Production issues of THGEMS at ELTOS

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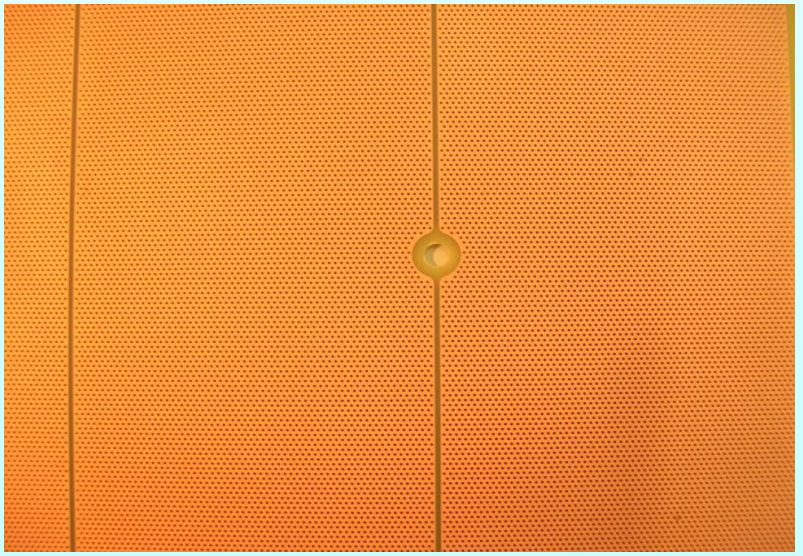


The production procedure

Quality checks

- visual inspection

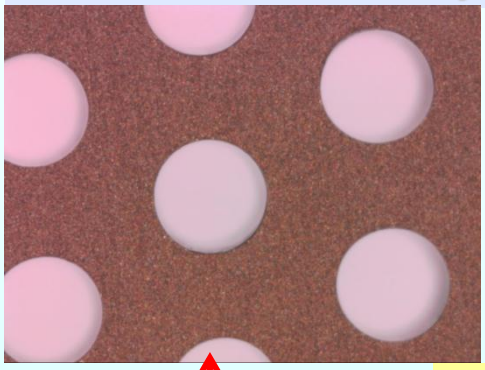
- electrical tests

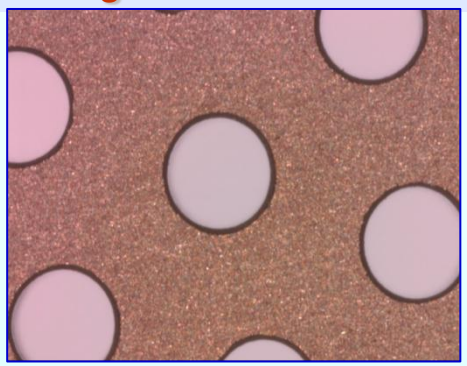
Problems we faced

Conclusions

THGEM production

Easy to get THGEM produced by industry: provide a Gerber file and a procedure to the pcb producer and place the order. High quality can be obtained, however that is not always straightforward.



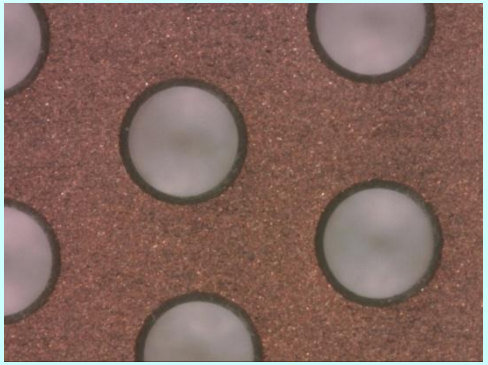


"no" rim, typical holes,

"n o" rim, bad hole

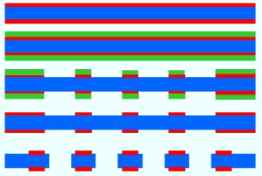
20 µm rim, typical

Example of THGEM with 100 x 100 mm2 with 20 µm rim expected, 40 µm obtained

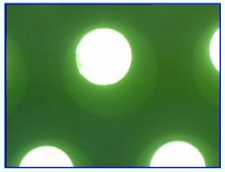


Four etching techniques:

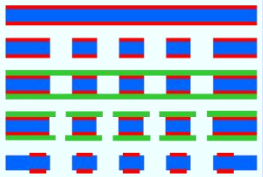
- I traditional



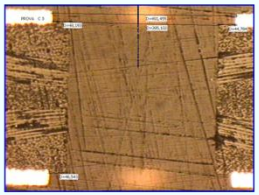
etching before drilling



- III large rim



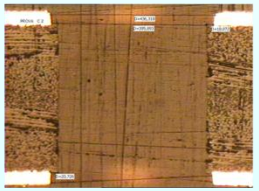
metallographic section



100 µm rim

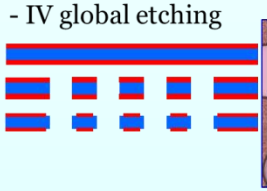
- II small rim

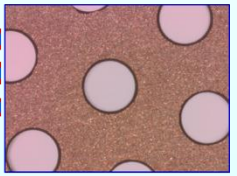
20 µm galvanic tin instead of photo-resist



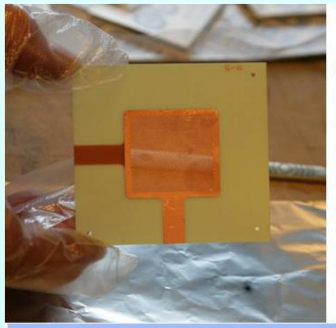
25 µm rim

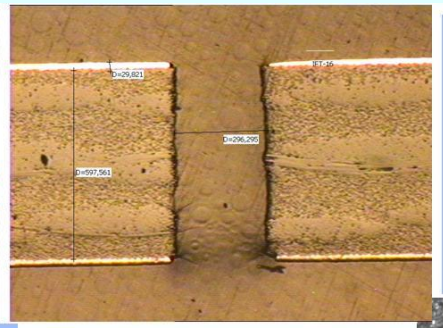
- IV global etching





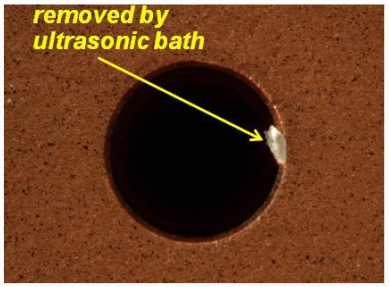
the most effective

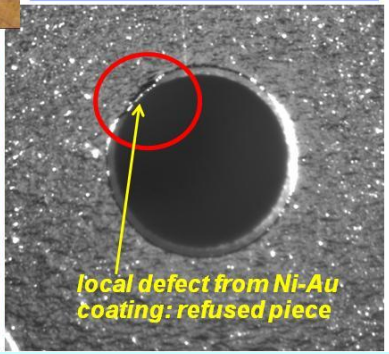




COMPASS THGEM pcb's are produced by an industrial pcb Company: ELTOS S.p.A. (Arezzo - Italy)

