick GEM plate is made with usual printed circuit board (PCB) while standard GEM is made with thin Kapton plate, and the thickness of Thick GEM plate has the order of sub-millimeters. It has been attracted as a radiation detector especially in the field of high energy physics because it is simple, robust and convenient to handle [3-4].

We made a few Thick GEM chambers and observed the electron multiplication with radiation sources and some proper circuits.

2. Methods and Results

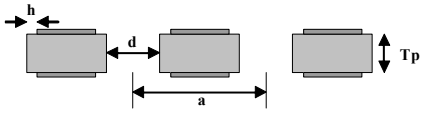
2.1 Thick GEM plates

Thick GEM plates are made of sub-millimeter thickness PCB plates and covered with copper layers on both sides. It also has many small holes where the electron multiplication arises. We have inspected all Thick GEM plates of Univ. of Texas at Arlington (UTA) and finally two Thick GEM plates, T1 and T2 are selected as GEM candidates.

The dimensions of T1 and T2 are listed on Table 1.

Table 1. Dimensions of Thick GEM, T1 and T2 in mm.

	a	d	H	Tp	Tc	Tt
T1	0.9	0.4	0.1	0.43	0.03	0.49
T2	1.0	0.3	0.1	0.40	0.01	0.42



Where, a : Pitch between the holes
d : Diameter of the hole
h : Naked distance from hole rim
Tp : Thickness of plastic part of PCB
Tc : Each thickness of top/bottom copper layers
Tt : Total thickness of Thick GEM plate

Because the voltage difference between top and bottom copper layers is about 2,000 V, spark is apt to arise through the holes. So, the holes of Thick GEM plates should be clean and dry to prevent spark. Ultrasonic cleaner and hot plate were used to clean and to remove humidity of T1 and T2 as shown in Fig. 1.

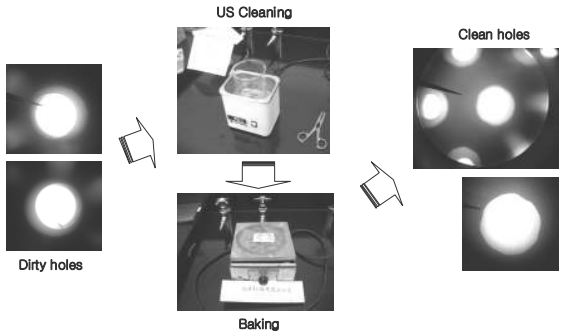


Fig. 1. Cleaning and dehumidification process

2.2 Chamber Design and Manufacturing

Design concept of Thick GEM chamber is as Fig. 2. Thick GEM is located between cathode plate and pad, and these are fixed with long plastic bolts. The spaces between each plate are adjustable. High voltage divider supplies voltages of -3,000 V, -2,500 V, -500V, 0 on cathode, top and bottom of Thick GEM plate, and pad, or same ratios.

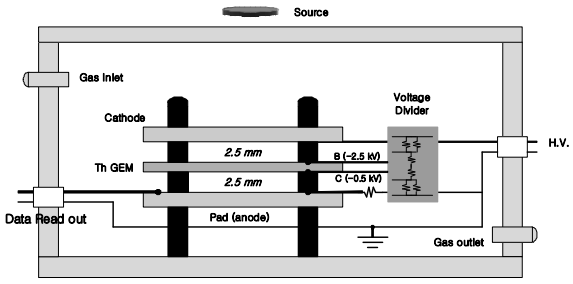


Fig. 2. Chamber design

Collected signals (i.e. electron multiplication signals) through the data read out line are amplified by a charge amplifier and then can be shown on oscilloscope screen.

Several types of Chambers are actually designed more and constructed as shown on Fig. 3. The sizes of chambers are around 10 ~ 20 cm in length or diameter.

Each chamber have tested its air tightness and electrical stability. As a result, chamber (d) is superior in such as H.V. stability, noise reduction and convenience of repetition of experiment.

