Single Mask GEM foil development in India

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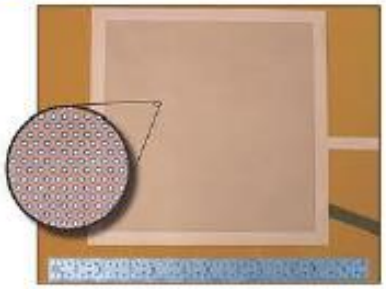
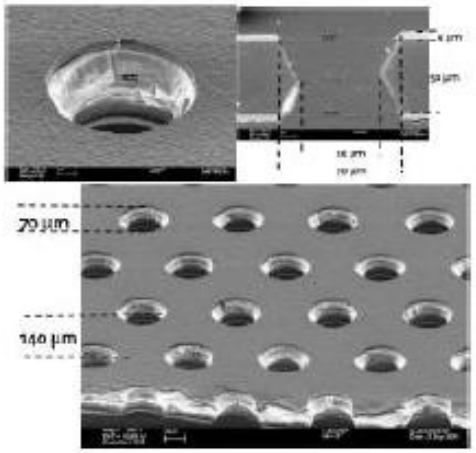
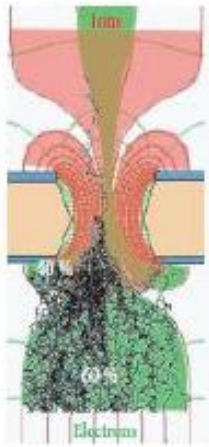
The Triple GEM for the CMS Muon System

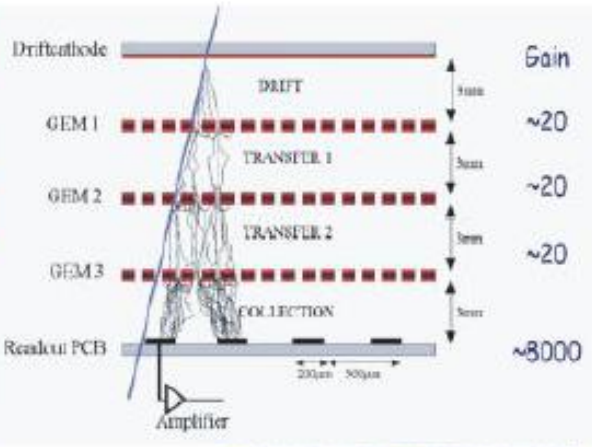
Rate capability : $10^5 Hz/cm^2$
Spatial/Time resolution: ~ 100 μm / ~ 4-5 ns
Efficiency > 98%
Gas Mixture: $Ar-CO_2-CF_4$ (non flammable mixture)

- Combine triggering and tracking functions
- Enhance and optimize the readout (η-φ) granularity by improved rate capability

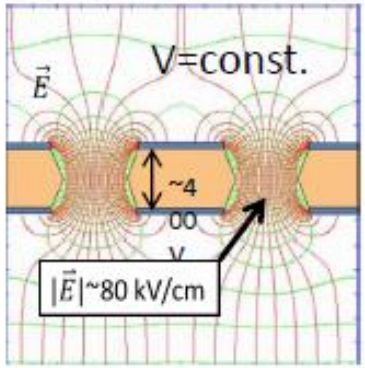








- GEM foils developed using PCB manufacturing techniques
- Large areas ~ 1m x 2m with industrial processes (cost eff.)
- Each foil (perforated with holes) is 50μm kapton sheet with copper coated sides (5μm)
- Typical hole dimensions : Diameter = 70μm, Pitch = 140μm,
- Long term (10 years) operation experience in Compass, and more recently LHCb and TOTEM



Micropack Limited – Company Brief

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- 100% privately owned Indian company
- Focus on small volume / high mix segment
- Factory is located at Jigani Industrial Area, in Bangalore, in 10 acres of land with a built-up manufacturing area of 60000 Sq ft.
- 170 employees, all technically qualified and trained to handle specialized processes
- Presently manufacturing multilayer rigid PCBs up to 30 layers.
- Fabricates approximately 450-500 designs every month including 300-350 fresh designs.
- In-house facility for all operations

Micropack Limited – Company Brief

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- **Markets segments catered –**
  Aerospace / Defence, Industrial Electronics / Prototype / Technology oriented projects with new materials / processes

- **Product & System Approvals -**
  MIL 55110 / MIL 50884 / AS9100 – ISO9001-2008 / ISO 14001

