Investigation of Double-THGEM in the cascade mode

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Introduction

The thick Gas Electron Multipliers (THGEM) is recent developments in gaseous hole-multipliers. The THGEM is cost-effectively fabricated from double-clad G-10 plates using standard printed-circuit board (PCB) techniques; it consists of mechanically drilled holes with chemically etched rims around each hole. THGEM is a simple and robust detector, with mill metric pixilation. Such devices may be produced to cover large area due to their mechanical robustness. The operation mechanism and properties of the single-THGEM fabricated in HFL, Hyderabad, India is described in [1]. In this report, we shall present the different properties of double-THGEM in cascade mode operated with soft X-rays using pre-mixed Ar/CO_2 (8:2) at atmospheric pressure where temperature and humidity were kept below 25^0C and 65% respectively.

Experiment

The schematic diagram of experimental set up for testing double-THGEM (THGEM1 & THGEM2) is given in Fig. 1. The two THGEMs are identical of thickness 1.6 mm, kept horizontally in cascade mode below a drift mesh. The drift mesh is made of gold-plated tungsten wires of thickness 20 µm and the pitch of the wires is 1 mm, soldered in one direction with respect to hole. The effective area of each THGEM is 5x5 cm^2. The conversion/drift gap and transfer gap were 5 mm and 2.5 mm respectively. The dead region gap between the source mounted at ceiling of the gas chamber and drift mesh was ~ 10.0 mm. The THGEMs and source ^{55}Fe are accommodated in a gas chamber made of perspex. The flushing gas inside the perspex chamber is Ar/CO_2 (8:2) at 1 atmospheric pressure. The electric field was generated between the two electrodes of THGEMs putting high voltages independently to two electrodes of each THGEM using two CAEN N471A modules. The signal from the bottom electrode of THGEM2 was recorded by an amplifier Ortec 570 via a charge sensitive preamplifier Ortec 142AH.

In Single-THGEM mode, the X-ray induced primary electron cloud in the conversion gap was transported and focused, under a drift electric field E_{Drift}, into the holes of THGM1 by the dipole field resulting from the voltage V_{THGM1} across the holes [1]. In double-THGEM mode, the initial avalanche electrons were extracted from THGEM1 by a transfer electric field $E_{Transfer}$, and focused into the THGEM2 holes by the electric field across THGEM2, V_{THGEM2}.

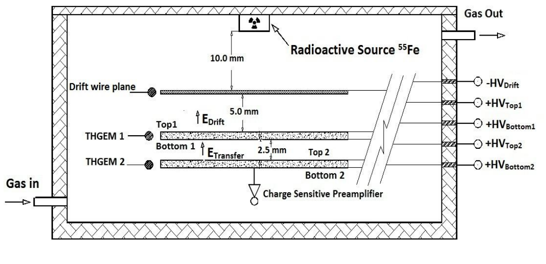

Fig. 1 A schematic diagram of double-THGEM operation mode

Results and discussion

The energy resolution was measured varying E_{Drift} = 0.1 to 0.8 kV/cm in a step of 0.05 kV/cm keeping V_{THGEM1} and V_{THGEM2} at 1500 V and 2500 V respectively i.e. at $E_{Transfer}$ = 4 kV/cm. The Fig. 2 shows at E_{Drift} = 0.45 V/cm, the energy resolution is best but after E_{Drift} = 0.6 kV/cm, the degradation of energy resolution occurs due to the pitch between two holes being large (2 mm) compared to the diameter of the hole (0.5 mm), and the drift direction of ionized electrons cannot be focused into the holes of THGEM by the dipole field of the hole.

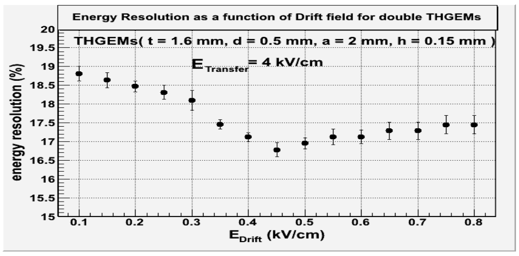

Fig. 2 Energy Resolution as a function E_{Drift}

The Fig. 3 shows the leakage current of two THGEM plates measured by varying V_{THGEM2} from 1875 V to 3375 V at 125 V intervals keeping V_{THGEM1} fixed at 1750 V i.e. at different $E_{Transfer}$ field (0.5-6.5 kV/cm) and the E_{Drift} was fixed at 0.45 kV/cm.

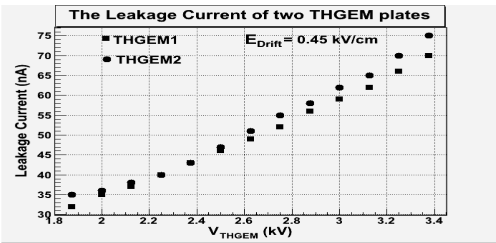

Fig. 3 Leakage Current as a function of V_{THGEM}

In Fig. 4, energy resolution is the best at $E_{Transfer}$ = 4 kV/cm, but values are at the higher side compared to Fig. 2 since V_{THGEM1} was at kept 1750 Volt which was 250 Volt higher than V_{THGEM1} = 1500 Volt.

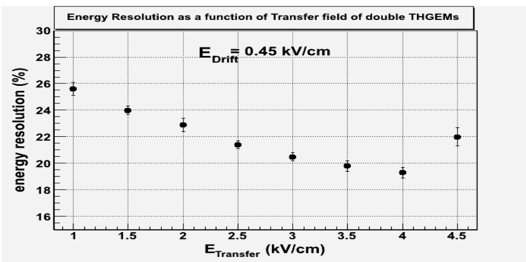

Fig. 4 Energy Resolution as a function of $E_{Transfer}$

The effective gain of double-THGEM was measured using the same calibration which we used to measure effective gain of single-THGEM [1]. The Fig. 5 shows the effective gain as a function of transfer field. A 2.3-fold increase of the charge gain was observed with increase of $E_{Transfer}$ in the range 1-5 kV/cm; this increase may be due to the more efficient charge extraction/transfer to the next element in cascade (THGEM2). The possible reason for limitation of the maximum gain observed in double-THGEM is the photon and ion-feedback effects and that has been investigated for the noble gas Kr in high pressure [2].

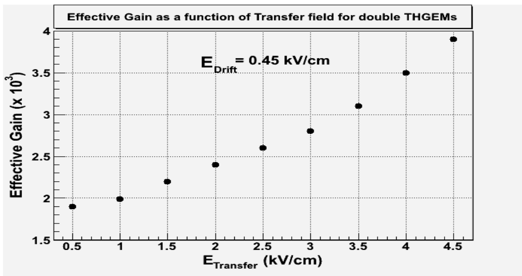

Fig. 5 Effective Gain as a function of $E_{Transfer}$

Summary

We have observed that energy resolution is better and gain is not appreciably higher in double-THGEM with respect to Single-THGEM [1]. We can measure energy resolution as a function of V_{THGEM} keeping a constant E_{Drift} and $E_{Transfer}$ field after inclusion of Read Out (R/O) in the next iteration of our experimental set up.

References

[1] T. Sinha et al., Proceeding of DAE Symp. Nucl. Phys. 55 (2010), 684.
[2] J.M. Maia et al., JINST 4 P 10006 (2009).