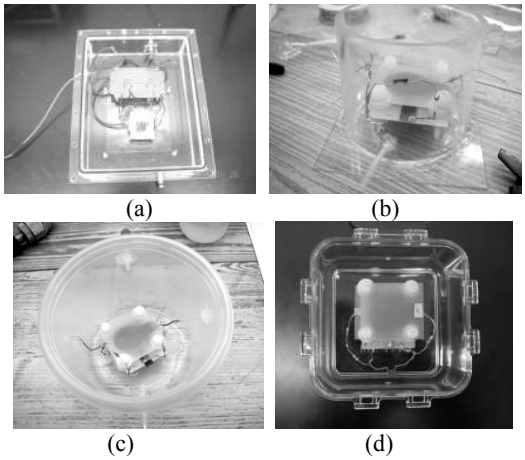


Fig. 3. Several types of chambers manufactured at UTA.

2.3 Multiplication Test of Thick GEM Plate

About 7 μCi of Cs-137 source is located just on the cathode plate of Thick GEM unit to maximize the radiation intensity when multiplication test is executed. The chamber is also filled with Ar(80%)-CO2 mixed gas. Applied voltage on both sides of Thick GEM plate is 1,800 V, which makes therefore 4,500 V/mm of electric field in this case. That was the maximum voltage to be loaded with stable condition. The distance between Thick GEM plate and pad is about 5 mm, which will affect the peak rising time. Multiplication signals collected on the pad are sent to pre-amplifier (charge amplifier). The amplifier whose gain is about 40, was provided by Fermi National Accelerator Laboratory (FNAL). In Fig. 4, the systematic arrangement of equipments is briefly shown.

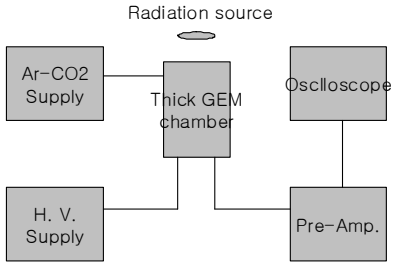
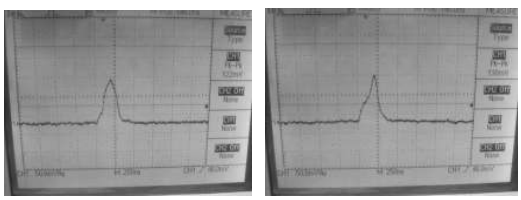


Fig. 4. Arrangement of equipment for multiplication test

Fig. 5. shows some multiplication signals obtained during the test. FWHM of each peak is about 200 ns and amplified amplitude of peaks are around 70 ~ 150 mV. The peak counting rate is 12 times/min.



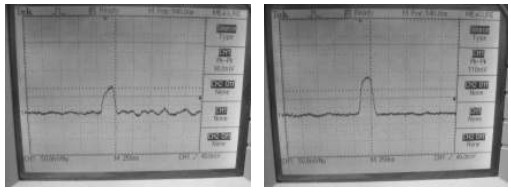


Fig. 5. Some electron multiplication evidences observed at UTA lab.

3. Conclusions

Several types of Thick GEM chambers were made and tested. Electron multiplication events were observed with manufactured chamber using of Thick GEM of UTA. The possibility of application of Thick GEM chamber as a radiation detector was confirmed.

REFERENCES

[1] R. Bouclier et. Al., The Gas Electron Multiplier (GEM), Nuclear Science, Vol. 44, Part 1, p.646, 1997.
[2] R. Chechik, A. Breskin, C, Shalem, D. Mormann, Thick GEM-like hole multipliers : Properties and possible applications, Nucl. Instr. And Meth., A535, p. 303, 2004.
[3] C. Shalem, R. Chechik, A. Breskin, K. Michaeli, Advances in Thick GEM-like gaseous electron multipliers, Nucl. Instrum. Meth. A558, p.475, 2006.
[4] R. Chechik et. al., Thick GEM-like Detectors and Their Possible Applications, SNIC Symposium (Staford, California), 0025, 2006