- **Customer Approvals –**
  ISRO / Goodrich Aerospace (UTAS) / BEL / HAL / NPCIL

- **Product Range –**
  Multilayer Rigid PCBs - Heat Sink / Impedance controlled / Blind and buried via PCBs, Rigid Flex PCBs, Flexible PCBs, Teflon PCBs

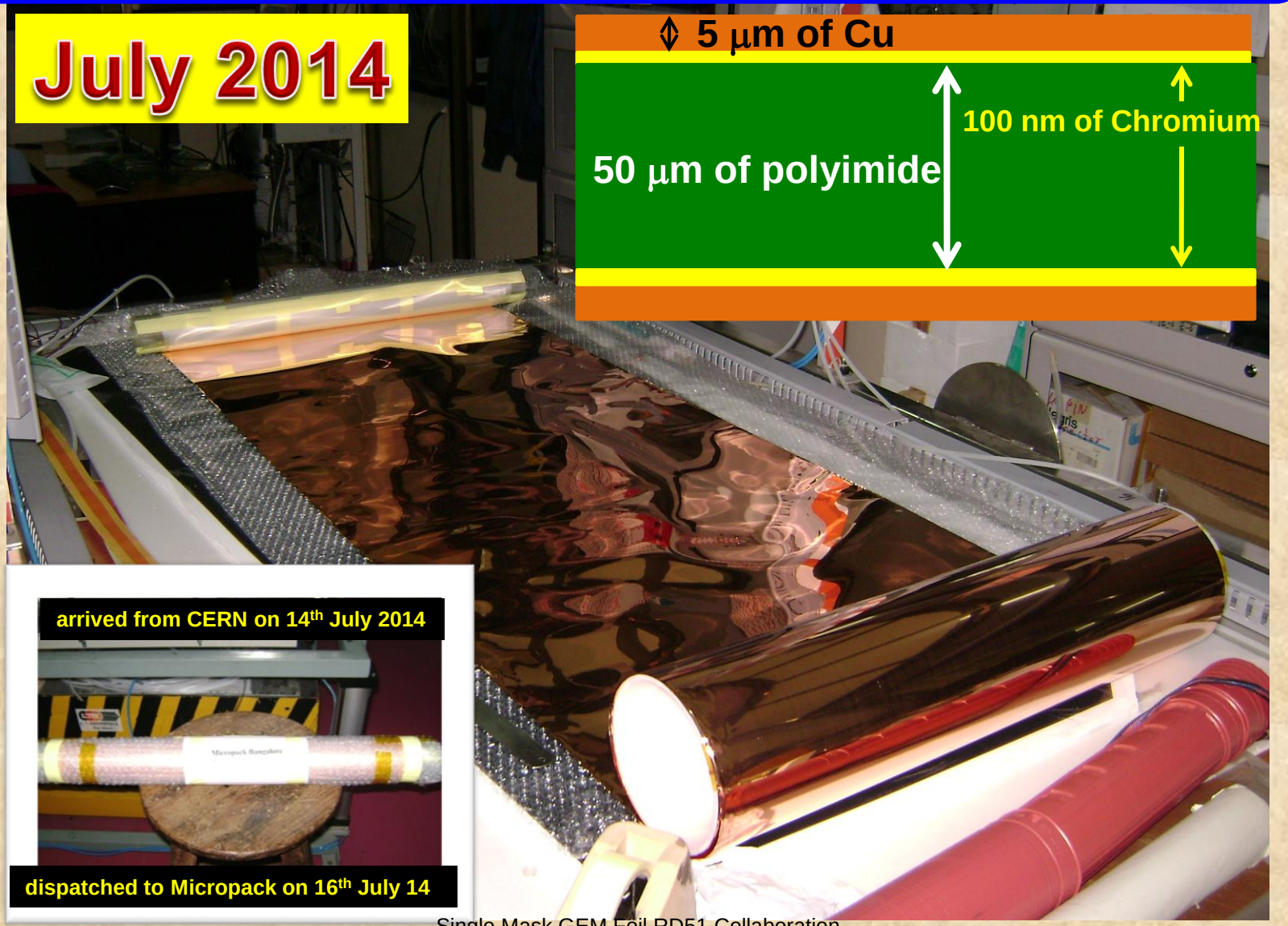
ROADMAP

S.No.	Item	1Q		2Q			3Q			4Q			1Q			2Q			3Q			4Q		
		2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	**License Agreement**	→																						
2	**100 x 100 Fabrication and QC Validation**																							
	- Rebuild equipments/utility for GEM Foil			→																				
	- Prepare raw materials(FCCL, mixed chemicals)			→																				
	- develop the ***prototype***					→																		
	- QC validate the prototype @COMPANY							→																
	- QC validate the prototype @COMPANY								→															
3	**100 x 100 Routine and standard production , 300 x 300 R&D**																							
	- ***100 x 100 routine*** & standard production									→												→		
	- develop the ***prototype of 300 x 300***										→													
	- QC validate the prototype @COMPANY/CERN												→											
4	**300 x 300 Routine and standard production , 500 x 500 R&D**																							
	- ***300 x 300 routine*** & standard production														→							→		