Defects are detected by a quality check procedure when THGEMs are received





THGEM PRODUCTION, materials

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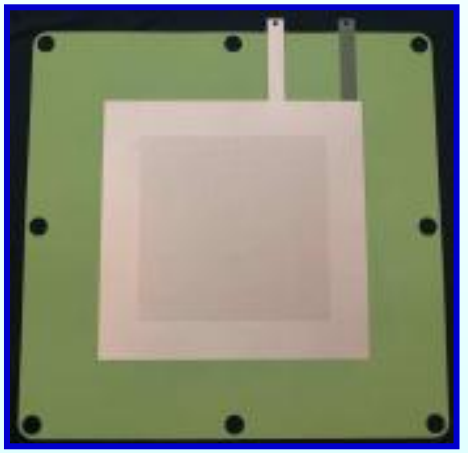
The large majority of our test using:

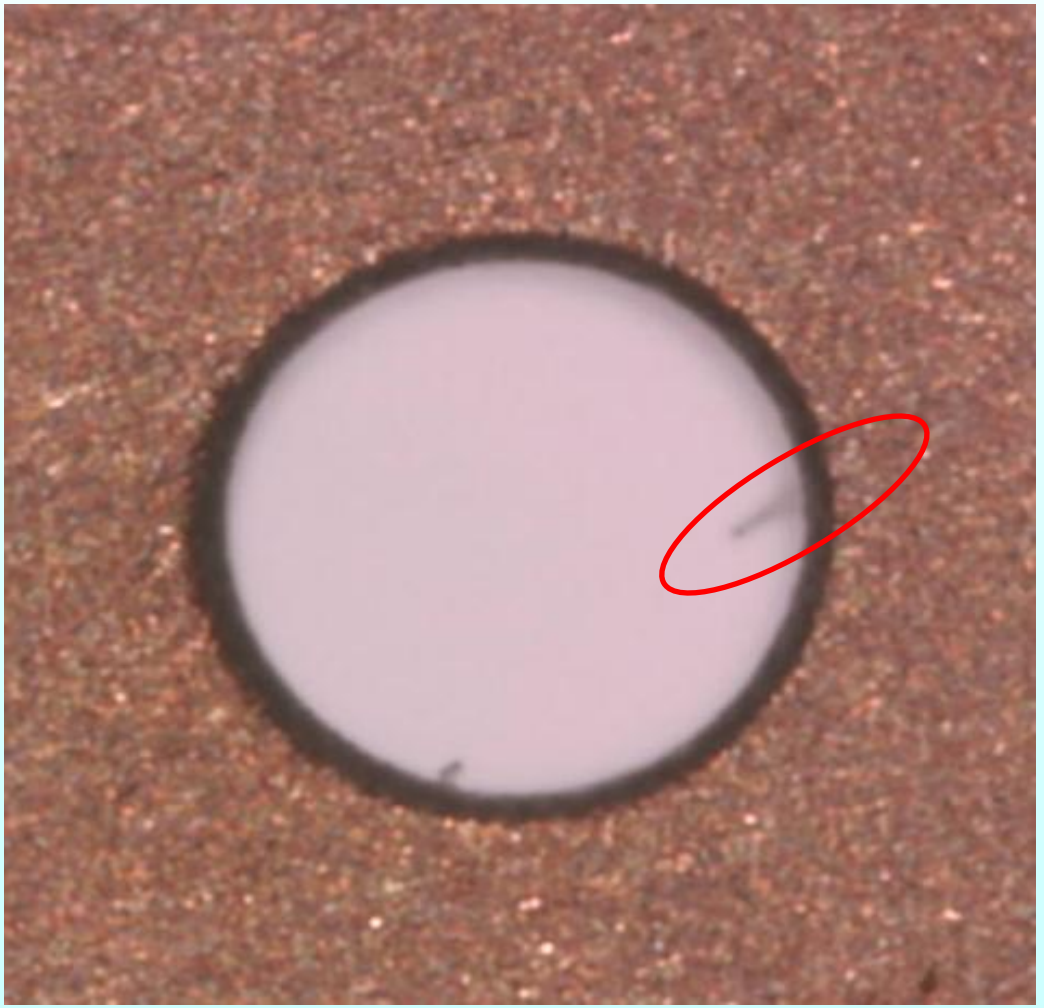


- **Halogenfree FR4, type R-1566(W) by Panasonic**
- **DE-156 Halogen free, type DE-156 by Isola**
- **A single test using Kapton, APICAL AV Kaneka Corporation**
  - **Not really stiff even if self-supporting**
- **Exotic substrates not explored by us**

Material

We tried two producers: Isola and Panasonic: no major difference seen

- Panasonic 1566 or other fiberglass is a category of fiberglass materials: the fiber size can change
  - for small holes (200, 300 microns) it is better to select the one with the smallest fiber diameter
  - During the drilling procedure some fiber remnants can stick out the hole, some mechanical process is needed to remove them (not trivial)



