MPGD Infrastructures :

-production facilities

-testing

-development

Rui De Oliveira

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Infrastructures/skills needed today to produce MPGDs

- Detector design:
  - CERN/Institutes
- PCB Design:
  - Industry/CERN/Institutes.
- Mechanical design:
  - Industry/CERN/Institutes.
- PCB technologies:
  - Industry/CERN
- Mechanical technologies:
  - Industry/CERN/Institutes.
- Micro structuring technologies:
  - GEM, uRwell
  - CERN/Few companies involved.
- Surface treatment/Vacuum deposition:
  - Micromegas, uRwell,GEM,uPIC,SRPC,THGEM,PicoSec
  - Few companies and institutes involved.
- PCB component assembly:
  - Industry/CERN/Institute.
- Detector final cleaning
  - CERN/Institutes
- Test:
  - CERN/Institutes.

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Topics under development at MPT

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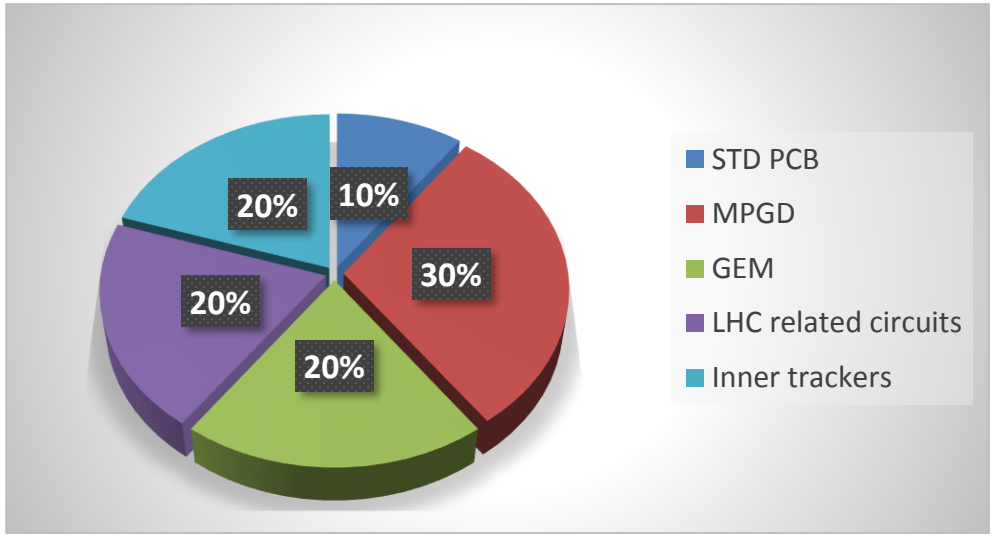
How opening this to industry ?

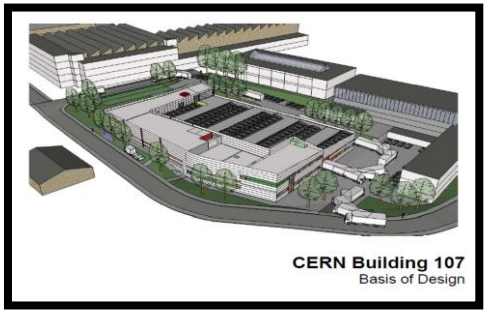
Topics under development at MPT

How opening this to industry ?

CERN MPT workshop

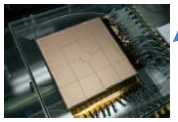


-Team of 20 persons.
-1400m2.
-100m2 clean room.
-First class environnement protection:
  -Water treatment plant.
  -Fumes scrubbers.
  -Fire extinguisment water containment.

