

WA105

DE LA RECHERCHE À L'INDUSTRIE

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STATUS OF THE PREPARATION FOR THE LEM (AND ANODE) PRODUCTION

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October 19th 2016

Technical Board vidyo meeting, october 19th, 2016

- Review of the LEM production sequence
- Technical specifications document for the LEM production call for tender
- Comparison of performances of LEMs produced by ELTOS (It) and ELVIA (Fr)
- Status of the LEM cleaning and testing equipments at Saclay
- Anode PCB specifications
- Conclusion



IDENTIFIED LEM MANUFACTURING C^{IES} ELVIA C^{IE} (COUTENCES, FRANCE) & ELTOS (IT)

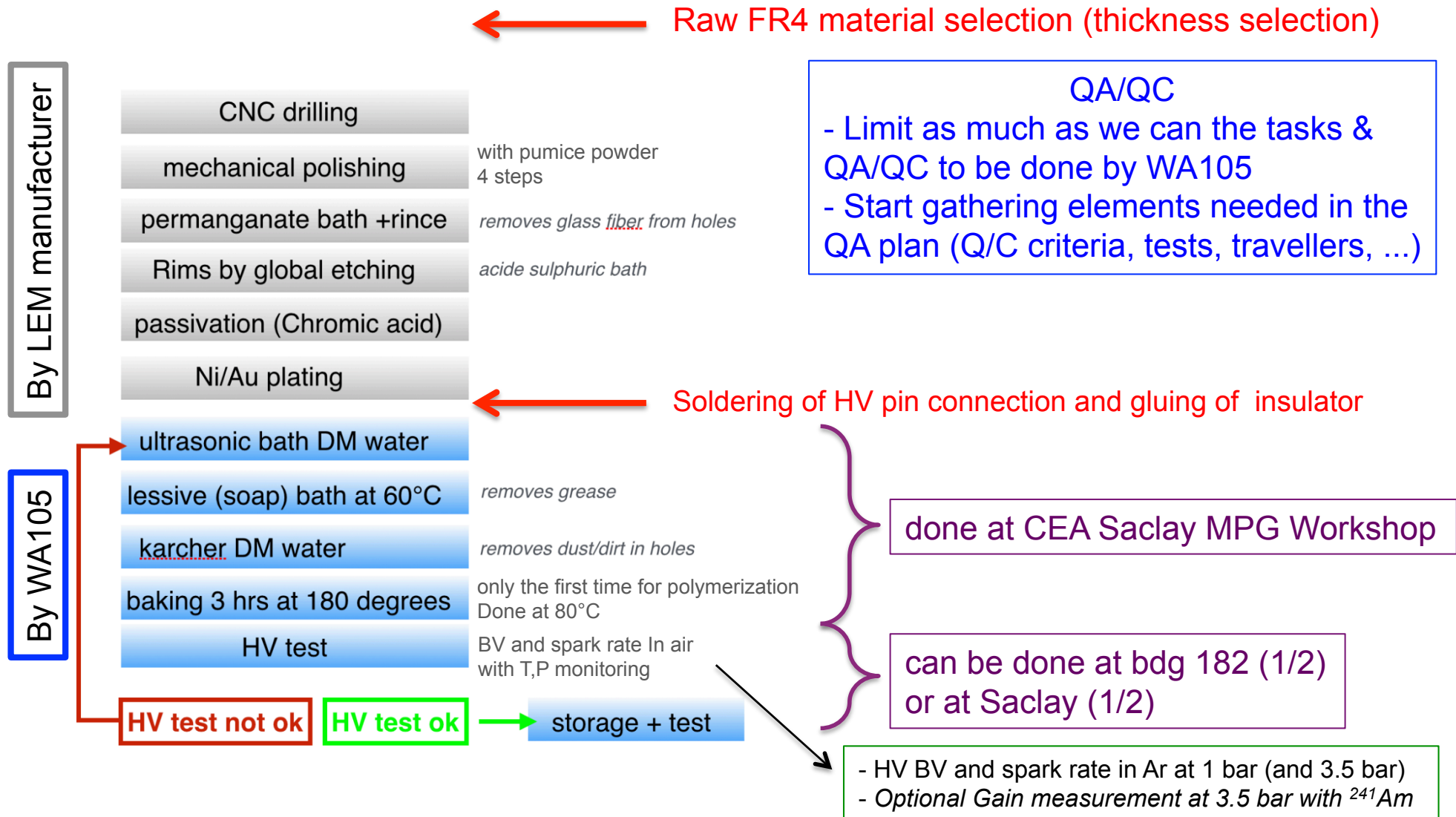
WA105

- Gathering of informations from the THGEM community, Sebastien M., CERN MPGD workshop, and ELTOS to derive the guidelines for LEM manufacturing according to the know-how on THGEM production.

- First contact with ELVIA in march and delivery on april 25th of four 10x10 cm² LEMs : Breakdown Voltage (BV) tests in ambient air at Saclay MPGD workshop, before and after “Saclay” cleaning procedure + gain measurement @ 1 bar (²⁴¹Am)
→ as good as ELTOS 10x10 cm² LEMs and even better after cleaning (BV≈4500 V)
- Meeting at ELVIA Coutences site on may 9th to review the “actual” procedure followed by ELVIA and set the procedure for the production of four 50x50 cm² LEMs
 - Procurement & selection of raw FR4 plates for < 4% thickness uniformity
 - Add a mechanical “polishing” step (before Ni/Au) for 2 of the 4 LEMs

- Four 50x50 cm² “3x1x1 WA105” LEMs produced and received on june 29th :
 - BV test in test box filled with synthetic air and 5.0 Argon (LEM “as received”)
 - As good as the 25x25 cm² ELTOS “Saclay cleaned” LEMs
 - To be done : test again after “Saclay cleaning” and perform gain measurement in HP vessel in 5.7 argon at 1 bar & 3.5 bar.

- We (Eddy & myself) had a meeting at ELTOS on july 25th to review the LEM prod.



Procurement of raw material in one batch at the beginning of the contract

← Raw FR4 material selection (thickness selection)

QA/QC in LEM manufacturing company

- Standard PCB QA/QC with A.O.I
- Measurements of thicknesses and rim dimensions on metallographic sections associated to each produced LEM
- *Optional HV test in ambient air*

By LEM manufacturer

- CNC drilling
- mechanical polishing with pumice powder
4 steps
- permanganate bath +rinse removes glass fiber from holes
- Rims by global etching acide sulphuric bath
- passivation (Chromic acid)
- Ni/Au plating