	- develop the ***prototype of 500 x 500***															→								
	- QC validate the prototype @COMPANY/CERN																→							

Status

- **ToT signed and agreed between CERN and Micropack Ltd., India : Jan 2014 for Single Mask GEM foil fabrication**
- **5 micron Cu clad polyimide foils received from CERN via BARC**
- **15 microns photoresist sourced from Korea**
- **Augmentation of resources for trial runs for the first 5 cm x 5 cm GEM foil (initial trials) with 200 microns / 400 micron pitch in progress :**

The Cu clad polyimide (5:50:5) from Korea via CERN (need to have an independent supply)



Project Status

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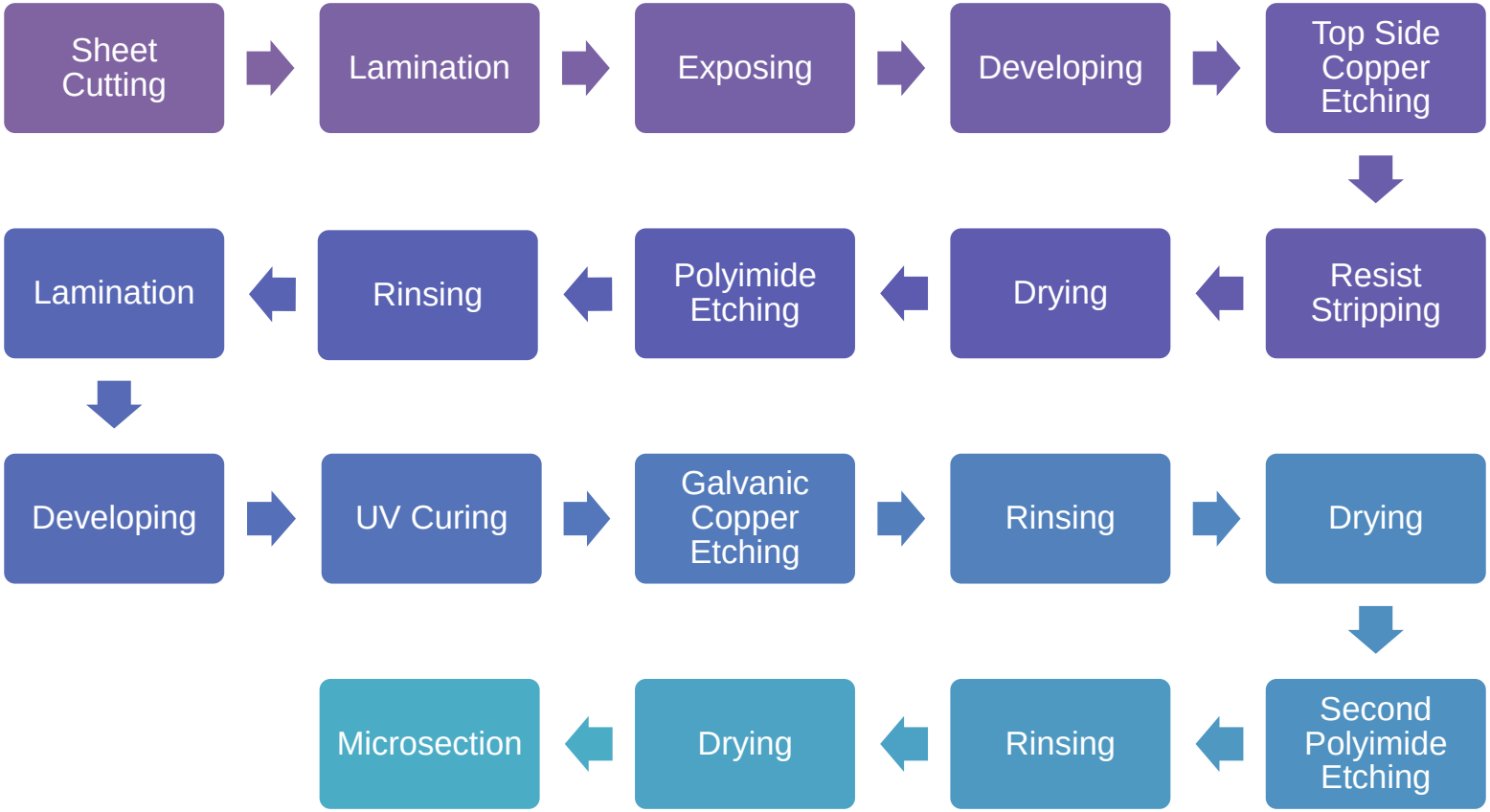
- **Project target – GEM Foils with 70 μm diameter holes at 140 μm pitch of 10cm x 10cm / 30cm x 30cm**
- **Initiated trials with of 5cm x 5cm**
- **Image transfer of 70microns / 140 microns well within the capability**
- **Process concerns in Polyimide etching and reverse copper etching**
- **SS 306 tanks for Polyimide etching is fabricated. Includes heaters/ circulation pump / exhaust lips**
- **BARC personnel visited Micropack on 11 Sep, to freeze the action plan**
- **Mr. Rui from CERN visited BARC & Micropack in October 2014**