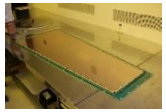


Examples of MPT activities

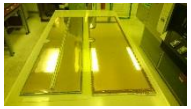
GEM :



Compass
CMS GEM GE1/1 →



CMS GEM GE2/1
ALICE TPC GEM
CBM GEM for Fair
BM@N (Baryonic Matter at the Nuclotron Dubna)
Low material budget detectors (Hampton university)

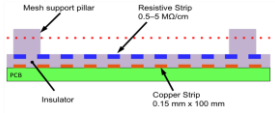


Kloe
Totem
LHC-B
Phoenix TPC (Brookhaven)
SBS tracker (Jefferson Lab)
EIC tracking detectors (Jefferson Lab)
Etc…

Micromegas

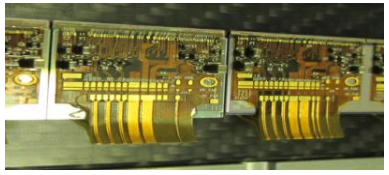
ILC Calorimeter
Minos TPC
T2K →

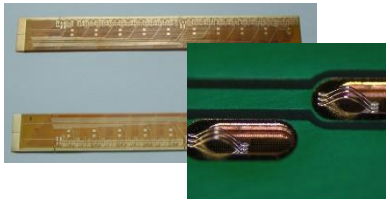
ATLAS NSW
Cast
Panda X uBulk detectors
TrexDM uBulk detectors
TPC's for Nuclear physics
Beam for School
T2K upgrade
Clas12
Scanpyramid
Etc…



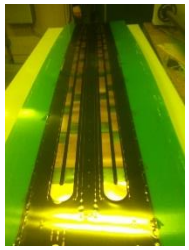
Inner trackers flexes

ALICE Inner tracker Al Bus
Phoenix TPC AL bus
ATLAS IBL
ATLAS ITK
LHCB data flexes





LHC



Cryogenic Magnet's quench heaters
Power Thick film resistors
Magnetic sensors calibration
Flexible heaters
Diamond beam monitoring detectors
Many Chemical milling

MPGD processes at CERN MPT

-Photolithography with solid resist (down to 50um line/space):
- -Laminators.
- -UV exposure : LDI , STD , large , scanner.
- -Devellopment machines.
- -Stripping machines.

-Photolithography with liquid resist in clean room (down to 15um line/space):
- -Spinner.
- -Collimated UV exposure lamp.

-Chemical etching:
- -metals :Cu,Al,Ni,Au,Ti,W etc..
- -Polymers : Pi , Epoxy.

-CNC Drilling/milling.

-Galvanic or chemical plating:
- -Cu, Ni, Au, In.

-Vacuum press gluing.

-Autoclave gluing .

-Optical , electrical tests.

CERN MPT special processes

-really difficult to find in industry
- or difficult to find in industry

-Polyimide and Epoxy chemical micro-structuring: -up to 2.2m x 0.6m.	GEM/uRwell/uBulk
-Part or detector final cleaning :	GEM/uRwell/uBulk/THGEM
-Large size photolithography (solid resist): -up to 20m x 0.6m for flexes -up to 2.2m x 1.2m for rigid boards.	MM/GEM/uRwell/THGEM/LHC
-Large size Cu wet plating: -up to 2m x 0.8m.	MPGD Read-Out/LHC
-Long double side flexes with or without PTH: -up to 20m x 0.6m.	GEM/uRwell/MPGD R-O/TPC/LHC
-Long rigid multilayer boards: -up to 2.2m x 0.6m.	MM/MPGD R-O/LHC

MPGD Test

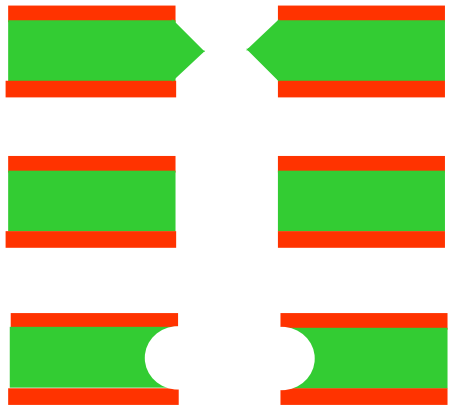
- CERN MPT workshop
  - Continuity and optical automated test
  - Leakage current test under HV in air

- Institutes and CERN GDD lab
  - Detector functional tests with acquisition
  - Beam test
  - Cosmic bench test
  - Aging test
  - Test with different sources
  - Test with different Gases
  - Gas leak tests
  - Etc..