← Soldering of HV pin connection and gluing of insulator

By WA105

- ultrasonic bath DM water
 - lessive (soap) bath at 60°C removes grease
 - karcher DM water removes dust/dirt in holes
 - baking 3 hrs at 180 degrees only the first time for polymerization
Done at 80°C
 - HV test BV and spark rate In air
with T,P monitoring
- HV test not ok
HV test ok
→ storage

done at CEA Saclay MPG Workshop

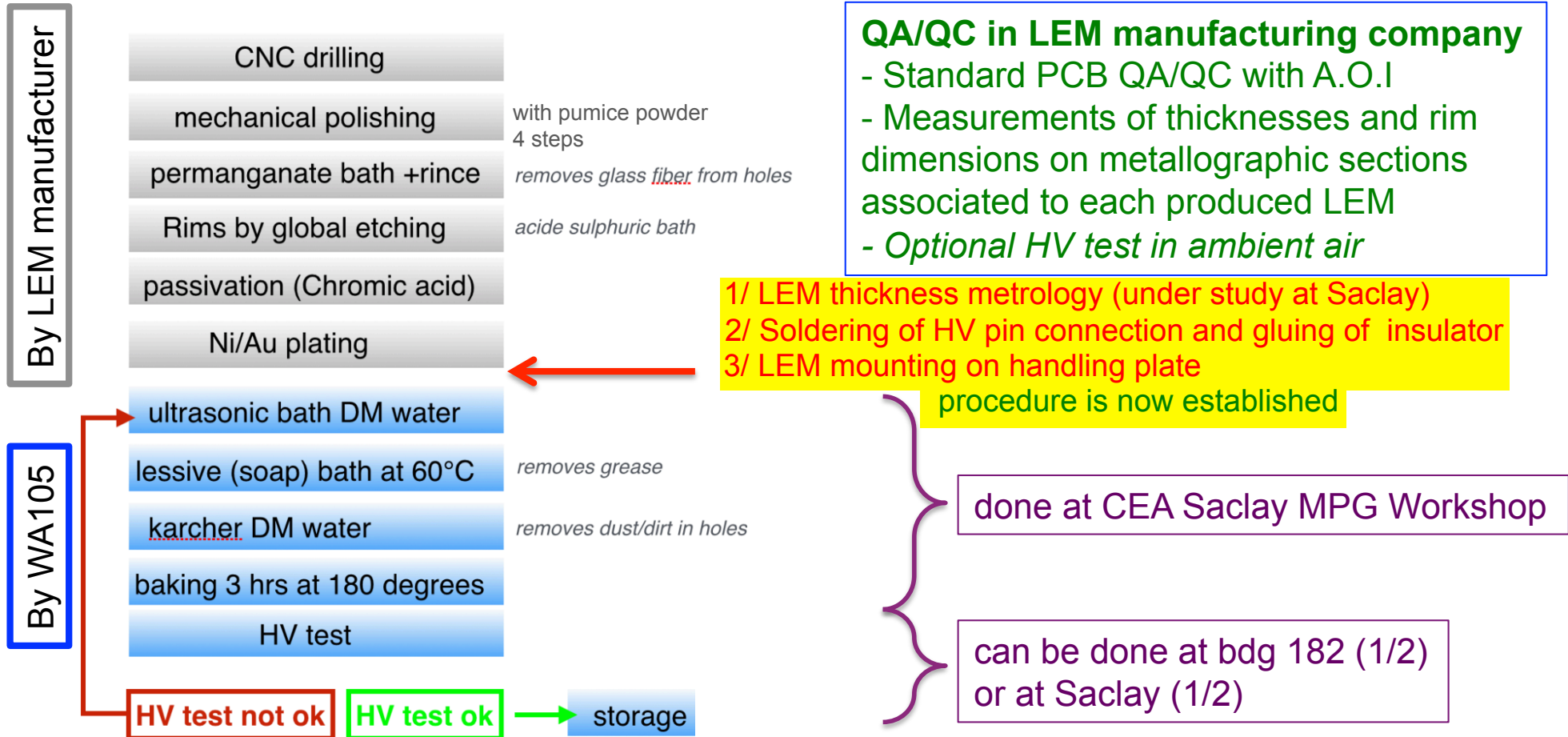
can be done at bdg 182 (1/2)
or at Saclay (1/2)

LEM MANUFACTURING PROCEDURE

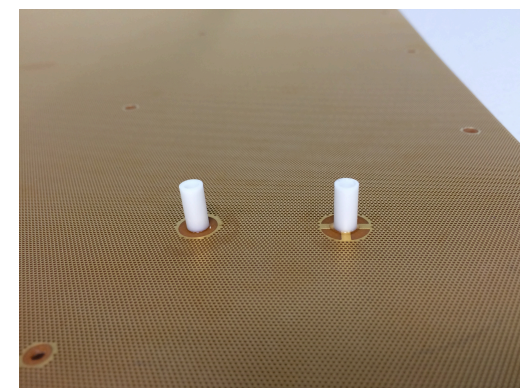
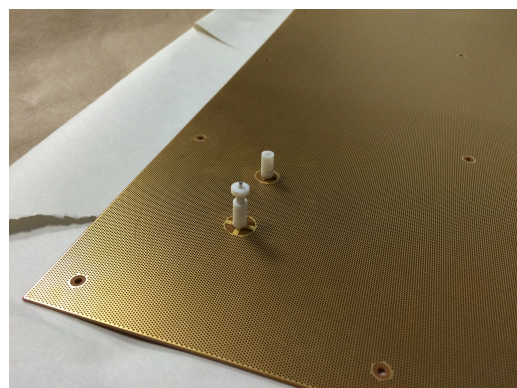
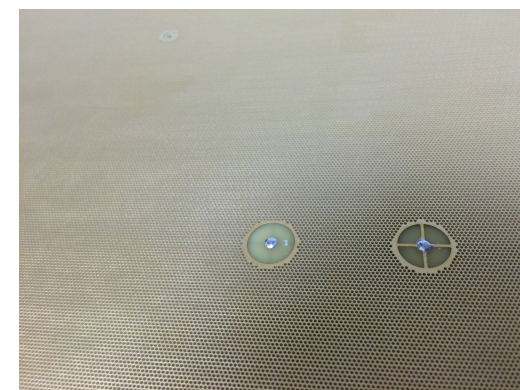
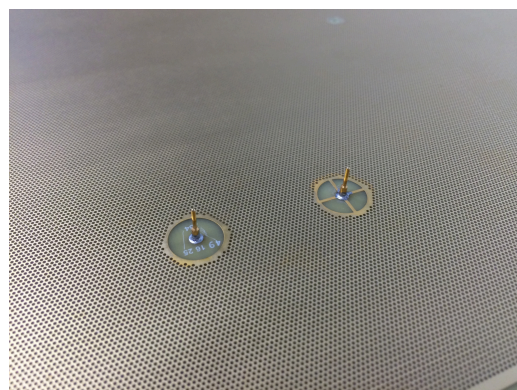
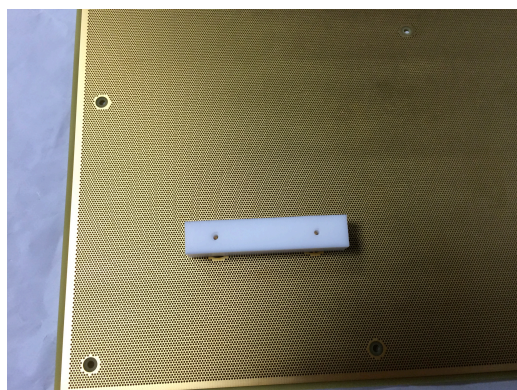
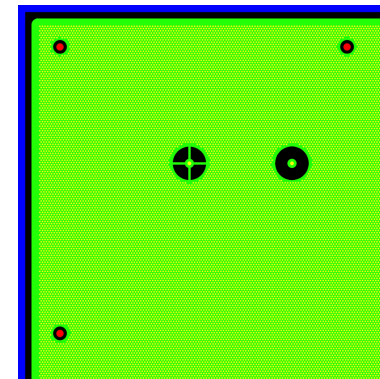
FIRST TASKS ONCE LEM DELIVERED

