Studies on UV Photon Detector with double thick GEM

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Introduction

Photon detectors play a significant role in different areas of applications ranging from particle detection, astronomy, to healthcare and homeland security. Detection of UV photons using micropattern gas detectors (MPGD) are widely used in particle identification detectors (PID) like Ring imaging Cherenkov (RICH) detectors [1]. UV photon detectors with high sensitivity, reaching to the level of single photon detection is on high demand, not only for PIDs, but also for imaging [2]. In the basic configuration, these detectors consist of a photocathode (cesium iodide), to convert the incoming UV radiations to photoelectrons, an amplifying structure that multiplies the electron signal in a gas medium and the readout system which can be either electronic or optical image readout system [3]. In this paper, we report on the use of Thick Gas Electron Multiplier (THGEM) [4], as the amplifying structure for UV radiation detection. THGEM detectors can be made in large area and provide high multiplication factor that permits efficient detection of UV light at single photon level. To detect single photoelectron it requires: efficient photoelectron yield from the CsI surface, maximizing the electron focusing towards the THGEM holes, high electron multiplication inside the THGEM hole and efficient charge transfer towards the next amplification stage/readout electrode.

In our work, the performance of UV photon detector in neon based gas mixture has been studied experimentally and the detection of single electron spectra is demonstrated successfully. Electron spectra were recorded and analyzed in order to observe about how they are affected by operating parameters like electric field.

Experiments

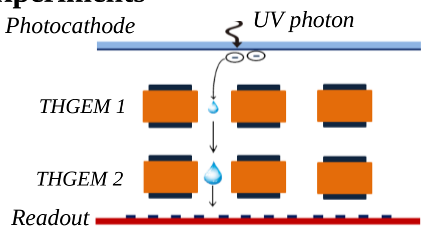

Fig. 1 Working principle of UV photon detector

Fig. 1 shows cascade of two THGEMs coupled with a CsI photocathode mounted in the semitransparent mode. Multi THGEMs are required to increase the gain for efficient detection of single UV photon. The photocathode, irradiated by a low pressure Hg lamp is used as source of UV photons. The photoelectrons generated from the photocathode are focused into holes of first THGEM (THGEM1), multiplied under high electric fields and transferred to the second THGEM (THGEM2). Signals generated on strip readout plate is processed and analyzed.

The in-house made test chamber was used in our experiments. Geometrical parameters of the THGEMs used in these studies were insulator thickness 250 µm, hole diameter 200 µm and pitch 450 µm. THGEM1 has the rim of 20 µm while THGEM 2 has the rim of 100 µm. Mixture of neon and methane with the ratio of 90:10 was filled at atmospheric pressure. Subsequently, the electron spectra were recorded.

Results and Discussions

The analysis of the electron spectrum is performed entirely on single electron detection mode. Single electron spectrum is ensured by reducing the intensity of incident radiation to a level below which the slope of the pulse height spectrum remains same. In a single electron counting mode, the slope corresponds to the detector gain. Gain is estimated from the fitted Polya Distribution [5] as shown in Fig. 2.

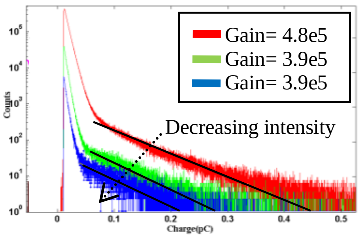

Fig. 2 Variation of Pulse height spectra from double-THGEM UV photon detector as a function of intensity of UV light

Single electron spectra were studied under different multiplication voltages. The gain, calculated from the slope shows an increase with multiplication voltage. The corresponding results are shown in Fig. 3.

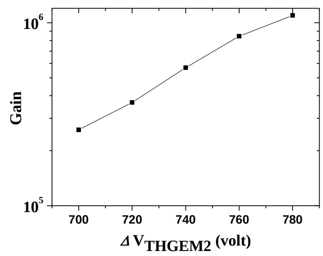

Fig. 3 Gain of a double-THGEM as a function of the voltage across the THGEM2 (ΔV_{THGEM2})

The electron spectra were compared for different drift fields applied between photocathode and the top surface of THGEM1 for a fixed multiplication voltage. It is observed that there is no change in curve slope in pulse height spectrum, which indicates fixed gain. However the total number of counts reduces for higher drift field as shown in Fig. 4.

Simulation studies have been carried out using ANSYS and Garfield to understand the above observation. Simulation procedure is detailed in our earlier work [6]. Simulation results also show that, as the drift field increases the number of electrons entering the THGEM aperture decreases. This results in a reduced count with drift field.

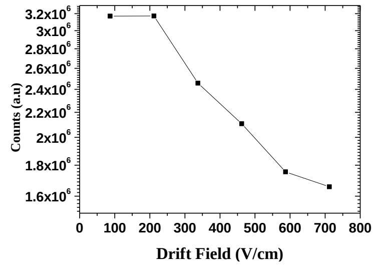

Fig. 4 Total counts for each spectrum as a function of drift field

Conclusions

We successfully demonstrated the operation of a THGEM based UV photon detector in single photon detection mode and analyzed the spectrum under various operating conditions like multiplication voltage and drift field. Single electron signals were found in the gain range of 2×10^5-10×10^5. The observation from the drift field variation study is well interpreted from simulation results. The analysis of the single electron spectrum is very critical for any detector's operation as it gives a clear understanding of the detector's behavior at a high sensitivity operating condition where secondary effects can be prevailing. Our future work proposed includes optimization of the detection efficiency from single electron spectrum and designing of an UV imaging device based on these studies.

References

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