Development topics at MPT workshop

- Vacuum deposition
- Subtractive micro-structuring
  - Chemical
  - Laser
  - Plasma
- Additive micro-structuring
  - 3D printing

GEM hole example



Pulsed DC magnetron reactive PVD

- Max foil size:
  -1.7m x 0.6m.
- Useful size:
  -1.7m x 0.5m.

- Budget:
  -25% INFN
  -25% CERN EP/DT group
  -50% CERN MPT workshop self financing

- Resistive layers:
  -DLC, semiconductors.
- Photocathodes:
  -Metallic, DLC, B4C, GaN, mix?
- Metals:
  -AL, Cu, Ni, etc..

- D/R →done
- M/S → 04/21
- I/T → 05/21
- P/O → 08/21
- Delivery → 02/22
- Operation → 04/22

- 5 targets.
- 3 simultaneous deposition.
- 3 gas inputs:
  - H2,N2,CH4,C4H10,Ne,Ar etc..
- 300deg heater.

Chemical micro-structuring

Present process:
-Open baths with EDA.
-Hood with scrubbers.
-Adapted IPE / procedures:
  -Swiss University for health at work # RF-18-0008
  -CERN procedure # 200-PS206 rev:8
-Constant security monitoring.
-Old CERN HF acid treatment hood recycled.

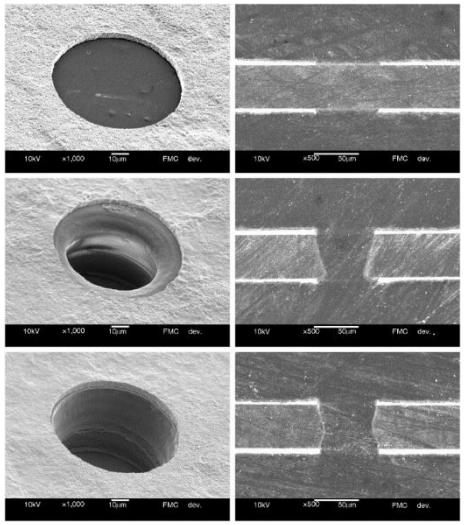
Horizontal machine trial to remove IPEs
→ Not hermetic enough to work without IPE.
→ Converted in resist development machine.

-The existing baths are ok for the existing market.
-The equipment design is a bit complex → needs experience.
-Many PCB companies are reluctant to do the effort to handle these corrosive etchants for this small market.
-There is a real need for a dedicated simple hermetic machine to help companies to make the step.
-We have done preliminary hermetic machine designs , they are presently evaluated by machine producers.

EDA: Ethylene diamine
IPE: Individual protection equipment
HF : Fluoridric acid

Laser micro-structuring

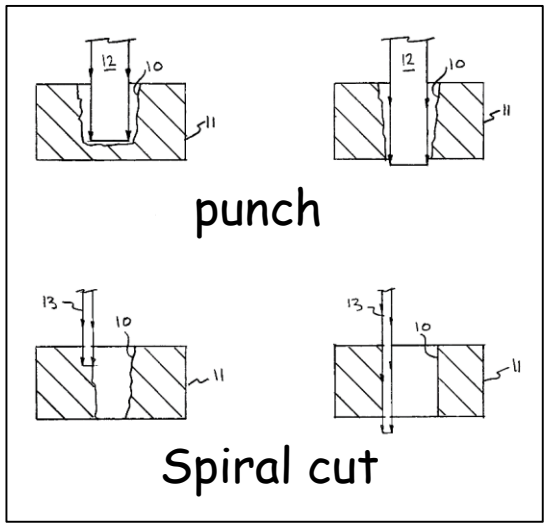
C02 laser



-2 photolithography steps are needed.
-Limited in size.
-Many base materials.