Procurement of raw material in one batch at the beginning of the contract

← Raw FR4 material selection (thickness selection)



- The proposed procedure was tested on 25x25 & 50x50 prototypes
- Solder pins with Core 230 no-clean wire solder
 - Use of a dedicated tool to position and maintain pins while soldering
 - Modified LEM PCB copper pattern and through hole diameter
 - Gluing of the POM insulating cylinders with 2010 Araldite using a centering tool



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- *Optional HV test in ambient air*

By LEM manufacturer

- CNC drilling
- mechanical polishing with pumice powder 4 steps
- permanganate bath +rinse removes glass fiber from holes
- Rims by global etching acide sulphuric bath
- passivation (Chromic acid)
- Ni/Au plating

- 1/ LEM thickness metrology (under study at Saclay)
- 2/ Soldering of HV pin connection and gluing of insulator
- 3/ LEM mounting on handling plate

By WA105

- ultrasonic bath DM water
- lessive (soap) bath at 60°C
- karcher DM water + regular water rining before DM water
- baking 3 hrs at 80°C degrees Polymerization at 160°C (instead of 180°C according to Tg)
- HV test
- HV test not ok
- HV test ok
- storage

“Saclay Cleaning”
3 mn Ultrasonic bath at 65°C with Soap NGL 17.40 sp. ALU III

procedure is now established

done at CEA Saclay MPG Workshop

can be done at bdg 182 (1/2) or at Saclay (1/2)

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can be done at bdg 182 (1/2) or at Saclay (1/2)


HV test not ok → HV test ok → storage

- HV BV and spark rate in Ar at 1 bar (and 3.5 bar)
- *Optional Gain measurement at 3.5 bar with ²⁴¹Am*

→ 2 batches of 6 LEMs is foreseen to be done every week
 → Dismounting from handling plate → LEM mounting on anode PCB (?) → packaging & shipping

After discussions at Irfu and given the very tight schedule for the beginning of the CRP production for the 6x6x6, we believe it will be easier and quicker for us to go through a tendering process for half of the production of the LEMs through the “Service Commercial” in Saclay (instead of CERN procurement office).

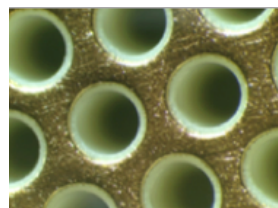
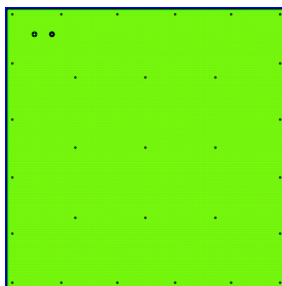
Matière de base	Approvisionnement en un lot de fabrication en début de production
Matériau	Résine epoxy PANASONIC R-1755C (or R-1566W ? - ELVIA)
Dimensions	530 mm x 530 mm mini
Épaisseur de résine epoxy	1 mm (-0.04 /+0 mm selon les spécifications PANASONIC du lot)
Épaisseur de cuivre	105 µm
Épaisseur totale moyenne	1,21 (-0.04/+0) mm +/- 0.04 mm sur les 88 plaques sélectionnées
Uniformité d'épaisseur	+/- 0.04 mm (sur la surface de la plaque de base sélectionnée)
PCB LEM fini	
Dimensions	499.5 mm x 499.5 mm +0/-0.2 mm
Couche de finition Ni/Au	OUI : 5 µm Ni + 0.1 µm Au
Sérigraphie	OUI (si choisie pour marquage d'identification du circuit)
Vernis épargne	NON
Épaisseur finale (Ni/Au compris)	1.15 (-0.04/+0) mm +/- 0.04 mm (moyenne sur 88 LEM et uniformité sur la surface du LEM)
Trous « actifs » avec RIM	≈ 400 000 trous non-métallisés de diamètre 0.5 mm
RIM (fini avec Ni/Au)	40 µm +/- 4 µm

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	LEM DU PROTYPE WA105 (DUNE/DP)	<i>Réf : CdCLEMWA105Fr</i> <i>Page 2 sur 20</i>

CAHIER DES CHARGES ET DES SPECIFICATIONS TECHNIQUES

PRODUCTION DES LEM DU PROTOTYPE WA105 (DUNE/DP)



HISTORIQUE DES MODIFICATIONS

Version	Date	Pages modifiées	Motifs
DRAFT	30/09/2016	Création	Pour diffusion restreintes et corrections
DA			Pour diffusion initiale pour l'appel d'offre

Rédacteurs		Vérificateurs		Approbateur
Nom	A. DELBART	E. MAZZUCATO	Y. PENICHOT	M. ZITO
Fonction	Chef de Projet	Resp. Physicien	Resp. QA	Resp. Scientifique
Date				
Visa				

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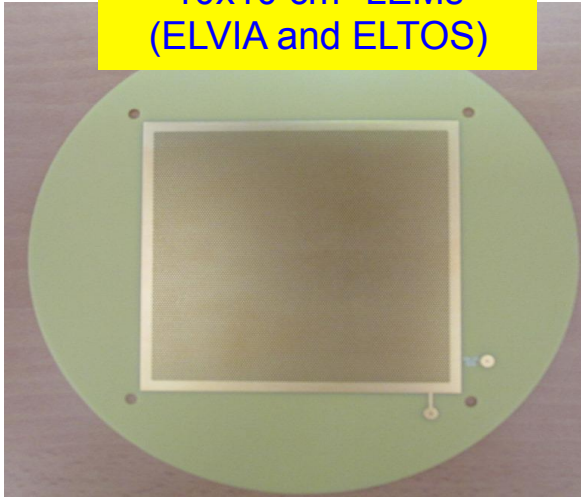
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Schedule	
T0	Signature of the contract & kick-off meeting
T0 + 2 weeks	Pre-production kick-off meeting Delivery of the LOFC (PAQ), gerber SAB, documentation as described in section 3.1
T0 + 5 weeks	Pre-production Acceptance meeting for the delivery of the 8 pre-series LEM and associated documentation.
T0 + 7 weeks	Production kick-off meeting and delivery of 3 batches of 24 LEM every 3 weeks . Decision for production of optional y<8 LEM before the start of the production of the last batch
T0 + 16 weeks	Closing meeting

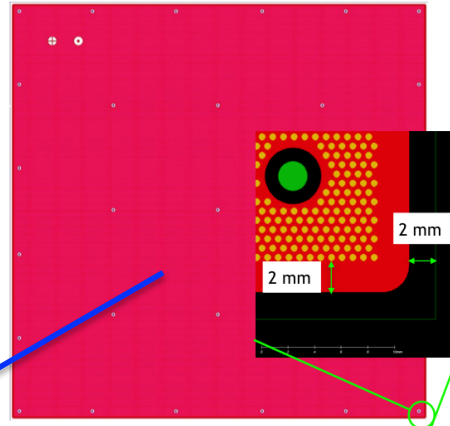
■ The List Of Manufacturing Operations and Controls (LOFC) and the Manufacturing Operations and Controls Traveller will be asked to the applicants with their offer and included as a criteria for company selection.