Production: techniques

Example of ELTOS specified production cycle

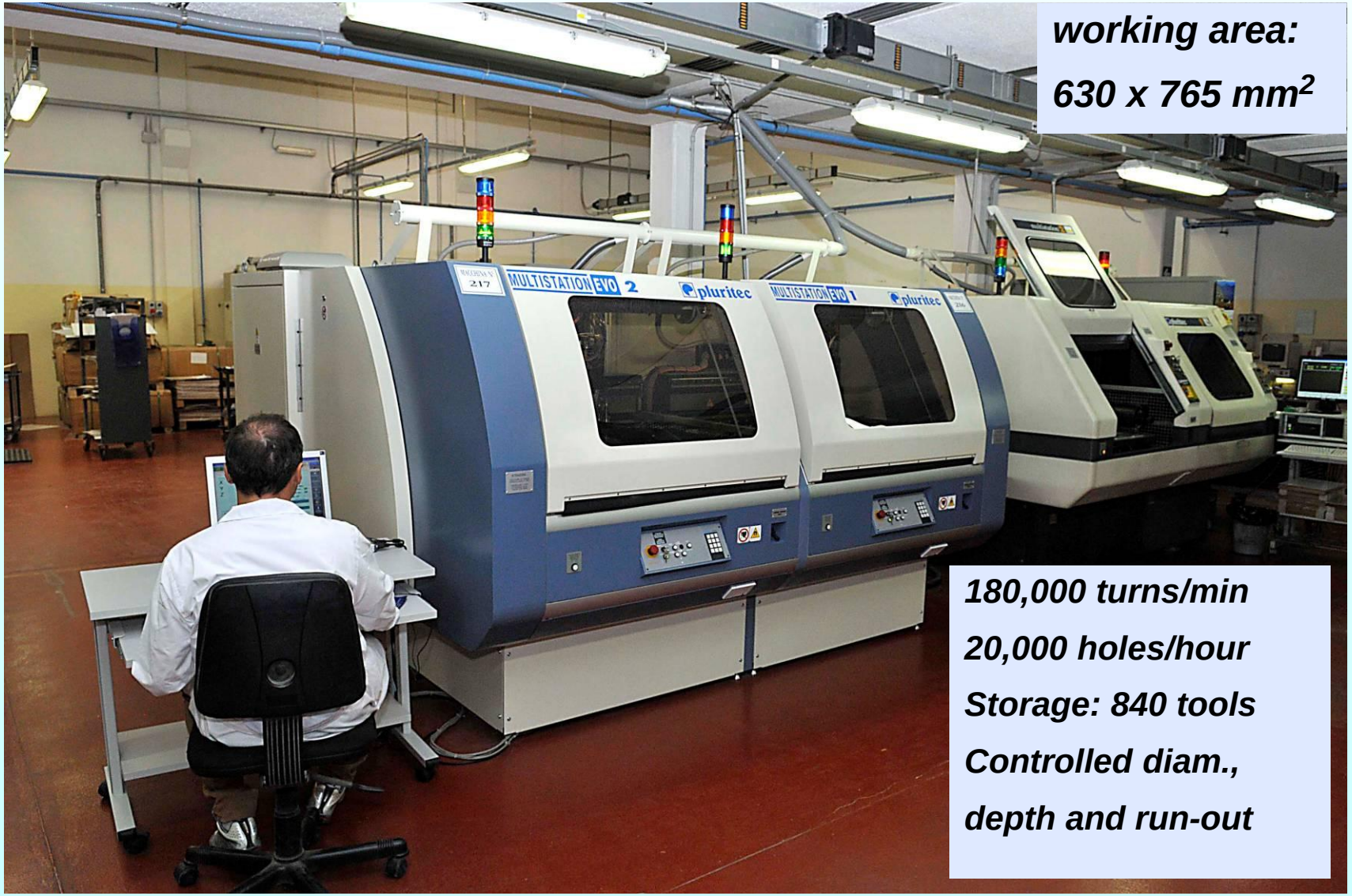
CICLO SPECIALE IFT-59					
FASE DI LAVORAZIONE	**N° QUA**	**Q.SC.**	**CS. SC.**	**DATA**	**FIRMA**
TAGLIARE 6 QUADROTTI = 0,8 35/35 338 X 375					
TAGLIARE 4 QUADROTTI = 0,4 35/35 338 X 375					
TAGLIARE 4 QUADROTTI = 0,3 35/35 338 X 375					
MATERIALE PANASONIC R-1566 HF					
STABILIZZARE INNER 140° 4 ORE					
FORATURA TOTALE					
SBAVATURA					
STAMPA ESTERNI INCISIONE DIRETTA					
INCISIONE AMMONIACALE RAME 35µ					
STRIPPAGGIO RISTON					
SCONTORNATURA					
LAVAGIO CON POMICE					
LAVAGGIO CIRCUITI AD ULTRASUONI IN ACQUA DEMINERALIZZATA					
MICROINCISIONE					
IMBALLO E SPEDIZIONE					

The selected technique for our application is based on the global micro-etching process with a well defined procedure (we tried many of them)

13 series (different rim or production)

Nam	eDrilling 0.4 mm	Rim 1 (µm)	Rim 2 (µm)	rim production	material
M1	Y	0	0	NO	Panasonic
M2	Y	25	0	Drilling	Panasonic
M3	Y	50	0	Drilling	Panasonic
M4	Y	100	0	Drilling	Panasonic
M5	Y	50	50	Two Sides Drilling	Panasonic
R	NO	NO	NO	NO	Panasonic
RI	NO	NO	NO	NO	Isola
C1	Y	10	10	Etching	Panasonic
C2	Y	25	25	Etching	Panasonic
C3	Y	50	50	Etching	Panasonic
C3I	Y	50	50	Etching	Isola
C4	Y	100	100	Etching	Panasonic
C5	Y	10	10	Laser + Etching	Panasonic
C6	Y	50	50	Laser + Etching	Panasonic
C7	Y	10	10	Global Etching	Panasonic

Pluritec Multistation Evolution (ELTOS)



working area:

630 x 765 mm^2

180,000 turns/min

20,000 holes/hour

Storage: 840 tools

Controlled diam., depth and run-out

Etching and Final THGEM stabilization

- **Micro etching**
  - **Smoothens the sharp edges and the copper residuals inside the hole, that usually ultrasonic bath can not remove**

- **The epoxy glue polymerization is usually incomplete for the standard fiberglass pieces**
  - **Eltos is applying a 4 hours baking procedure at 140 C, but it is insufficient**
  - **Full polymerization is obtained with 4 hours at 180 C**
  - **To be performed at the end of the production allowing moisture/gases to be outgassed**

THGEM RIM PRODUCTION

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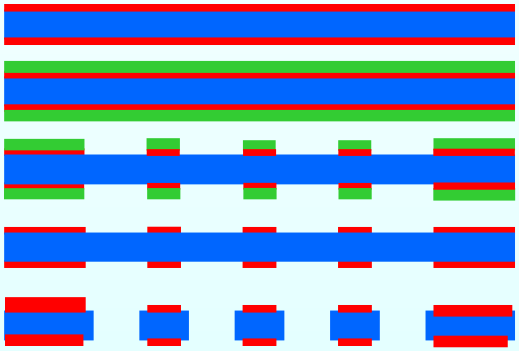
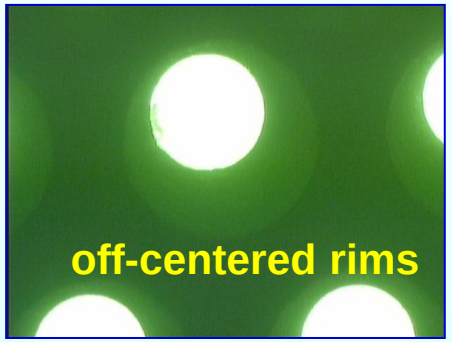
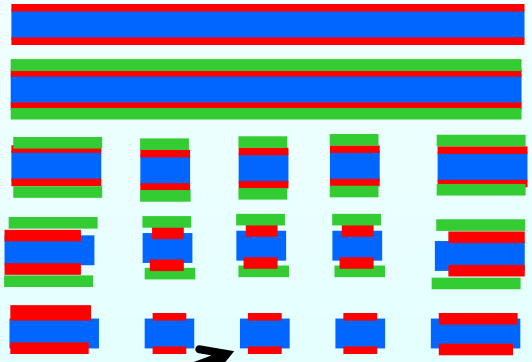
1)traditional



