Process stabilization in development of Single Mask GEM foils in India

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Introduction :

The GEM foils consists of 5 μm of Cu clad on both the sides of 50 μm polyimide (PMMA/kapton) (5/50/5), produced exclusively in South Korea, the schematic of which is shown in Fig. 1. The Cu layer remains bound to the polyimide through 100 nm of Chromium and does not involve any adhesive glue.

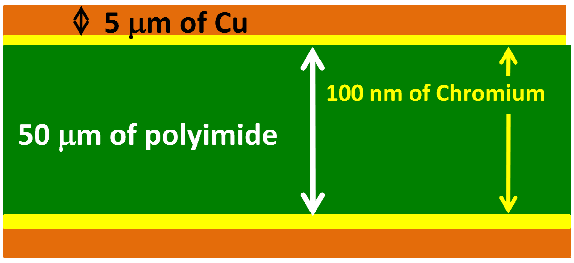

Fig. 1 : Schematic of Cu clad ployimide (5/50/5)

The large area (~ 1 m^2) GEM foils have immense applications in the field of tracking and triggering detectors for particle physics, homeland security and medical applications. The technology for building large area Single Mask GEM foils in India is a multi tier staged programme with NPD-BARC and M/s Micropack, Bangalore, collaborating in this venture with expertise from CERN [1]. We report in this paper, the process stabilization for chemical etching (wet process), achieved in India, for the 100 μm holes with a pitch of 200 μm, an important milestone achieved, before launching the targeted holes of 70 μm diameter with a pitch of 140 μm.

The chemical etching process :

Present chemical processes for making GEM foils involves Photolithography and Chemical/ Electrochemical etching of copper and polyimide layers. The processes involve the following four major stages :

1. For removal of Cu from one side, standard photolithography and chemical etching with ferric perchloride, is involved, as in any PCB manufacturing.
2. In the second stage, the photoresist is stripped with ethanol and $KMnO_4$.
3. The Cu etched foil is then moved to a different bath of ethylene diamine for anisotropic etching of polyimide. The third stage needs to be optimized, because of evaporating fumes and dissolving of polyimide in the etchant itself, in a temperature controlled environment.
4. Finally, the Cu on the other side of the ployimide is removed using Galvanic etching (reverse etching) in a different bath of chromic acid. Currents need to be optimized as per the size of the foils for the reverse etching process of Cu in the fourth and final stage.

With our ongoing efforts in development of Single mask GEM foils, we have stabilized the process for chemical etching for the 100 μm diameter, holes with a pitch of 200 μm as shown in Fig. 2. The next step was to go for the targeted holes of 70 μm diameter with a pitch of 140 μm, as has been optimized for a triple GEM amplifier for the GEM upgrade of CMS [2]. Fig. 3, shows three of the four stages achieved in that direction. The last and final stage of reverse etching, which removes the copper from the other side and opens up a clear hole, is in progress at the time of writing this paper. The same shall be presented during the time of symposium.

GEM foil testing facility at NPD-BARC :

The GE1/1 kit has also arrived at NPD-BARC from CERN. The maximum expected hit rate within the

GE1/1 acceptance is about 5 kHz/cm^2 for HL-LHC running at 14 TeV and 5×10^{34} $cm^{-2}s^{-1}$. An intense x-ray source with associated shielding (Fig. 4) is also operational at NPD-BARC, which can illuminate GE1/1 and similar sized detectors and civil work is in progress to develop a class 100 (hundred) volume for handling indigenously developed foils and translating them into a triple GEM amplifier and characterizing them. Adequate gases, gas mixing system ($Ar/CO_2/CF_4$: 45:15:40) [3] and VME based DAQ with 1k of TDC channels already exists in the lab.

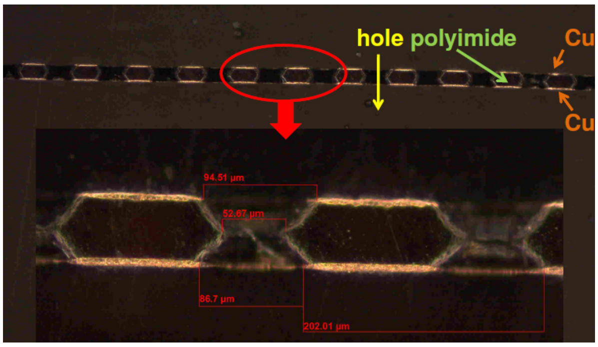

Fig. 2 : Process stabilization & the conical shaped profile for Single Mask GEM foils (100 µm holes with a pitch of 200 µm)

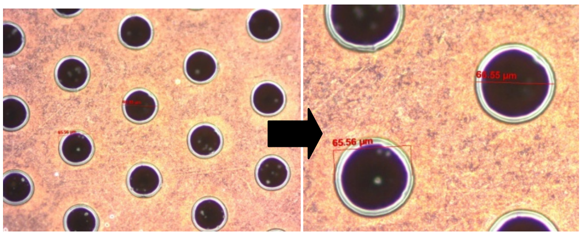

Fig. 3 : Three of the four stages achieved for developing ~ 70 µm holes with a pitch of 140 µm in a hexagonal pattern

Conclusions :

The chemical etching process has been stabilized for the 100 µm/200 µm configuration and is being evolved for the 70 µm/140 µm configuration in a hexagonal pattern. Once that is stabilized for the 70 µm/140 µm configuration, the further road map for development of Single Mask GEM foils envisages, production, in a phased manner, of 10 cm x 10 cm foils followed by 30 cm x 30 cm foils by the second/third quarter of 2016, followed by QC validation at NPD-BARC and CERN.

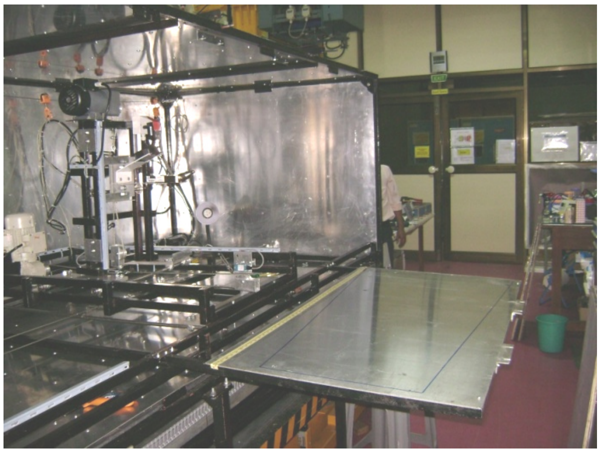

Fig. 4 : An intense x-ray source with x,y,z positioner, inside a lead (1mm thick) cubicle for illuminating and characterizing GE1/1 and similar sized GEM detectors at NPD-BARC

References :

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[3] A. Cardini, G. Bencivenni, and P. De Simone, "The Operational Experience of the 4499 Triple-GEM Detectors of the LHCb Muon System: Summary of 2 Years of Data Taking", 4500 IEEE Nucl. Sci. Symp. Med. Imag. Conf. Rec. (2012) 759–762,