■ The “Technical specifications” document is under discussion with the Commercial Division of CEA-Saclay. A “procurement officer” is identified and is currently preparing the documents for the call for tender. The invitation to tender may be published and opened in november for a selection of the company(ies) before christmas. Start of production will be triggered according to WA105 collaboration decision after test and qualification of the performances of the LEMs in the 3x1x1 prototype.

10x10 cm² LEMs
(ELVIA and ELTOS)

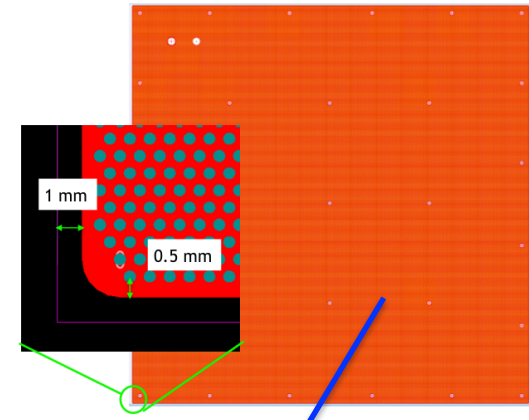


50x50 cm² LEM with 2 mm guard ring
and 2 mm FR4 clearance for cold test

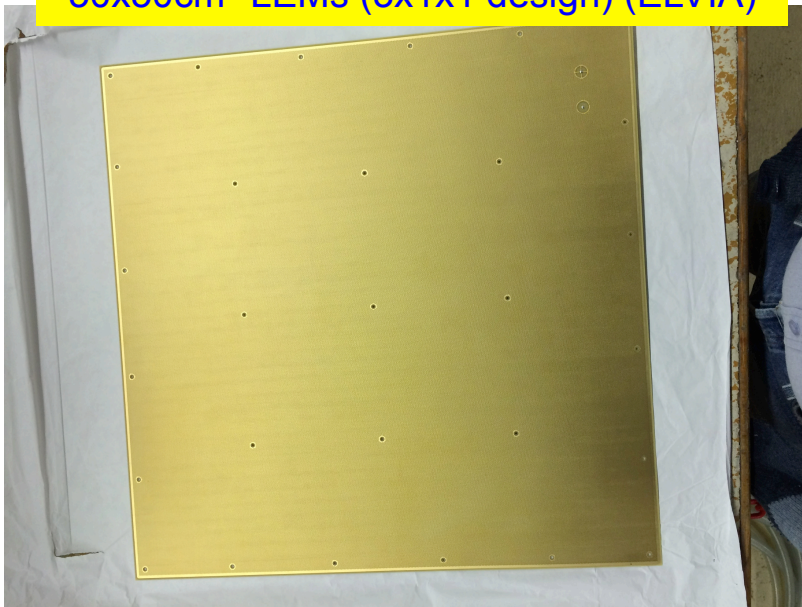


proposal:

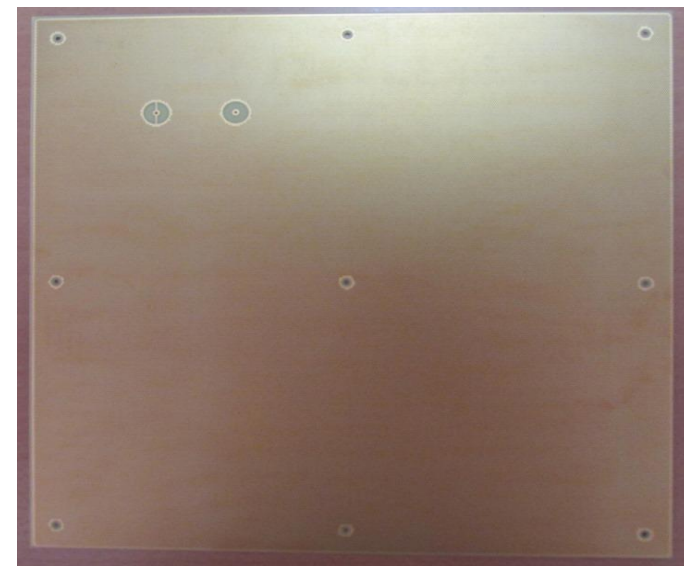
50x50 cm² LEM with 0.5 mm guard ring
and 1 mm FR4 clearance



50x50cm² LEMs (3x1x1 design) (ELVIA)

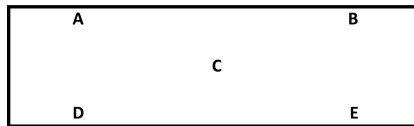


25x25cm² LEMs (ELTOS)