Current Process flow



Setup

Collimated UV Exposure

Acid Etcher

Setup

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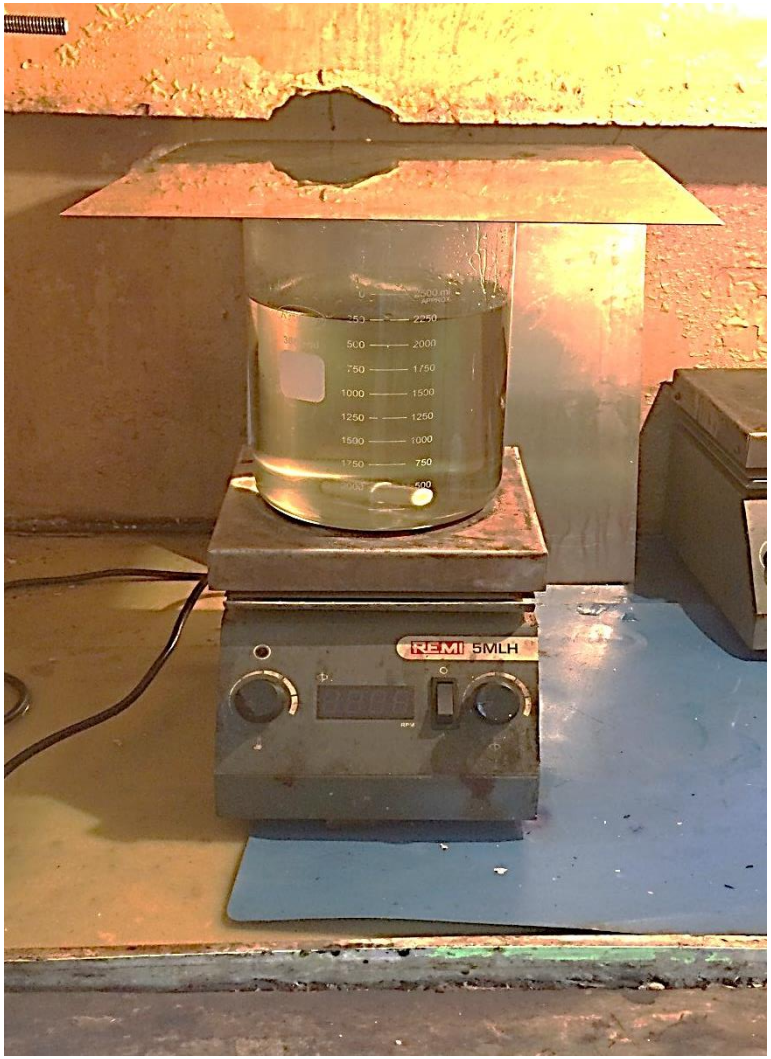

