Development Position-Sensitive Gaseous Radiation Detector Based on Glass Gas Electron Multiplier

*Moh Hamdan[1], Yuki Mitsuya[1], Kenji Shimazoe[1], Hiroyuki Takahashi[1]
[1]Department of Nuclear Engineering and Management, School of Engineering,
The University of Tokyo

Abstract

In many cases, Gas Electron Multipliers (GEMs)-based gas detectors are widely utilized for imaging purposes. In this work, an imaging detector is developed by integrating a Glass Gas Electron Multiplier (G-GEM) detector with a charge division readout system based on dynamic Time Over Threshold (dToT). Characterization results and imaging demonstrations using X-ray and Beta rays show that the detector is promising for application in radiation imaging systems.

Keywords: Glass Gas Electron Multiplier, Charge Division Readout, Dynamic Time Over Threshold

1. Introduction

Micro Pattern Gas Detectors (MPGDs)-based detectors that utilize Gas Electron Multipliers (GEMs) are widely utilized to obtain a large sensitive area. The implementation of individual readout has been widely applied as a readout anode. However, the complexity, power consumption, and construction cost will increase especially in the accompanying readout electronics for large are applications. In this work, the Photosensitive Etchable Glass (PEG3 or PEG3C) Glass Gas Electron Multiplier (G-GEM) was chosen in consideration of its capability to be developed as a large-area detector. In addition, the high gain without a cascade system provides its own advantages. Charge division readout utilizing 2D continuous resistive films was implemented mainly due to their simplicity for large sensitive areas in the future while maintaining their spatial resolution performance. The linearity of dynamic Time Over Threshold (dToT) is a special consideration to accurately resolve the interaction position in the implementation of the charge division scheme [1]. First, the gain and energy resolution of the detector will be characterized followed by a demonstration of imaging with X-ray and Beta ray. The test results show the promising potential of the detector as an imaging system.

2. Materials and Methods

The PEG3C GEM substrate has sensitive areas of 100 100 mm^2. The thickness, hole size, and hole pitch are 680 µm, 170 µm, and 280 µm respectively. The G-GEM was placed inside the chamber between the aluminized Kapton cathode and readout anode with gaps of 5 mm and 3 mm, respectively. The chamber window was made of Kapton foil. GEM was supplied with Ar/CH_4 (90/10) or Ar/CF_4 (90/10) gas in gas flow mode with a flow rate of 20 mL/min and a pressure of 0.1 MPa. The GEM is read by a 2D continue resistive film with a charge division scheme readout board connected to a charge-sensitive preamplifier, shaping amplifier, dynamic time over the threshold, and DAQ system for each output channel as shown in Fig. 1(a). The coincidence time window of 20 µs was scanned to optimally retrieve real events and separate false events that generally originate from discharge phenomena in G-GEM holes. The effective gain characteristics and radiation distribution of the collimated beta ray from the ^{90}Sr radiation source in the center of the window were evaluated as the preliminary result.

3. Results and Discussions

The first result was the effective gain of the G-GEM as a function of the voltage difference of the G-GEM electrodes (ΔVG-GEM) which is shown in Fig. 1(b). The effective gain reached a value of up to 1.7×10^4 before a severe spark. This value is much higher than the gain of the standard GEM and comparable to its triple cascade. The second result was the radiation distribution of the beta ray from the ^{90}Sr radiation source using a 3.5 mm Cu collimator that shows an almost centered circular distribution of radiation as shown in Fig. 1(c). However, the spreading of smaller events appears with a much lower count. This is due to the wide energy distribution of ^{90}Sr from low energy to its maximum value at around 2.2 MeV.

(a) (b) (c)

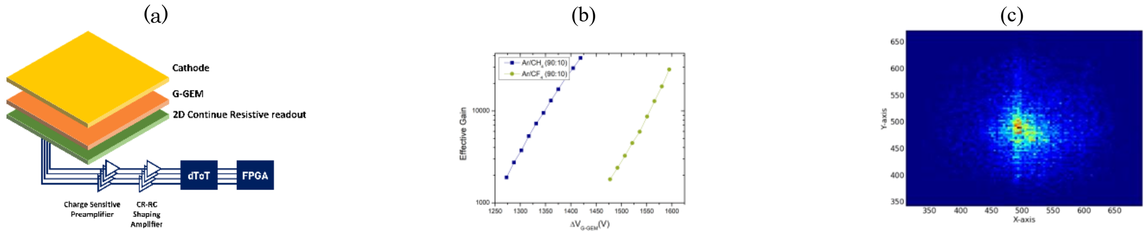

Fig. 1. (a) Imaging detector using PEG3C G-GEM; (b) Gain calibration using 5.9 keV of ^{55}Fe source; and (c) Beta ray distribution from collimated ^{90}Sr.

4. Conclusion

G-GEM-based imaging detector has been successfully developed by utilizing charge division readout and dToT-based signal processing. The gain characteristics of order 10^4 without cascade with 23% of energy resolution are very promising to be utilized for low-energy nuclear radiation imaging systems. The imaging demonstration using a beta ray from a ^{90}Sr radiation source also shows a reasonable result.

References:

[1] K. Shimazoe et al., *"Dynamic Time Over Threshold Method"*, IEEE trans. On Nuc. Sci, Vol59. No.6. pp3213-3217, 2012.