Matière PANASONIC R-1566W
1mm diélectrique + cuivre 105/105

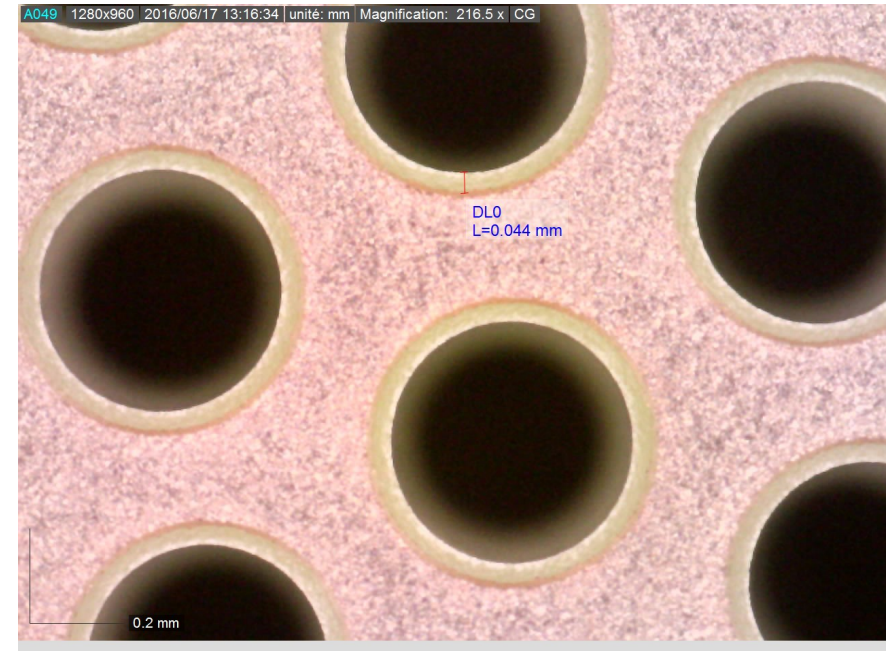
Lot : EP22534



Avec Cuivre
Diélectrique seul

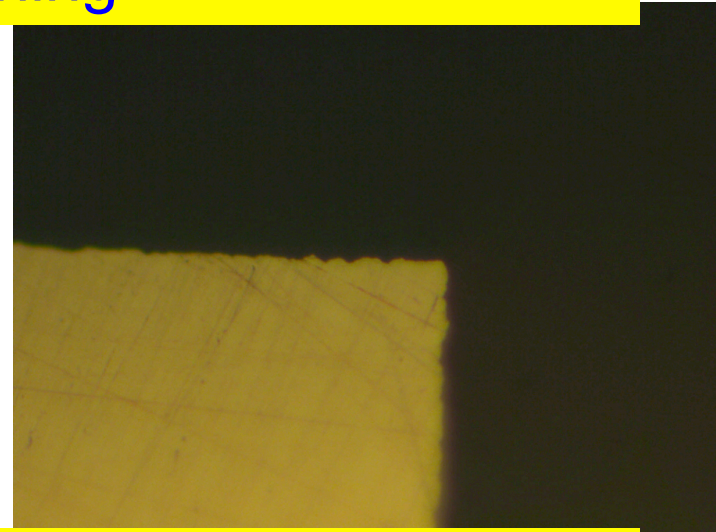
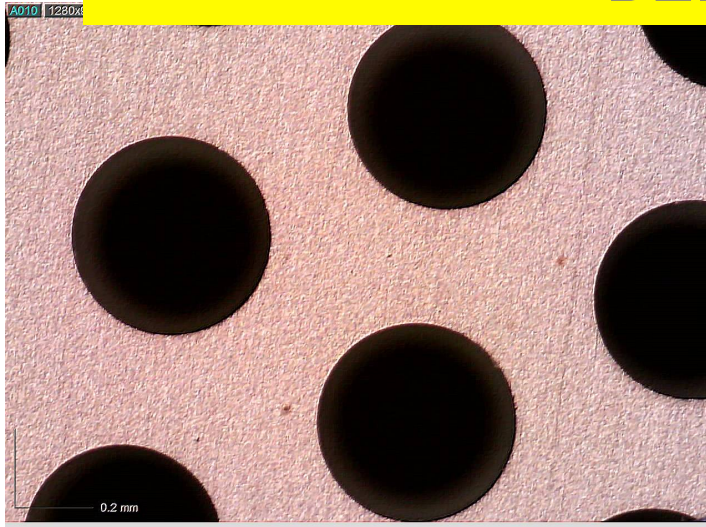
	A	B	C	D	E	moy
1	1100 900	1180 980	1170 970	1170 970	1200 1000	1164 964
2	1200 1000	1190 990	1200 1000	1170 970	1150 950	1182 982
3	1210 1010	1180 980	1200 1000	1140 940	1150 950	1176 976
4	1200 1000	1190 990	1170 970	1170 970	1150 950	1176 976
5	1200 1000	1190 990	1170 970	1130 930	1160 960	1170 970
6	1170 970	1180 980	1200 1000	1150 950	1180 980	1176 976
7	1200 1000	1200 1000	1160 960	1170 970	1140 940	1174 974
8	1140 940	1190 990	1160 960	1160 960	1150 950	1160 960
9	1190 990	1200 1000	1160 960	1150 950	1150 950	1170 970
10	1200 1000	1200 1000	1190 990	1170 970	1150 950	1182 982
11	1180 980	1190 990	1170 970	1150 950	1140 940	1166 966
12	1160 960	1140 940	1100 900	1200 1000	1150 950	1150 950
13	1200 1000	1200 1000	1170 970	1120 920	1100 900	1158 958
14	1150 950	1120 920	1090 890	1200 1000	1150 950	1142 942
15	1150 950	1170 970	1190 990	1140 940	1170 970	1164 964
16	1200 1000	1180 980	1170 970	1160 960	1130 930	1168 968
17	1180 980	1170 970	1140 940	1130 930	1100 900	1144 944
18	1180 980	1170 970	1150 950	1140 940	1100 900	1148 948
19	1180 980	1170 970	1160 960	1120 920	1110 910	1148 948

RIM before Ni/Au finish (5 μm)

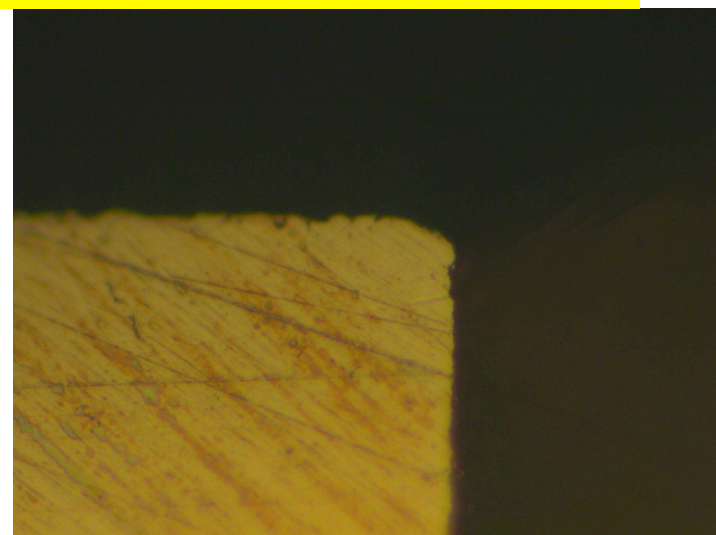
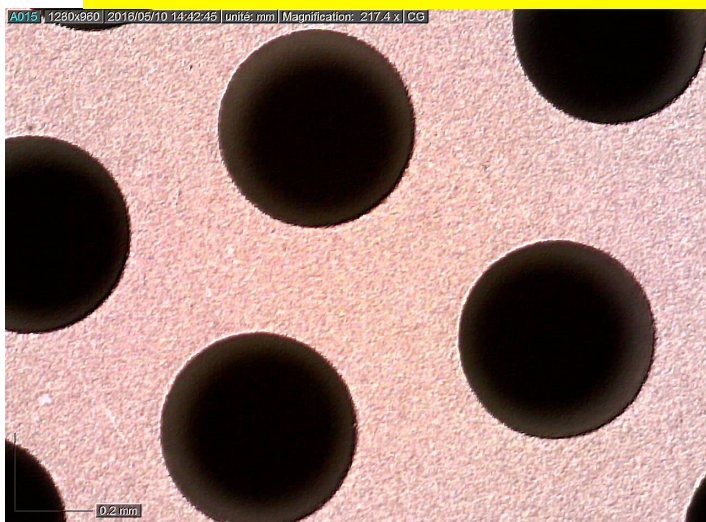