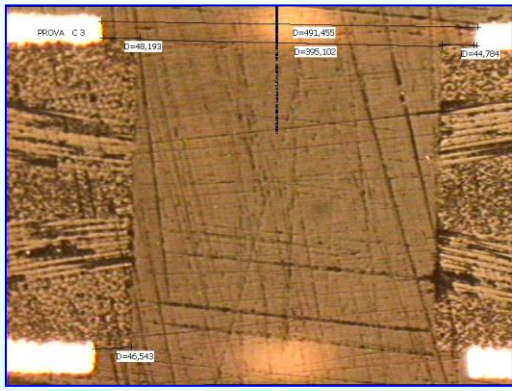
etching before drilling



2) large rim



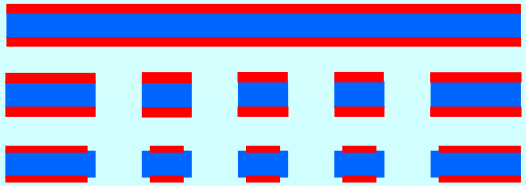
metallographic section



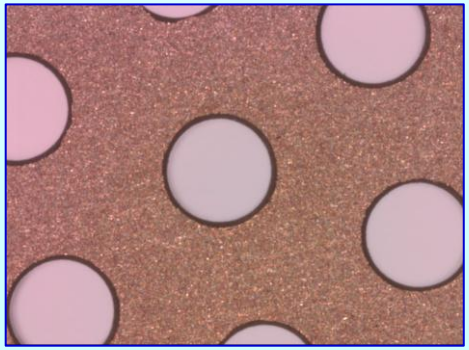
100 µm rim

CERN approaches R. De OLIVEIRA

3) *Global microetching*



uniform and smooth



our choice:
global micro-etching

Irregular rim

During the drilling of the holes part of the epoxy glue used for the fiberglass lamination is deposited onto the copper layer

The chemical bath is not effective on the area with deposited epoxy glue

The only way to avoid is to apply a desmearing: chemical attack to the epoxy glue, process to be applied before etching

Flash removals procedure is applied using abrasive material (pomice stone) in a polishing cylinder machine.

- **The procedure can be applied more than once if needed (after visual inspection)**

Protection and cleaning

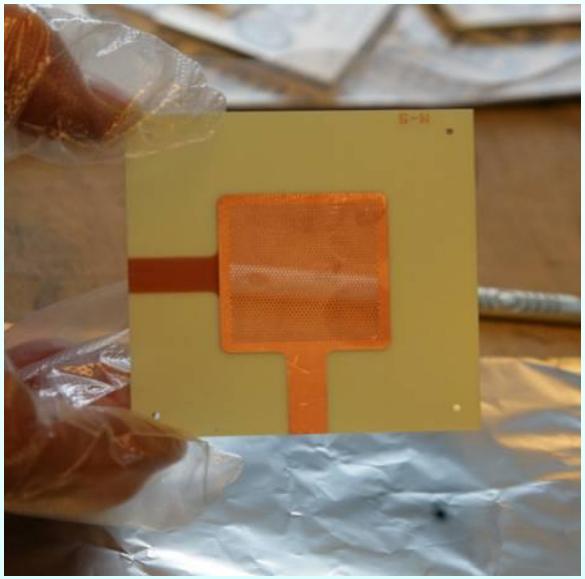
Copper protection

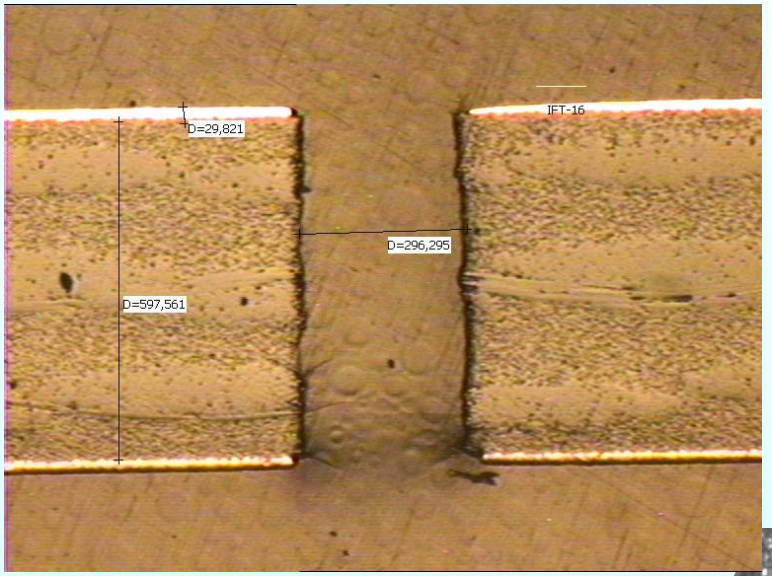
To avoid copper oxidation a passivation process can be applied using Chromic acid: same protection as gold coating but less expensive, suite for those layers which are not used as photocathode

Washing

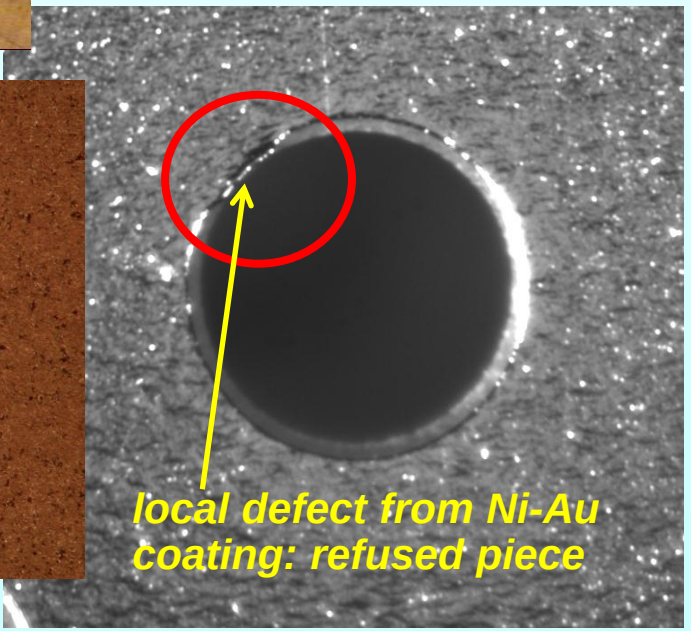
High pressure demineralized water to remove the dust residual.

