# First signals from indigenously produced GEM foils

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## Introduction

Gas Electron Multiplier(GEM) [1] detectors belong to the family of micro-pattern gas detectors (MPGD) which are advanced detectors for radiation detection in High Energy Physics (HEP) Experiments and imaging applications[2]. These are high rate detectors, can provide high position resolution (< 50 µm) and can work in quite harsh radiation environment. They also have the advantage of being amenable to large area requirements which is often desired for the detectors in HEP experiments, such as those in PHENIX, ALICE, CBM, etc. GEM foils which is the main amplifying element of the GEM detector is composed of 50µm thin polyimide layer with 5µm copper layer on both its surfaces. Holes of ~50µm diameters are pierced all over the surface with a pitch of 140µm. A voltage of 400-500 V when applied across the two surfaces of the foil creates high electric field inside these holes. When placed in gas, the primary ionization electrons which passes through this holes initiate an avalanche of electrons thus multiplying the number of final electrons reaching the readout. Multiple planes of such amplification layers can be put together to achieve high gas gains. The production procedures for making such perforated foils are complex and there are only few places in the world where they are manufactured. An indigenous attempt has been made by ECIL, Hyderabad, to produce such foils for the first time. In this paper, we report the fabrication process and first test results of one such indigenously built GEM foil.

## Foil Fabrication

There are several procedures for fabricating such micro-holes in the foils. The most commonly followed and reliable technique is via chemical etching, namely, double-mask etching technique and single-mask technique. In this report, we present the results for GEM foils produced using double mask etching technique. A schematic picture of this fabrication process is shown in Fig.1.

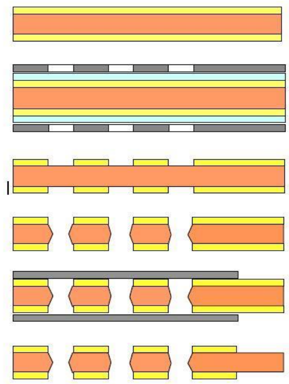

**Fig.1** Schematic of GEM foil fabrication process

The main steps involved in the fabrication is mentioned below :
1. The raw material used is 50-µm adhesiveless double sided copper clad (5µm) polyimide.
2. Thin dry film photoresist is hot laminated under pressure on a suitable size cut sheet of the raw material.
3. GEM hole pattern masks are exposed on both sides using a collimated UV source using CCD based alignment system and developed following a standard procedure.
4. Top and bottom copper holes are etched in a ammonical etching line.
5. After stripping the resist, holes in the polyimide are etched using the copper apertures formed as mask pattern.
6. The foil is laminated for a second time and the necessary borders and HV tails are etched.
7. Final cleaning and passivation is done before leakage current measurements.

Several 10cm x 10cm GEM foil were thus fabricated. Appropriate measures were adopted to ensure uniform and circular holes during the production. The zoomed picture of a region of one such foil is shown in Fig.2.

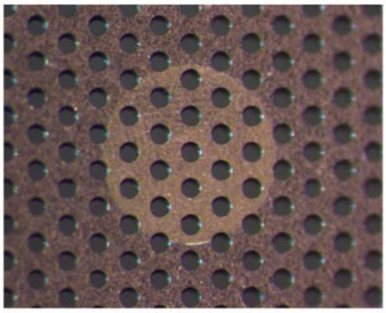

**Fig.2** First GEM foil produced by ECIL Hyderabad that was tested successfully with radioactive sources.

## Results

The GEM foils were cleaned and treated at VECC. All the foils were scrutinized thoroughly to rule out any defects. Leakage current tests were performed on them and only those foils that had leakage below 5 nA were selected for tests with radioactive sources. A single-GEM detector was fabricated for tests with 5.9 keV X-ray source. A premixed gas-mixture of $Ar/CO_2$ in the ratio(70/30) was used for these tests. The first pulse height spectra obtained from this indigenous foil is shown in Fig.3, corresponding to $\Delta V_{gem}$~505 volts. The major(5.9 keV) and the escape peaks are clearly resolved. A voltage scan studying the variation of this peak-pulse height with varying GEM voltage is shown in Fig.4. The gain of the detector increase exponentially with applied voltage as is revealed by the exponential fit. At its highest value shown in the figure, the gain was estimated to be ~900. Further improvements in the GEM-hole profile by ECIL is underway. The next tasks involve measuring the uniformity of response over the entire area for such samples and perform other stability tests.

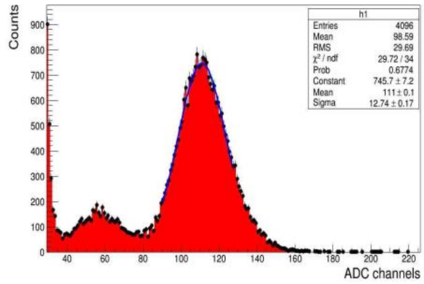


**Fig.3** Pulse height spectra obtained using $^{55}Fe$ source

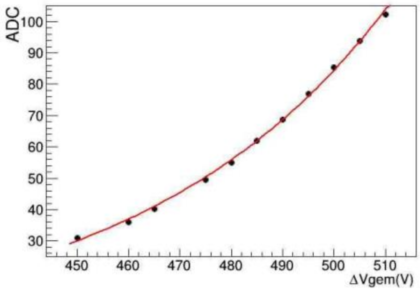


**Fig.4** Variation of Peak Pulse height (ADC) with $\Delta V_{gem}$ (Volts).

The mastering of this technology in the country has the potential to build high resolution detectors and cater to the ever growing demand of the GEM foil worldwide.

## Acknowledgements

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## References

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