2 of the 4 LEMs were shipped to CERN
and are currently under thickness
metrology

BEFORE polishing



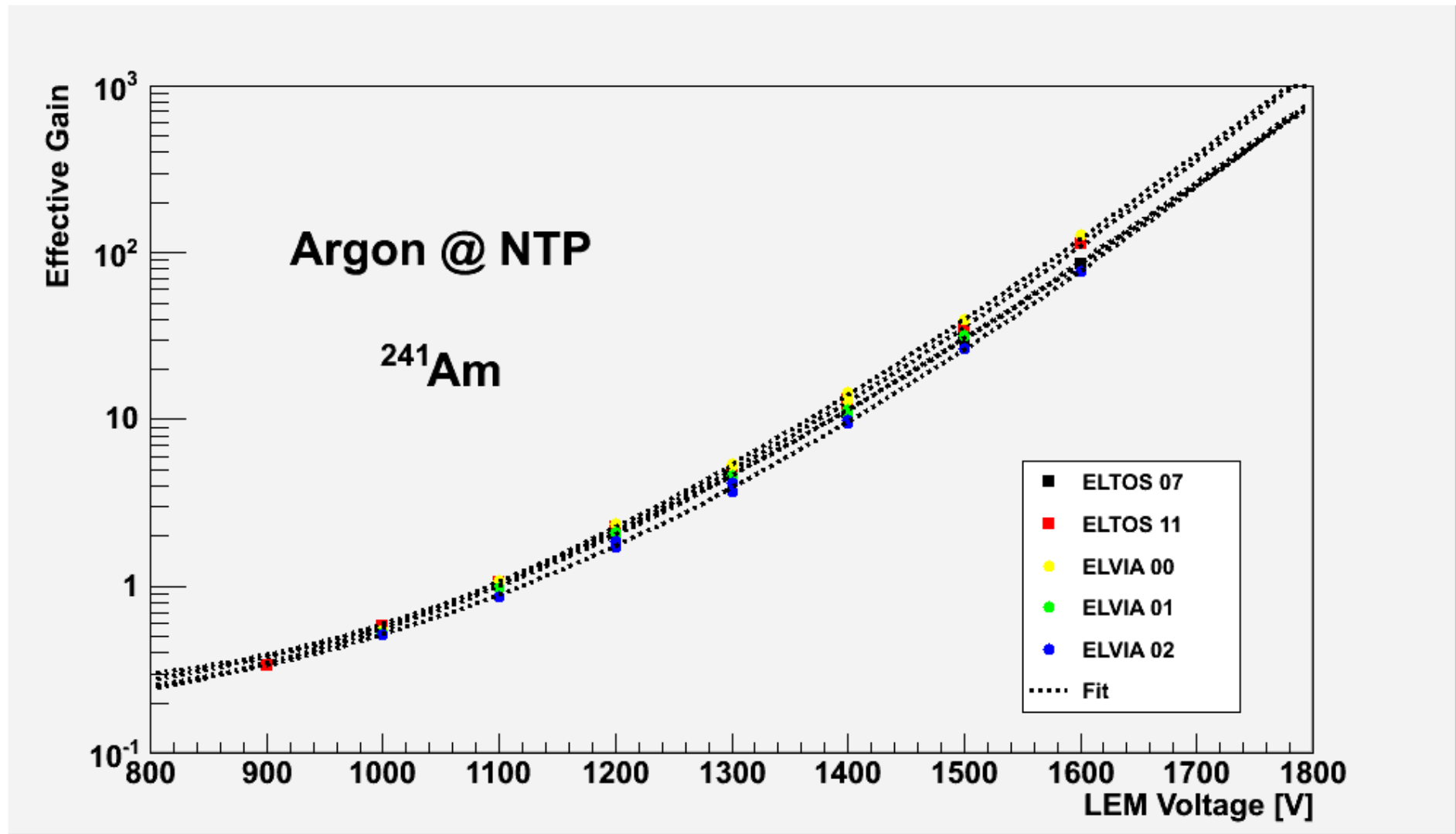
AFTER polishing

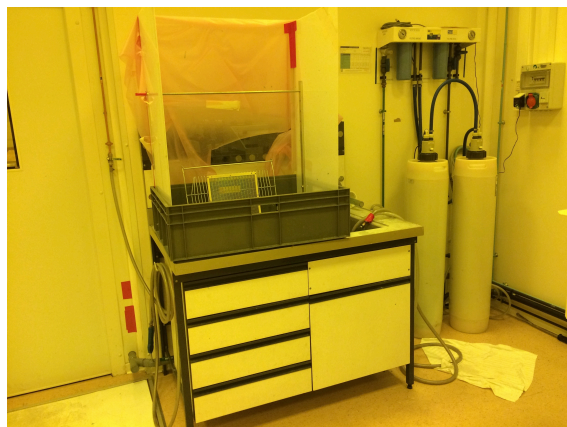


- ELVIA uses PANASONIC R-1566W halogen free FR4 (130-140 °C Tg)
 - ELTOS uses PANASONIC R-1755C halogen free FR4 (150 °C Tg)
- Material choice for WA105 6x6x6 ?

LEM		FR4 Measured thickness (mm)	Breakdown Voltage in ambient air	Breakdown Voltage in synthetic 5.0 air	Breakdown Voltage in 5.7 Ar	Comments
LEM type	LEM #					
ELVIA 10x10	01	0.993	4500 V / < 0nA			
	02	0.998	4500 V / < 0nA			
ELTOS 10x10	07	0.995	3800 V / 4nA			"old" brush cleaning process
	04	0.985	4000 V / < 0nA			"old" brush cleaning process
ELTOS 25x25	01	0.969		4400 V / 0.5nA 5 sp. / 6 mn	1600 V / <0nA 6 sp. / 6 mn	
	02	0.968		4300 V / 0.5nA 5 sp. / 10 mn	1700 V / <0nA 5 sp. / 5 mn	
	04	0.971		4500 V / 1.4nA 5 sp. / 4 mn	1800 V / 0.4nA 6 sp. / 6 mn	
	08	0.967		4400 V / 1nA 3 sp. / 2 mn	1850 V / <0nA 6 sp. / 6 mn	
	11	0.970		4450 V / 2nA 4 sp. / 4 mn	1650 V / 0.1nA 1 sp. / 6 mn	sparks on borders at 1700 V
ELVIA 50x50	1 polished	0.96-0.98		4600 V / 2.4nA 3 sp. / 3 mn	1700 V / 0.6nA 8 sp. / 9 mn	19 raw FR4 sheets measured 12 sheets selected (0.96-0.98 mm) no tracking of sheet # Vs LEM #
	2 polished	0.96-0.98		4550 V / 2nA 6 sp. / 6 mn	1700 V / 0.7nA 13 sp. / 15 mn	
	03	0.96-0.98		4400 V / 1.7nA 5 sp. / 5 mn	1650 V / 0.15nA 15 sp. / 20 mn	
	04	0.96-0.98		4400 V / 1.7nA 5 sp. / 5 mn	1700 V / 0.7nA 13 sp. / 15 mn	