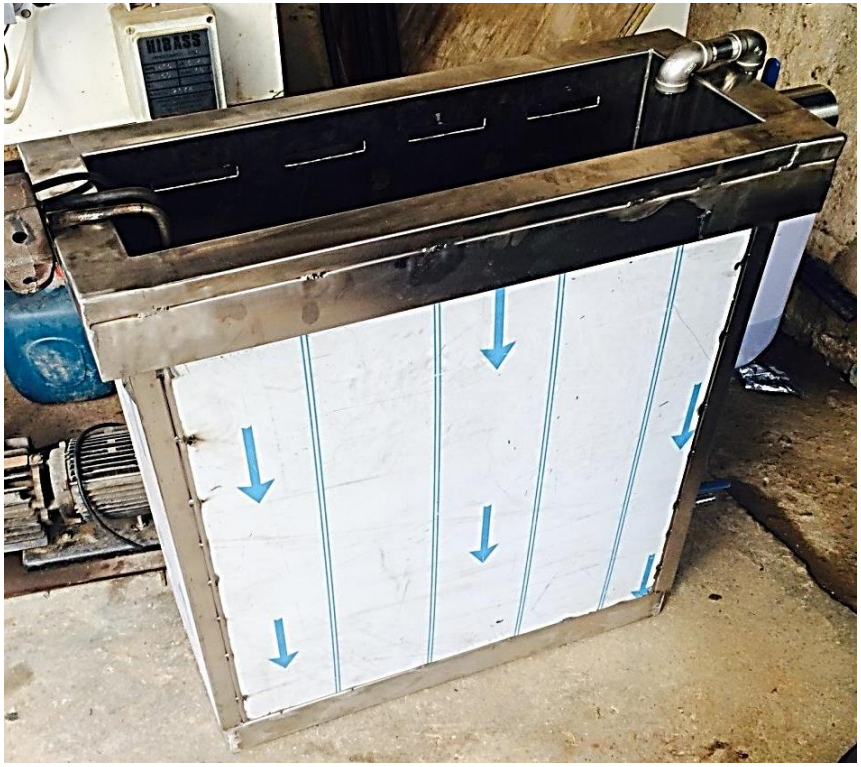

- The left image shows our current lab scale setup being used for the trials
- Top image is the SS 306 tank for Polyimide etching which was fabricated and is at the factory

Trial Summary (all 200 microns dia / 400 microns pitch)

