Study on the performance of a single-THGEM gas detector

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1. Introduction

The electron multipliers is the subject of numerous studies and widely applied in the field of high energy physics experiment. The thick gas electron multiplier (THGEM) is mechanically an expansion of standard GEM, with its various dimensions being enlarged by factors ranging from 5 to 50 [1]. The spatial resolution of THGEM being sub-millimeter is not good as GEM's (a few tens of microns), but THGEM is more robust, cheaper and can gain us more than GEM. Moreover, THGEM has several applications at atmospheric and low-pressure both [2]. In this report, we have investigated mainly energy resolution and effective gain using ^{55}Fe source and pre-mixed Ar/CO_2 (80:20) at atmospheric pressure.

2. Experimental set up

The schematic diagram of experimental set up for the testing of the single THGEM detector is shown in Fig. 1. The THGEM was obtained from HFL, Hyderabad in the middle of June, 2010. The template is 1.6 mm FR-4 PCB with 34.1 μm copper and over that solder mask as insulation. The diameter of holes is 500 μm while the insulation thickness of hole's rim is 300 μm which is etched copper around the hole and the pitch is 2 mm. The effective area of THGEM is 50 mm x 50 mm, and there are 686 holes on the plate. The THGEM and source are accommodated in a gas chamber made of perspex of dimension 25 cm x 25 cm x 12.4 cm. The Ar/CO_2 (80:20) gas at 1 atm. pressure was allowed to flush through the gas chamber. The electric field between two electrodes of THGEM was generated putting high voltages independently to two electrodes using CAEN N471A. The signals from the detector was recorded by an amplifier Ortec 570 via a charge sensitive preamplifier Ortec 142AH.

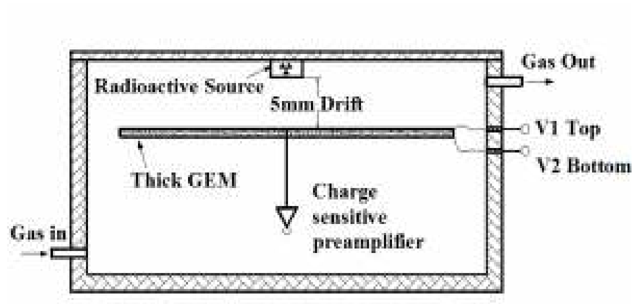

Fig. 1 A schematic diagram of experimental set up

3. Results

The 5.9 keV X-rays from ^{55}Fe source, entering in the gas volume of the detector interact with gas molecules through photoelectric absorption, photoelectrons are emitted and full energy is deposited in the sensitive volume of detector. In the energy spectrum, detected peak position is proportional to the energy of X-rays. If the energy of X-rays is greater than the threshold energy for an argon K-shell ionization (3.203 keV), X-ray may create Ar-Kα X-ray. If such an event occurs and if the Ar-Kα X-ray escapes from the detector, an amount of energy is lost from the detector equal to the energy of the escaped Ar-Kα X-ray i.e. (2.96 keV). 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 5.9 keV X-ray by an amount equal to the energy of Ar-Kα X-ray i.e. 2.94 keV (5.9 keV-2.96 keV) and is known as argon escape peak .

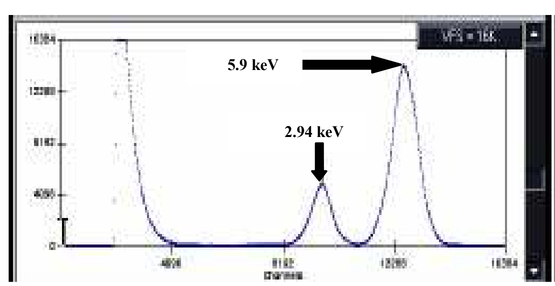

Fig. 2 A typical energy spectrum at V_{THGEM} = 2600 V

The leakage current of THGEM plate was measured from 2200 V to 2700 V at 50 V intervals when air humidity and temperature were below 70% and 25^0C respectively. The leak current at 2700 V is 31 nA, i.e. insulation resistance of THGEM plate is in the order of 87 G Ohm.