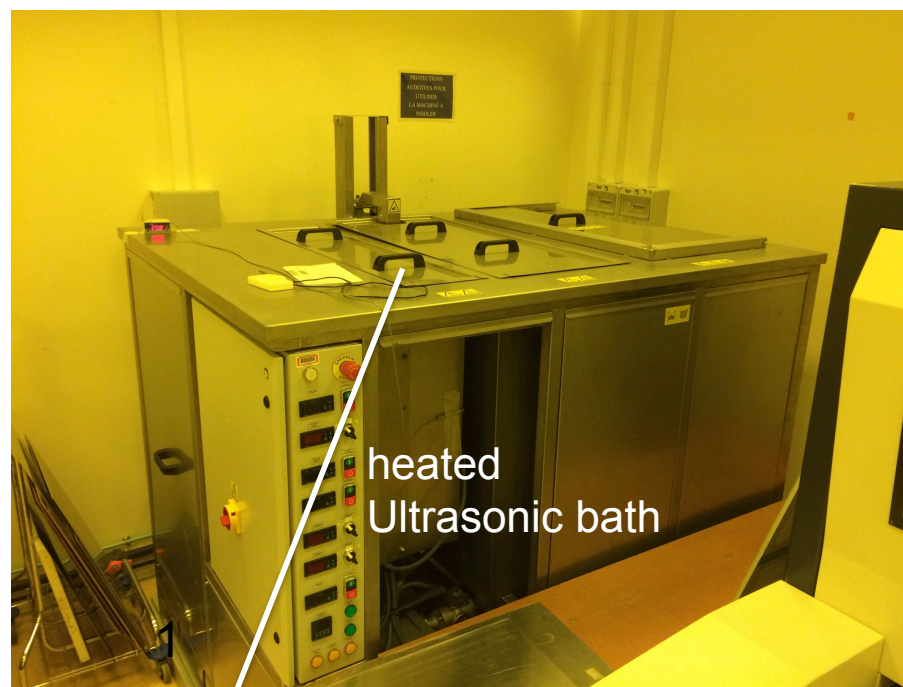
Spark counting was done manually. A Labview program is under development to monitor & record sparks with an automated procedure for HV increase up to BV.





Dedicated area for “Karcher” cleaning

Ultrasonic cleaning machine
Multi-clean 3-120



heated
Ultrasonic bath

- 720 l capacity
- Up to 300 °C
- Mechanical convection
- 1 °C accuracy
- For 80°C baking and 160 °C polymerisation



Heating chamber BINDER FED720



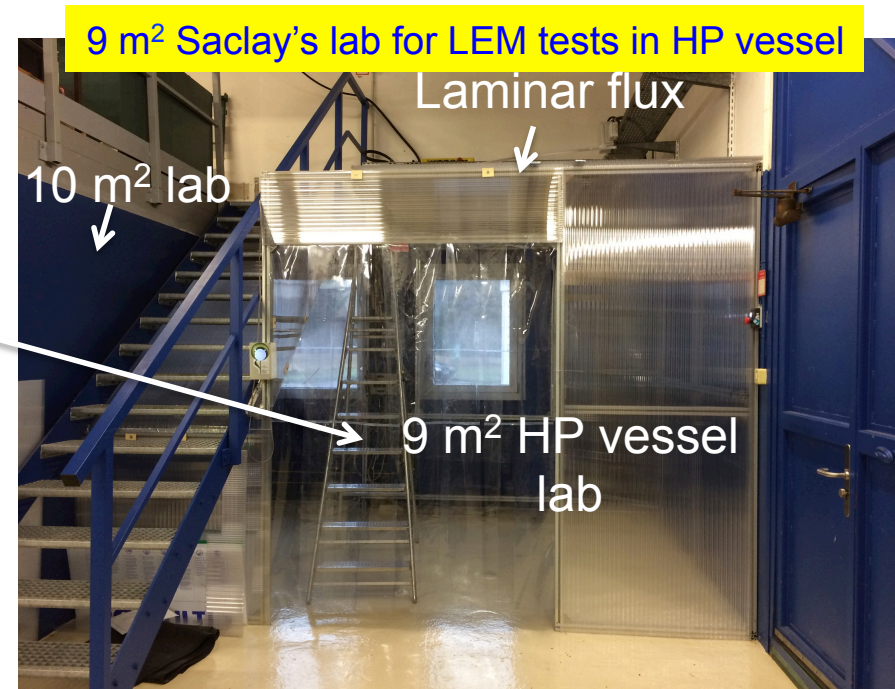
- « Saclay cleaning »
- Soap NGL 17.40 sp. ALU III
 - 2 kW / 40 kHz
 - 65°C +/- 0.1°C bath
 - Successfully tested with 10x10 cm² and 25x25 cm² LEMs

- On september 20th , the High-Pressure Chamber (up to 10 bars) was successfully tested for 14.3 bar with plain flanges and 4.5 bar with 4/6 vacom-made DN50 HV feedthroughs flanges.
- @ 10^{-4} mbar, $1.4 \cdot 10^{-8}$ Pa.m³.s⁻¹ leaks were measured with He injection with vacom HV flanges (10^{-6} - 10^{-7} Pa.m³.s⁻¹ on the rupture disk and the safety valve).
- We are waiting for the 2 remaining Vacom HV flanges to complete the certification of the chamber with home-made DN100 signal feedthrough flanges and have it delivered at Saclay.

HP and leak tests at RAVANAT company



- Irfu-Saclay has prepared a 9 m² with a 1.2x0.6 m² laminar flux for the HP vessel. In the same hall, a 10 m² lab is dedicated to storage and assembly tasks. Another 10 m² lab is used for control-command of the tests performed in the HP vessel.
- Safety documents are currently reviewed by the Saclay Safety division for an official review on site with the vessel foreseen in 2-3 weeks.
- A tower of 6 LEMs is assembled under the laminar flux to be tested in the vessel for Breakdown Voltage qualification.



- The same process as for the preparation of LEM's production just started to gather specifications, prepare PCB production and KEL connectors soldering.
- The “good” news is that it seems the cost for ½ production may be lower than the 25 k€ threshold (≈ 350 €/PCB) which demands to proceed by a call for tender : 3 quotations will be asked to select a company. 2 weeks for administrative procedure will be required to make the order. Writing of the “Technical specifications” document is on-going. A rather “standard” PCB production (to be confirmed) is foreseen.
- Soldering of the KEL connectors may be done by manual positioning of connectors on brazing paste and global soldering in a convection oven. A cost of ≈ 30 €/PCB (20 KEL connectors) for 160 anode PCBs could be reached.
- Q/C by the manufacturer should be standard ones driven by the IPC standards but Q/C of KEL soldering connections has to be done by WA105 (not so easy and so probably too expensive in the company).

CERN-818

110

**WA105 3x1x1 anode PCB produced by ELTOS
3,51 mm designed thickness**

part no.: _____ ref. Cart.: _____

				CERN-818.IN1	CERN-818.C
TOP	18 μ +Plating		45		
	1,55 18/18	FR-4 HF	1550		
2	18 μ +Plating				
	1 X 1080				
	1 X 7628	H.F.	320		
	1 X 1080				
3	18 μ +Plating				
	1,55 18/18	FR-4 HF	1550		
BOTTOM	18 μ +Plating		45		
TOTAL:			Total: 3510	CERN-818.IN2	

PREPREG
 LAMINATE
 COPPER
 HOLE

MODIFICATO

238/4
227/7 · H.F. *SP*
3.H

Matière : PANASONIC.

