Development of Single Mask GEM foils in India

L. M. Pant[1,*], A. K. Mohanty[1], O. J. Pinto[2], S. Gadhadharan[2], Pradeep Menon[2], Archana Sharma[3], Rui De Oliveira[3]

[1] *Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai, 400 085, India,*
[2] *Micropack Limited, Bengaluru, 560 105, India*
[3] *CERN, Geneva, Switzerland*
** email : lmpant@barc.gov.in*

Introduction:

There are various techniques available around the globe for making punch through holes for Micro Pattern Gas Detectors (MPGDs), such as Gas Electron Multipliers (GEMs). The GEM foils consists of 5 μm of Cu clad on both the sides of 50 μm polymide (PMMA/kapton) (5/50/5). At present these foils are developed in South Korea without having any adhesive between the Cu and polymide. The available techniques range from chemical etching, reactive plasma etching and laser etching. However, for GEM detectors, having an active area upto 5000 cm^2, the chemical etching process using a Single Mask has been developed at CERN which is faster from the viewpoint of mass production of such foils for the upgrades which are foreseen in a couple of years with the Large Hadron Collider facility at CERN [1,2]. The technology for the same has been transferred to India from CERN and we are in the process of building large area Single Mask GEM foils in a multi tier staged programme with the help of Indian industry at M/s Micropack, Bangalore which basically deals with flexible PCBs, apart from various other products developed by them for various Indian agencies. We report in this paper, the first trial runs and the action plan to be followed as a joint collaboration between NPD-BARC, Micropack and CERN. Single Mask GEM foil has an advantage over the earlier developed, Double Mask GEM foils, as one gets rid of the alignment required for the pattered holes on the two sides of the polymide and is a faster process.

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

1. Removal of Cu from one side using the standard photolithography and chemical etching with ferric perchloride, involved in any PCB manufacturing (Fig.1)
2. Photoresist stripping with ethanol and $KMnO_4$
3. The Cu etched foil is then moved to a different bath of ethylene diamine for anisotropic etching of polymide (Fig.2)
4. Lastly, the Cu on the other side of the ploymide is removed using reverse etching in a different bath of chromic acid.

To start with a sample of the foil of 5 cm x 5 cm was taken to develop 200 μm diameter holes at a regular pitch of 400 μm. The etched Cu and the polymide are shown in Fig. 1 and Fig. 2, respectively. The anisotropic polymide etching shows a wedge shaped conical passage with the wider diameter at ~ 200 μm tapering down to ~ 140 μm. As can be seen in Fig. 2, some amount

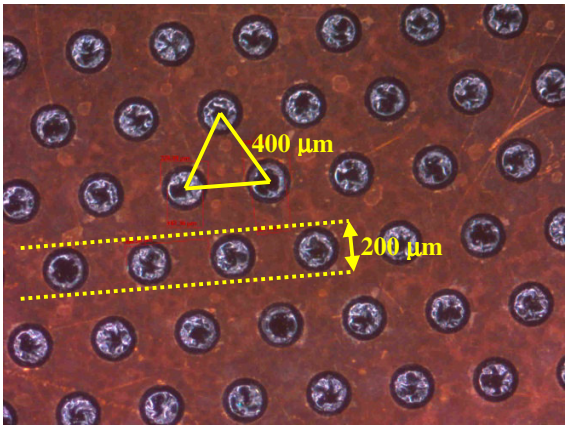

Fig. 1 : Removal of Cu through the process of photolithography and chemical etching

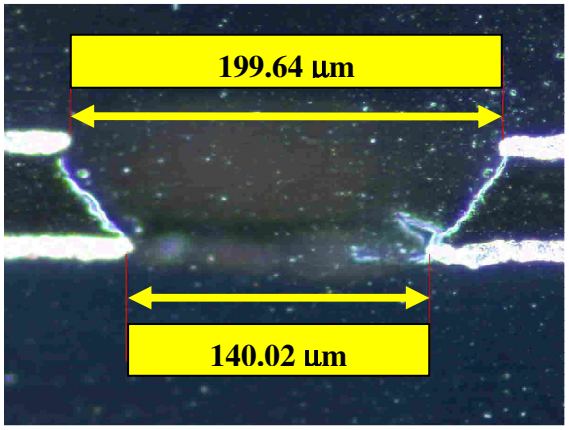

Fig. 2 : The conical shaped profile for GEMs

Fig. 3 : SS tank for polymide etching of GEM foils, each of size 300 mm x 300 mm, developed at Micropack, Bangalore, with exhaust lips

of polymide is still not fully etched at the periphery which leads to problems while performing the reverse Cu etching.

The first trial runs, with horizontal loading of the samples, conducted at Micropack, are quite encouraging and efforts are underway to stabilize the etching processes in all the four stages mentioned above. The third stage needs to be optimized, because of evaporating fumes and dissolving of polymide in the etchant itself. Currents need to be optimized as per the size of the foils for the reverse etching process of Cu in the fourth stage. There are issues with nichrome etching too, which binds the Cu to polymide, and are being addressed to. The second set of trial run is expected to start soon and the results of same would be presented during the symposium. Proper tooling is also being developed to handle foils of 30 cm x 30 cm dimensions, with vertical holding. Fig. 3, shows an SS tank with circulation pump and exhaust lips for immediate removal of fumes generated in the third stage and to simultaneously handle about ten GEM foils, each of size 30 cm x 30 cm developed and presently being commissioned at Micropack, Bangalore.

Conclusions :

The road map for development of Single Mask GEM foils envisages, process stabalization of all the four steps mentioned above and then produce in a phased manner, 10 cm x 10 cm foils followed by 30 cm x 30 cm foils by the first quarter of 2015, with reduced diameters of 70 µm at a pitch of 140 µm in an equilateral triangular geometry, along with QC validation at NPD-BARC and CERN.

References :

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