THGEM quality test



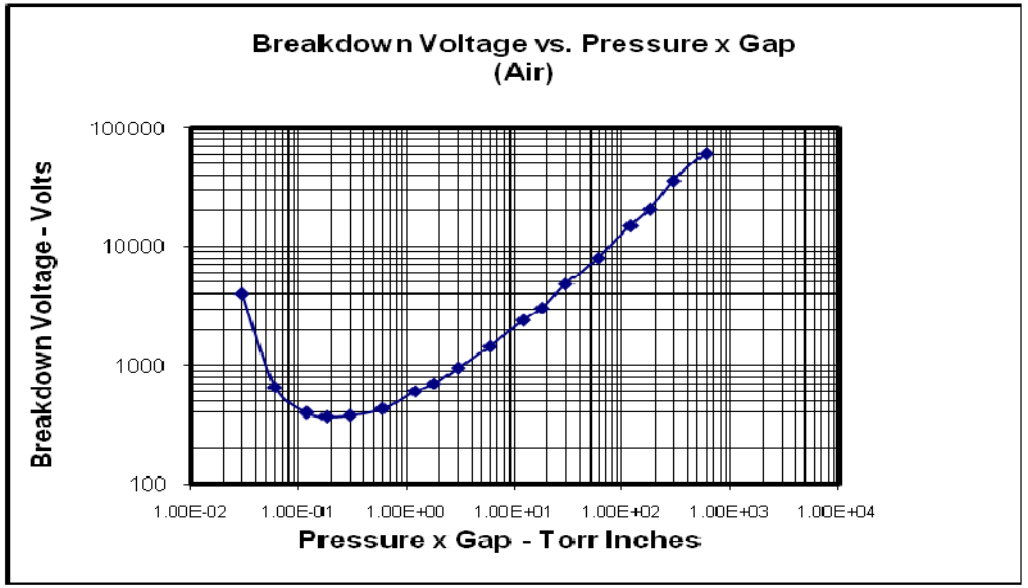


Defects are detected by a quality check procedure when THGEMs are received



Quality check

- **Visual inspection**
  - Microscope inspection to check the effect of the treatments
- **Electrical tests**



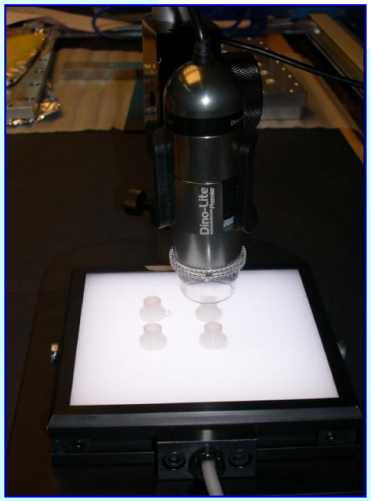
Max biasing voltage:
HV tester with nA current limit (N471A)
Must respect the Paschen curve expected value.
40% Air humidity 3kV on 0.7mm

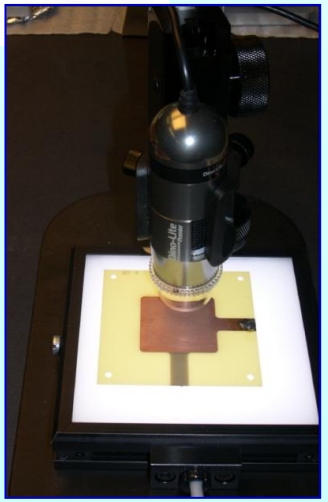
MEASUREMENT OF THE RIM SIZE

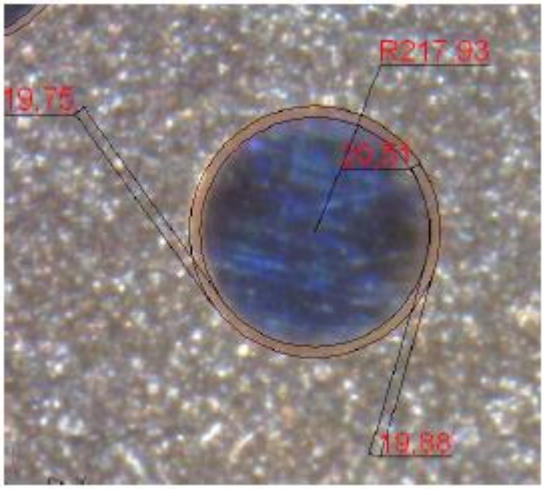
Microscope with direct USB interface to any PC:

Dino-Lite AM7013 MZT

(x 250, 5 Mpixels)







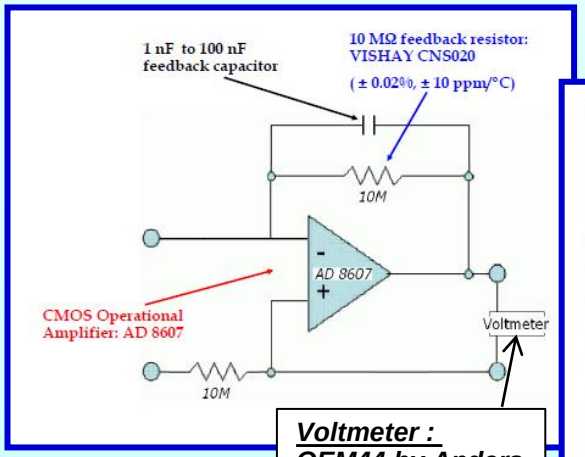
RIM measurement, method:

- ***Microscope Image***
- ***imported in AutoCad***
- ***fit of the circles***
- ***scale calibration using the radius of the hole (mechanics, i.e. good precision)***

Important tool: Picoammeters

1) **Commercial, 1 ch.**
   - **Keithley 6517A (current res. down to 0.1 pA)**

2) **Home-made, battery powered (fully floating) (current res. down to 0.1 pA)**
   - **Read-out by imaging acquisition, by a Lumenera photocamera type Lu275 [100] reading the picoammeters and a clock; off-line data processing via a MATLAB-based application performing pattern recognition**