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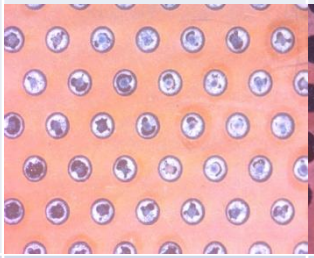
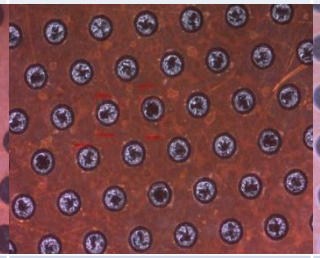
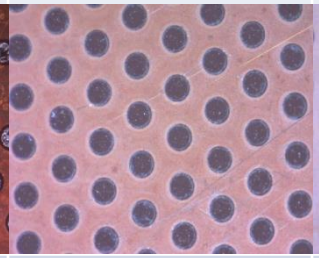
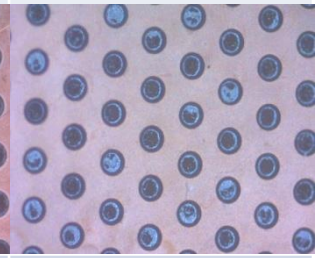
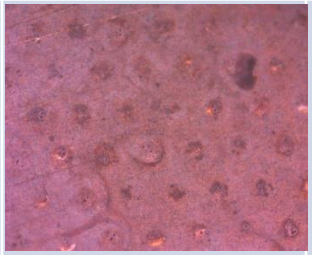
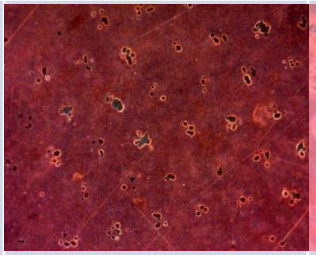
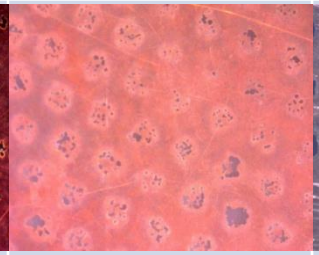
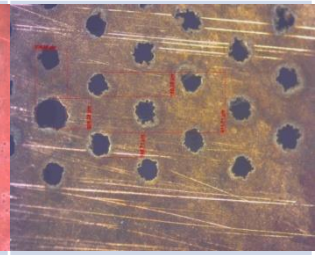
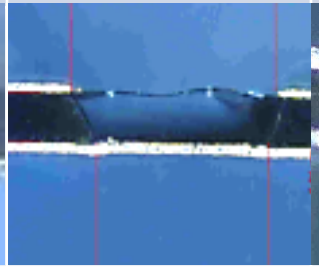
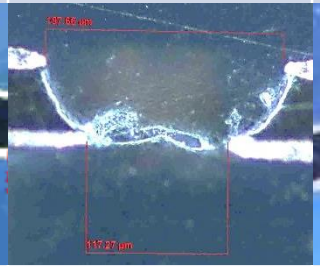
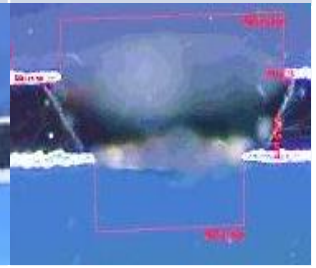
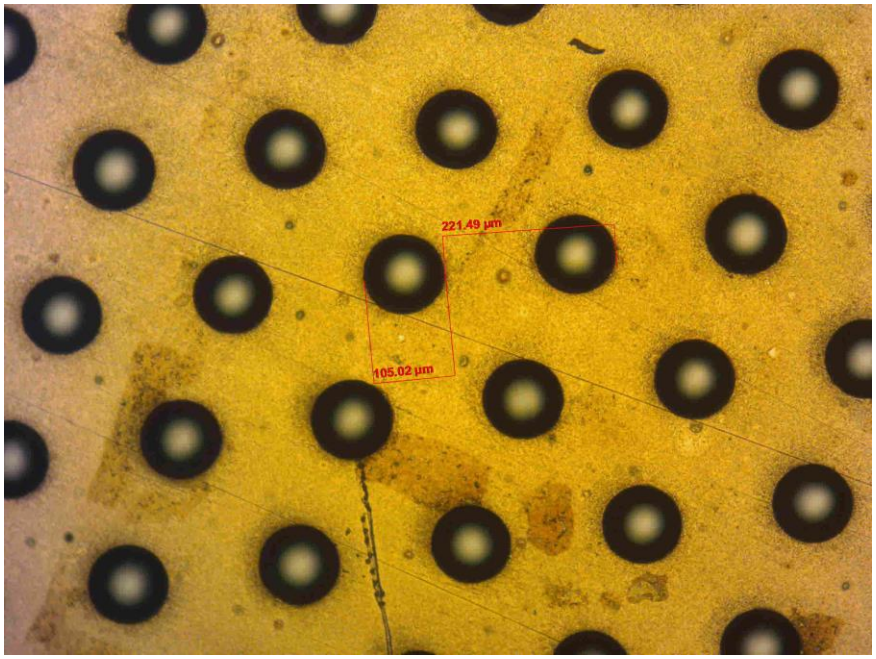
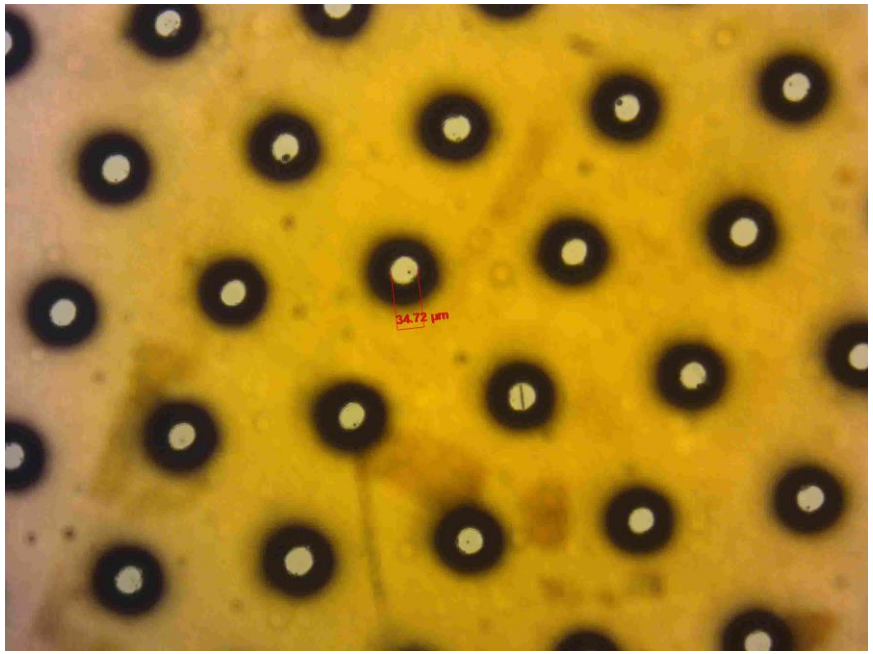
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Time Period	July – 3rd Week	August – 2nd Week	September – 1st Week	September – 3rd Week	October – 1st Week
Polyimide Etching					
Reverse Copper Etching		NO IMAGE			
Micro Section Image					