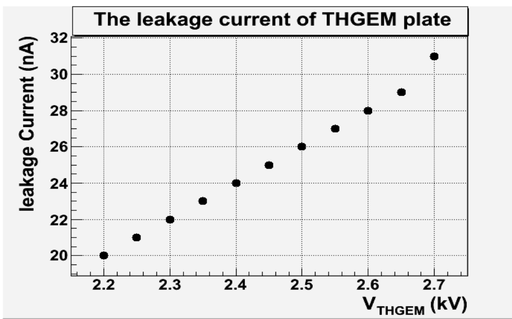

Fig. 3 The leakage current of THGEM plate

It is very clear that the energy resolution becomes worse at lower V_{THGEM} since argon escape peak and full energy X-ray peak can not be separated out, energy resolution is 17% at V_{THGEM} = 2600 Volt where two peaks are separated out nicely. A further increase of voltage will lead small discharges and worsen the energy resolution.

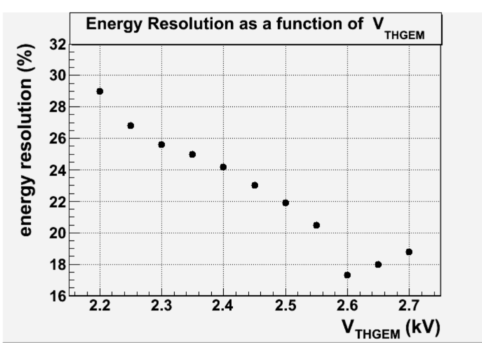

Fig. 4 The energy resolution as a function of V_{THGEM}

The calibration was done using a known capacitor (0.5 pF) directly connected to the pre-amplifier input and to a precision pulse generator in which voltage was varied from 50 mV to 350 mV keeping frequency 1000 HZ.

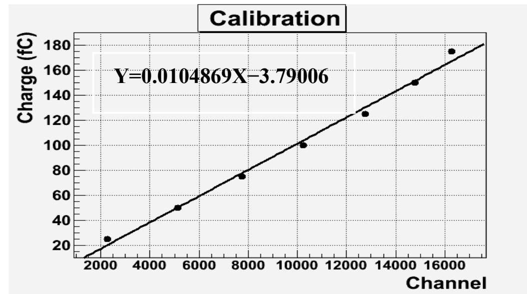

Fig. 5 The calibration plot: charge (fC) as a function of ADC channel

The charges in fC were calculated for different ADC centroids of the corresponding V_{THGEM} using calibration coefficients. The secondary electrons were calculated from the charges. The effective gain was measured from the ratio of secondary and primary electrons.

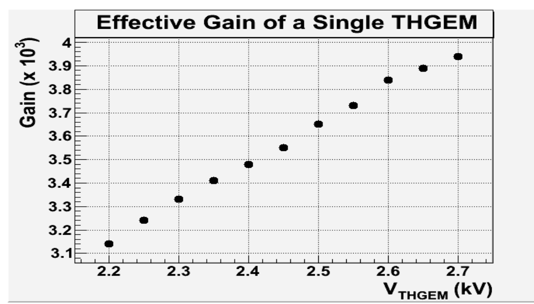

Fig. 6 The effective gain of the THGEM multiplier

The gain stability testing was done over a time period of 25 hours and a decrease of gain of ~1% has been observed.

4. Conclusion and discussion

The effective gain of single THGEM may be increased decreasing hole diameter of THGEM electrode plate. This improvement is foreseen during next production.

References

[1] Chinese Physics C (HEP & NP), 2010 34 (1) 83-87; 34 (4) 479-481.

[2] NIM 558 (2006) 468-474; 475-489.