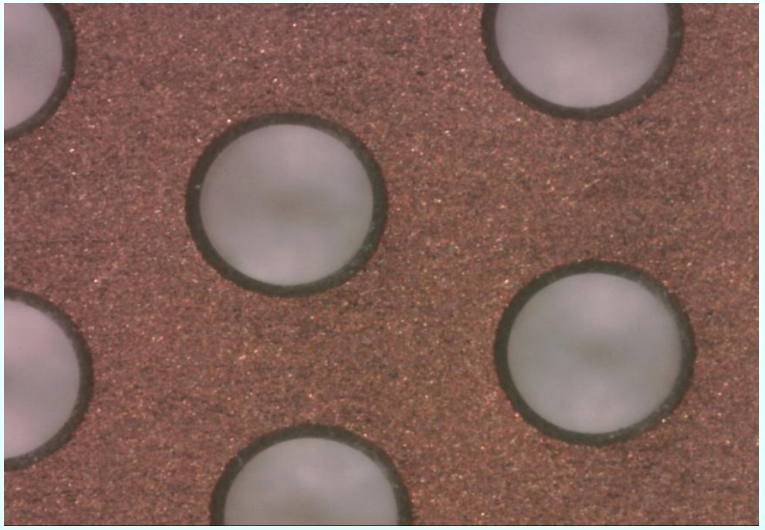


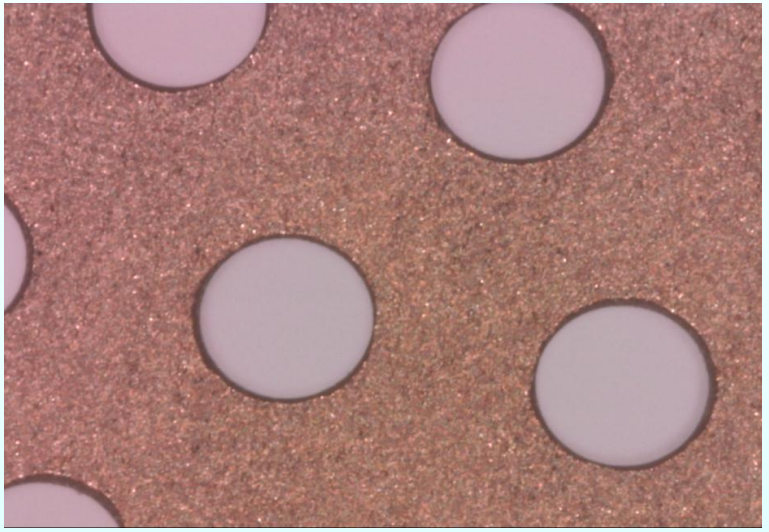
Voltmeter : OEM44 by Anders

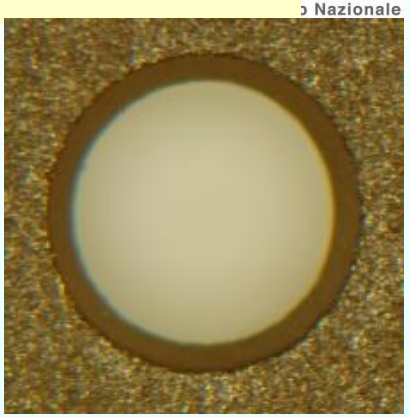
various problems we faced

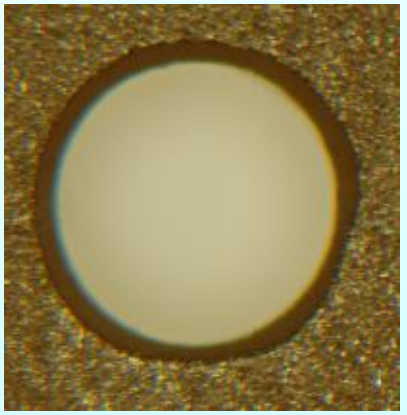
- Quality of the raw fiberglass: thickness uniformity, glass fibre quality
- Drilling uniformity (decision: change tool every 1000 holes)
- Hole edge quality: Cu detachment, badly cut fibres
- Remnants from production phases: photoresist or other products
- Spikes or sharp edges (decision: microetching)
- Rim defects: non uniformity, incorrect rim size, incorrect centering
- Isolated holes with rim in a no-rim THGEM (decision: external printing first)

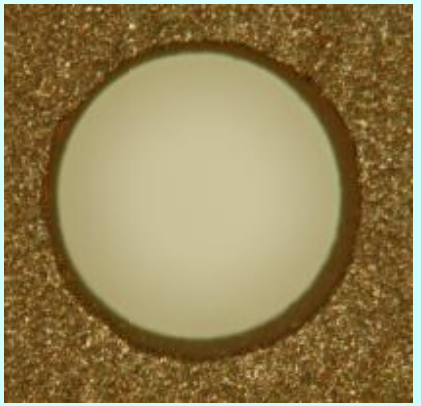
Problem: control of rim quality and size