Trial 6 (Oct 2nd week) – Wet Polyimide Etching





- Trials with 100 microns dia / 200 microns pitch
- Taper in Polyimide etching observed
- The diameter obtained at the top of the hole was measured at 105.02µ
- The diameter obtained at the bottom of the hole was measured at 34.72µ
- The pitch obtained between the holes was measured at 221.49µ

Trial 6 – Galvanic Copper Etching

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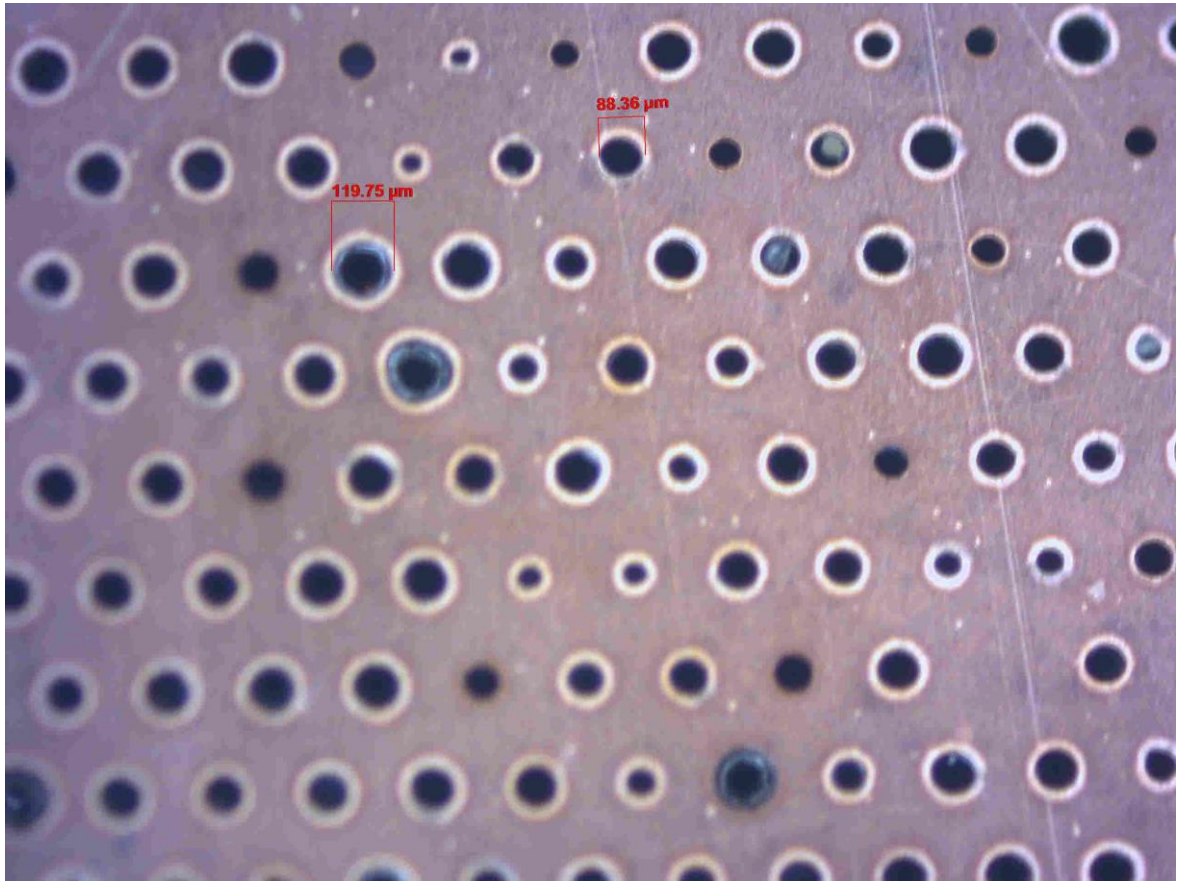

- Copper removal seen on the bottom side
- However, uniformity of hole opening was not obtained.
- A maximum hole diameter of 119.75µ was obtained
- A minimum hole diameter of 88.36µ was obtained
- No opening was obtained at 10-12 locations (total of 12000 holes) , possibly due to incomplete removal of polyimide

