Investigation of the gain with a RETHGEM Detector

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Introduction

The hole-type micro pattern gaseous detector is Gas Electron Multiplier (GEM) developed at CERN by Fabio Sauli. In spite of a great progress in the development and optimization of the GEM it is still a rather fragile detector, for example it requires very clean and dust free conditions during its manufacturing and assembling process and could be easily damaged by sparks which are almost unavoidable at high voltage operations to obtain high gain. Previous studies indicated that the maximum achievable gain of the hole-type detectors increased with their thickness [1]. Based on this studies the so called "thick GEM" (THGEM) was developed. The various dimensions of THGEM mechanically can be expanded by factors ranging from 5 to 50. Such a THGEM has been designed and fabricated by Indian effort [2]. The THGEM is 1.6 mm FR-4 PCB with 34.1 μm copper present with solder mask on top as insulation. The insulation resistance of this THGEM is in the order of ~G Ohm. So, it is called as Resistive Electrode Thick Gem (RETHGEM) since its electrodes are resistive electrodes. This RETHEM is very robust, can be operated in dusty conditions, does not require special cleanness of its surface or the gas chamber with the gas system and can operate in poorly quenched gases [3]. In this report, we will discuss the gain property of this RETHGEM in single-mode operated with soft X-rays using ^{55}Fe source and Ar/CO_2 (70:30) at atmospheric pressure. The gas-mixture with 30% quencher was prepared using a Mass Flow Controller (MFC). The temperature and humidity were recorded 25^0C and 70% respectively.

The experimental set up with MFC has been described elaborately [3]. The Ar/CO_2 (70:30) gas was flushed accommodating the source, drift plane and RETHGEM in a gas chamber. The electric field between the two electrodes of RETHGEM was generated putting high voltages independently to two electrodes using CAEN N471A. The signal from the detector was recorded from the bottom electrode of RETHGEM by an amplifier Ortec 572A via a charge sensitive preamplifier Ortec 142IH. The X-ray induced primary electron cloud in the conversion gap was transported and focused into the holes of RETHGEM by the dipole field resulting from the voltage $V_{RETHGEM}$ across the holes under a drift electric field E_{Drift}.

The Results

In the energy spectrum, detected peak position is proportional to the energy of the X-rays. If the energy of the X-rays is greater than the threshold energy of argon K-shell ionization (3.203 keV), X-ray may create Ar-Kα X-ray and it escapes from the detector. A small peak will be observed along with full energy X-ray peak, the energy of the small peak will be less than that of the incident photo peak and is known as the Ar-escape peak. Fig. 1 shows a typical energy spectrum obtained from Multi Channel Analyzer (MCA) for RETHGEM operation.

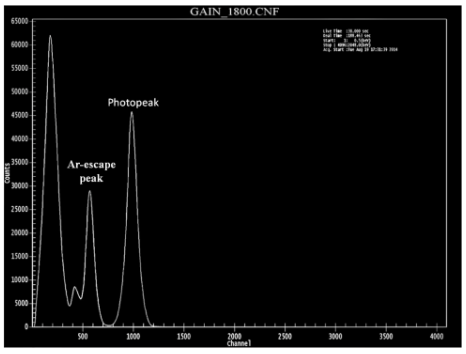

Fig. 1 A typical MCA energy spectrum at $V_{RETHGEM}$ = 1800 V for Ar/CO_2 (70:30)

The Calibration

The calibration was done using a capacitor (5.6 pF) directly connected with charge sensitive preamplifier Ortec 142IH and to the pulse generator in which voltage was varied from 75mV to 275mV keeping frequency fixed at 1000 Hz. This calibration was done for Ar/CO_2 (70:30). This calibration has been depicted in the Fig. 2.

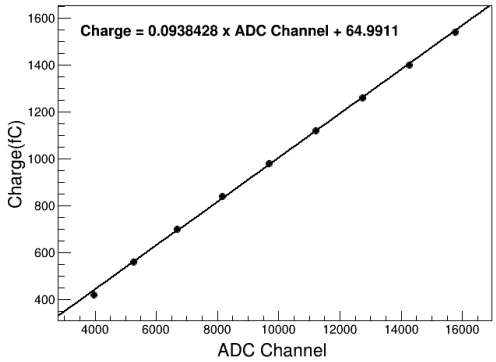

Fig. 2 Charge (fC) as a function of ADC channel

The Gain

The charges in fC were calculated for different ADC centroid channels of the corresponding $V_{RETHGEM}$ using calibration coefficients. The secondary electrons were calculated from the charges. The gain was measured from the ratio of secondary and primary electrons. The primary gain is taken from the known number of electron-ion pairs per conversion for photo peak 5.9 keV X-ray [4]. The gain of the single RETHGEM multiplier for Ar/CO_2 (70:30) is shown in Fig. 3.

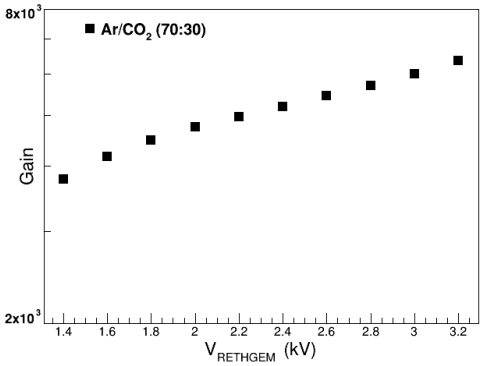

Fig. 3 The Gain as a function of $V_{RETHGEM}$

The Discussions

This RETHGEM had been operated smoothly up to 3200 Volt without sparking. The leakage current was measured 80 nA at $V_{RETHGEM}$ = 3200 V when the detector was flushing with gas-mixture. But the gain had been achieved $6.4x10^3$ at $V_{RETHGEM}$ = 3200 V which is not sufficient. So, up gradation of geometry of this first version of RETHGEM is needed. The up gradation are the followings: to reduce ratio of dimension of pitch and hole diameters, to reduce the insulation thickness of hole's rim, to make the hole shape cylindrical. The incorporation of Read Out (R/O) will reduce the noise at lower ADC channel which is seen in Fig. 1. The study on the properties of this RETHGEM incorporating R/O is the future plan of this work.

References

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