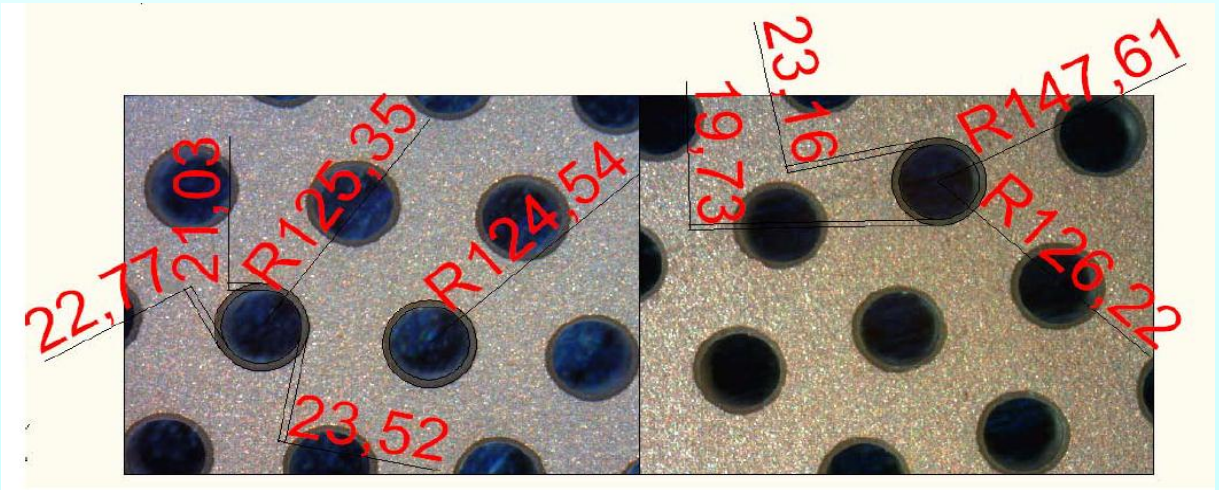












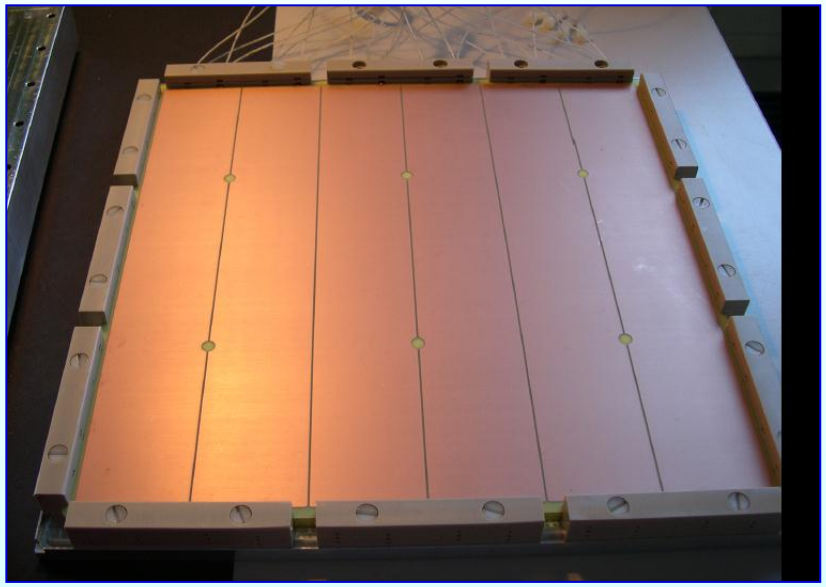
expected rim: 20 µm
measured rim: 40 µm

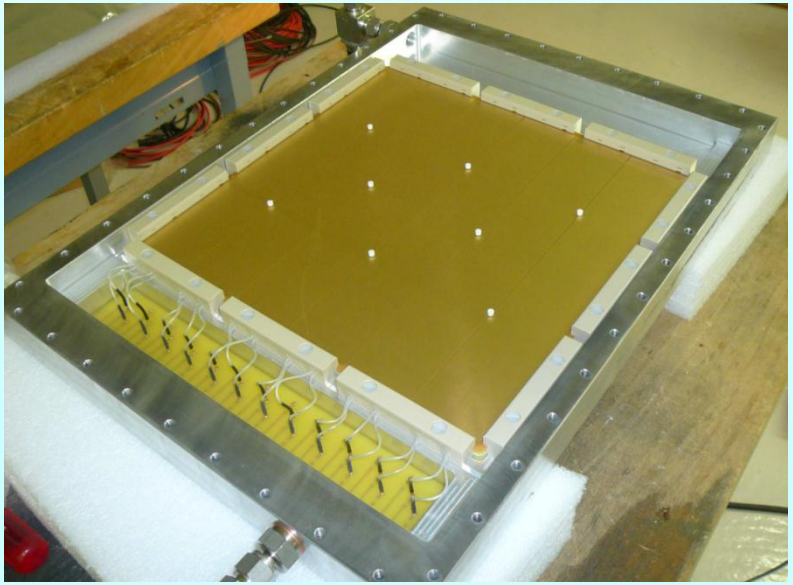
100 x 100 mm² prototipes

now we use very small rim

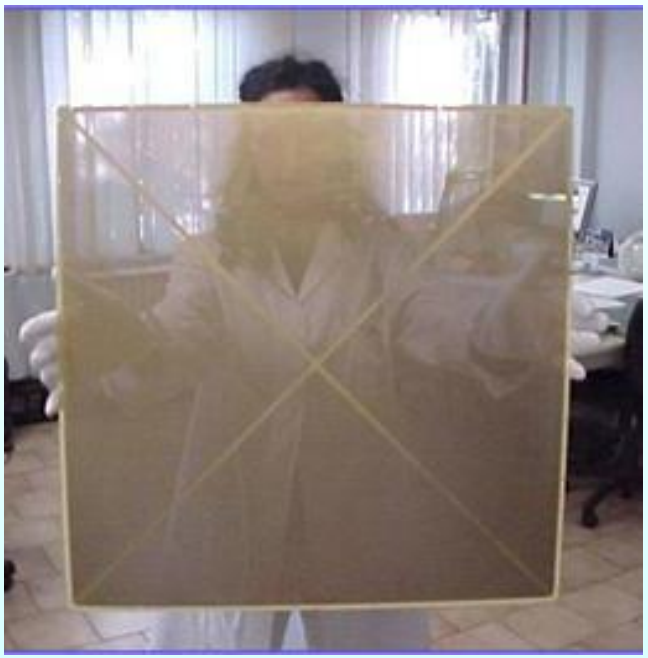
large THGEM production

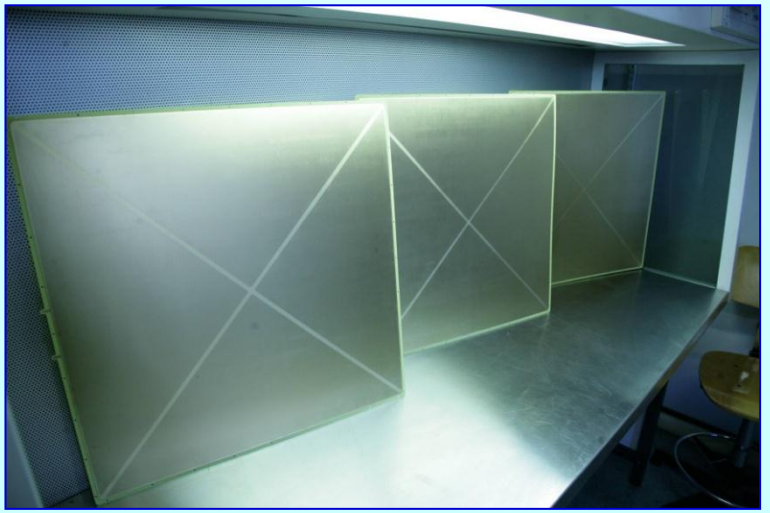
"Standard" THGEMs 300 x 300 mm^2





Test production of 600 x 600 mm^2





300 x 300 mm² THGEMs planarity

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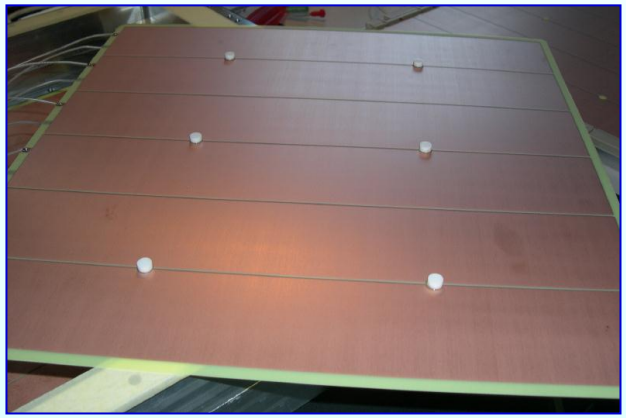
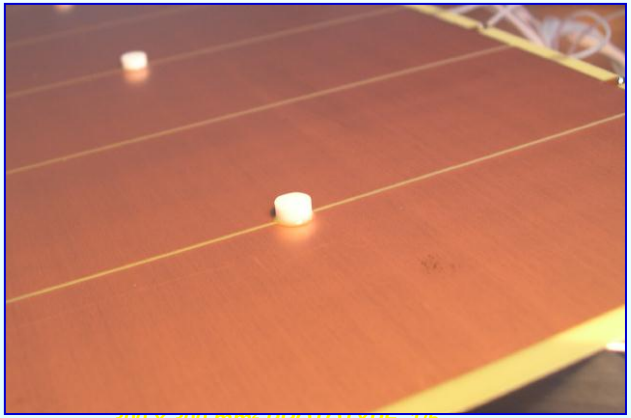
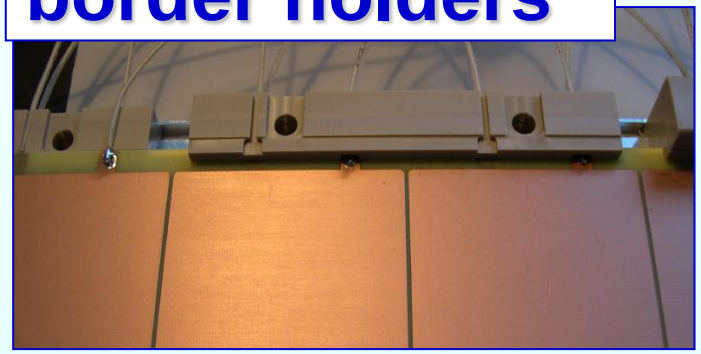