Trial 6 – Microsection Image of GEM Foil

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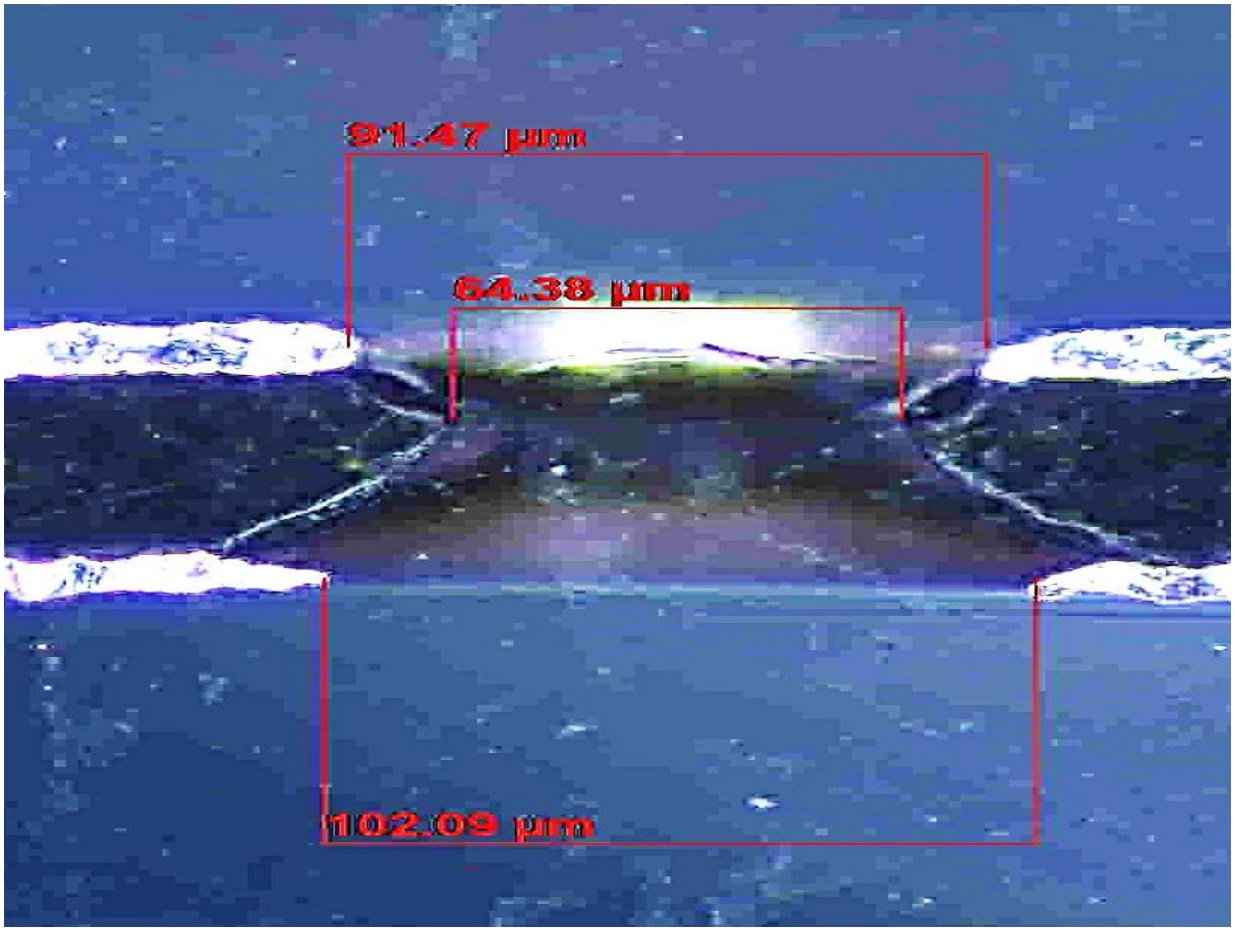

- The bi-conical structure was obtained

Location	Diameter
Top	102.09µ
Throat	64.38µ
Bottom	91.47µ

- Over-Etching of polyimide was observed due longer dip time during polyimide etching

Project Outlook:

- Trials to be continued with process modifications based on the learning from each trials
- Process modifications suggested by Mr. Rui to be tried within the next 3 weeks
- Trial results to be shared with BARC / CERN on a weekly basis for suggestions / process improvements

Micropack is committed to achieve the goal of realizing Single mask GEM foils in India and will strive to continuously improve the process / align resources to meet this objective.

Thank You