Raw material : Panasonic halogen free TG=150°C (520x520 mm²)

- A.O.I. tests of inner layers before assembly & external layers at the end of the prod.
- Electrical continuities and insulations were tested on an ATG Flying Probe Tester.

- The ELVIA company produced 10x10 and 50x50 LEMs (3x1x1 prototype design) whose performances were measured as good as ELTOS LEMs in terms of Breakdown Voltage in NTP Argon and synthetic air, and gain in NTP Argon conditions (10x10 cm²)
- This enables us to have these 2 companies in competition for WA105 LEM prod.
- The High Pressure Vessel will be soon available at Saclay to study prototypes (four 25x25 cm² LEMs side by side, 50x50 cm² LEMs with border minimization, ...) and for qualification of the WA105 production LEMs.
- The preparation of the call for tender is on-going at Saclay. The goal is to be ready for production beginning of 2017 once the launch for production will be decided.
- A internal review of the Irfu/WA105 project by the IRFU management will be held on november 21st in order to allocate ressources for half the WA105 production.
- Handling the post-production tasks (HV pin soldering, LEM cleaning, LEM BV tests) at Saclay for the full 144 LEMs is under study and requires at least 1 FTE support from the collaboration during the production phase.

Product overview

Panasonic
ideas for life

Product designation Properties	FR4 - Dicy cured			FR4 - Phenolic cured			LOW Dk Materials	ARCC-FOIL	FLEX Laminate	
	CONVENTIONAL	HALOGEN FREE		HIGH PERFORMANCE						
	MC-100MS/EX MC-Rheopreg	R-1566(W) R-1551(W)	R-1566V R-1551V	R-1755C R-1650C	R-1755 R-1650	R-1755V R-1650V				R-5715 R-5610
Standard Tg 130-140°C	●			●					●	
Medium Tg 150°C		●	●							
High Tg ≥ 170°C					●	●	●	●		
Degradation Temperature	310	330	360	364	364	340	310	400	350	
Thermostable, high T 250, T 288		●	●	●	●	●	●	●	●	
TCT -40°C/+125°C, 1000 cycles				●						
TCT -40°C/+140°C, 1000 cycles		●	●			●		●		
CTE (z) < 70ppm/K	●				●		●			
CTE (z) < 55ppm/K			●	●		●		●		
CTE (z) < 40ppm/K		●								
$\epsilon_r, D_f < 3,9$ at 2 GHz							●	●	●	
Tan $\delta, D_f < 0,01$ at 2 GHz								●		
High frequency application							●	●		
CAF-resistant		●	●	●	●	●	●	●		
High thermal conductivity		●	●	●		●				
Leadfree		●	●	●	●	●	●	●	●	
RoHS conform	●	●	●	●	●	●	●	●	●	●

This technical data sheet and the information it contains is not intended to supersede any terms and condition of sale and does not constitute a specification, promise, representation, or warranty, whether express or implied, except to the extent required by applicable law. The data contained herein is believed to be accurate based on our current knowledge. It remains the responsibility of the customer to check the useability of the products.

Rev.4 30.10.2008

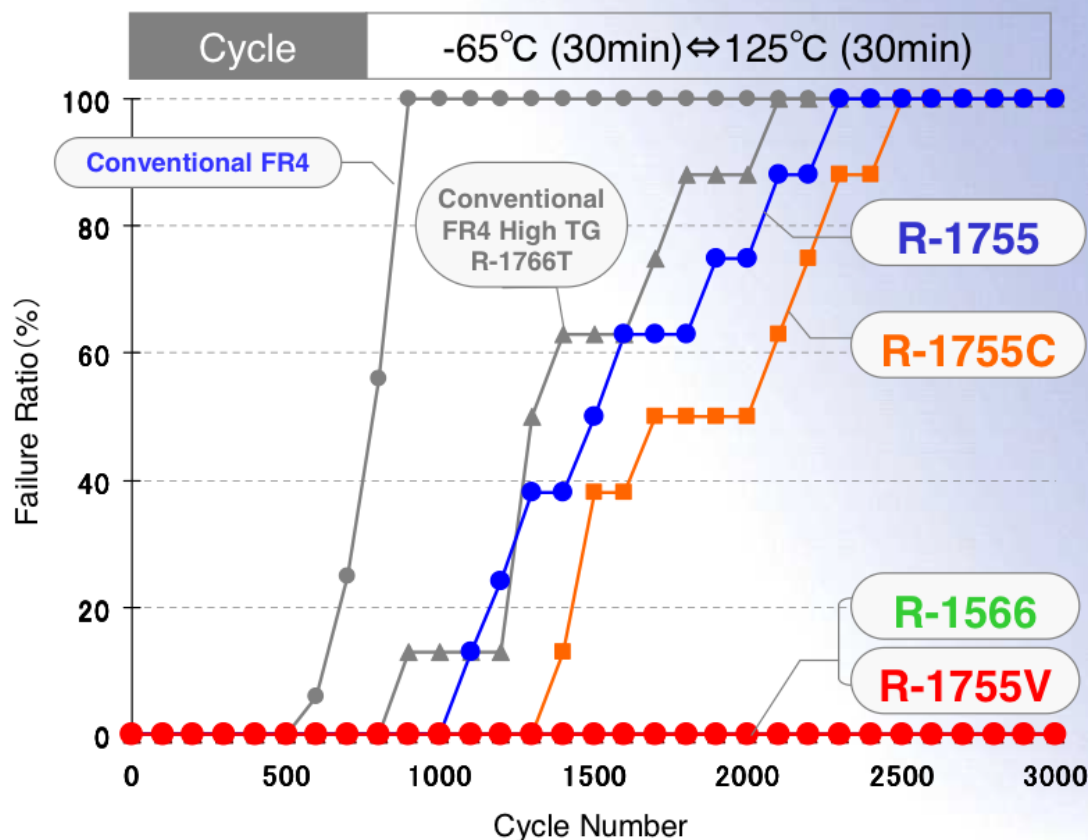
Panasonic Electric Works Electronic Materials Europe GmbH

Walchshofer /092009
Slide 17

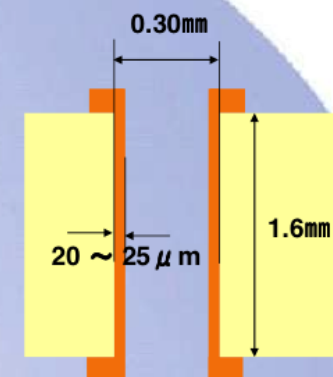
Through hole reliability - 1



Result



Test Sample



Throwing power
(Uniformity of plating thickness): 80% or more

Definition of failure:
10 % resistance change

The above data are our actual values and not assured values.