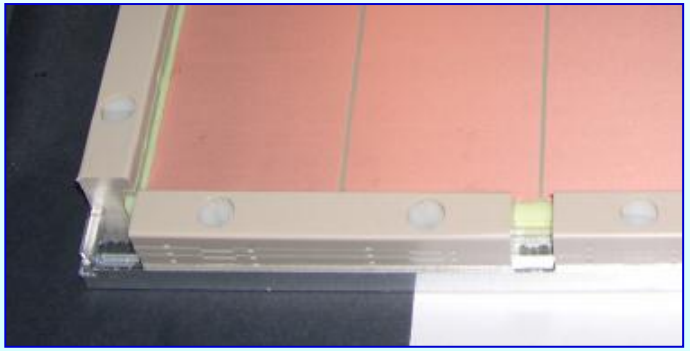
central holders

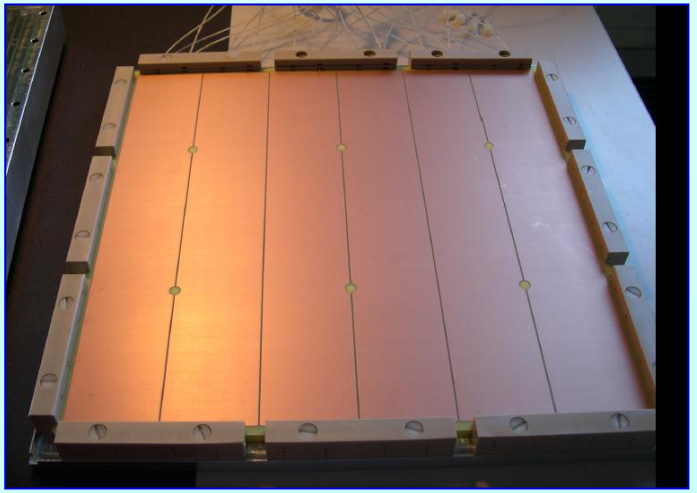




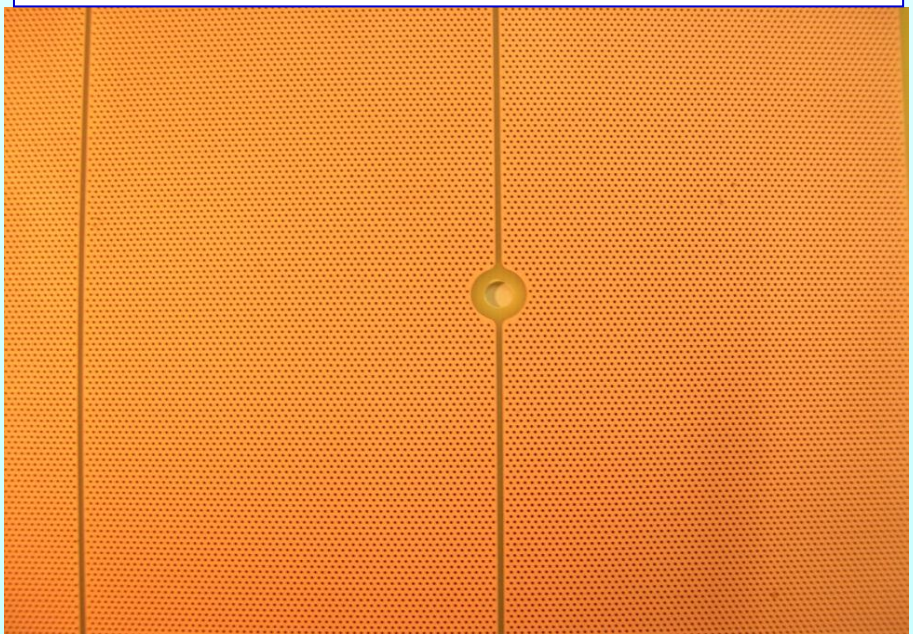
border holders

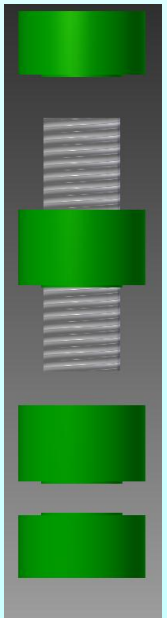






new solution





Summary of ELTOS THGEM production

- About 60 different type of THGEMs produced for our R&D by ELTOS (~500 pieces in total) 30x30, 100x100, 300x300
- Most of the production has very good quality drilling
- Many small problems have been faced and solutions found
- Converging toward a standard production procedure
- Small area THGEMS well understood
- Mastering of large area production is progressing