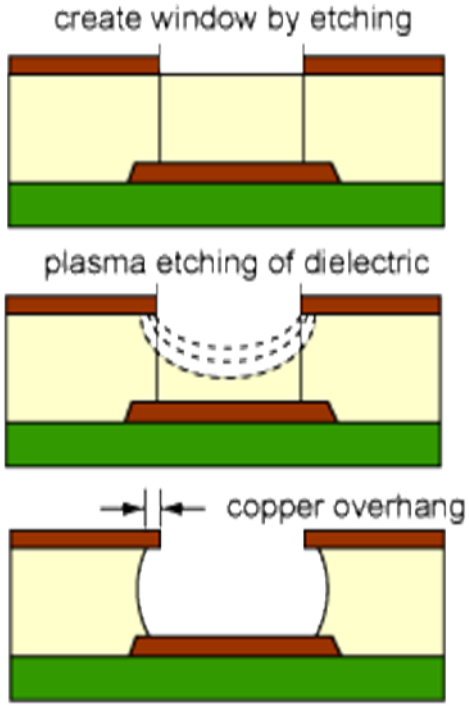
-Laser machine on the market are still too slow and too small to compete with chemical etching .
-Machine cost is out of our self financing possibilities.

UV laser



-1 photolithography step is saved.
-Direct laser punching.
-Many base materials.
-200 holes/sec max by punching.
-Spiral cut too long.
-limited in size.
-Carbonization.

Plasma micro-structuring



Reactive Ion Etching (RIE) machines:
-Not uniform on large size.
-Size too small : 50cm x 50cm max.
-Etching Isotropy too prononced.
-But the machine cost is moderate.

Directive RIE (DRIE) machines:
-Perfect cylindrical holes.
-Size too small : dia 20cm max.
-Machine cost really high .

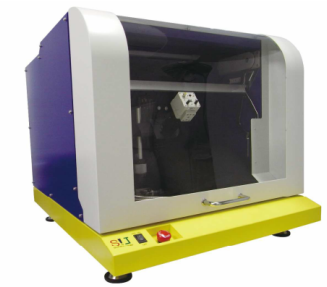
Additive Micro-structuring

Super Inkjet printer (SIJ-S050)

◇**Super fine patterning**
Droplet volume:0.1fl (femtoliter) ～10pl (picoliter)

◇**Wide range of viscosity**
Viscosity range:0.5～10,000cps (non-heated)

◇**Large variety of usable fluids**



Type	SIJ-S050 (desktop system) ※includes PC, monitor and software
Data format	Vector form data
Patterning design	Arbitrary shape (dot, line, circle, polygonal shape)
Patterning area	50×50mm
Number of nozzles	Single nozzle
Repeatability of work stage	±0.2μm
Fiducial camera	Real-time observation camera×1, Alignment camera×1
Power	AC100-120V 50/60Hz ※Including a transformer.
Body size	620(W)×880(D)×690(H) mm
Weight	Approximately 64Kg

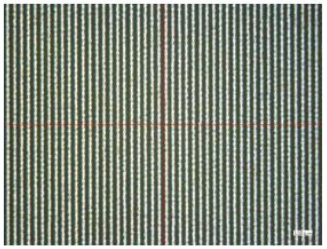
Features

■Droplet volume : 0.1fl (femtoliter)～10pl (picoliter), Line width 0.5 μm ～ several dozen μm Smallest droplet volume !

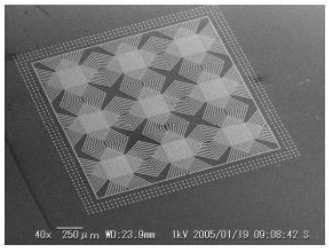
■Viscosity range : 0.5～10,000cps (non-heated) Wide range of viscosity !

■Large variety of usable fluids : Conductive ink, Insulating ink, Resist ink, UV ink, Solvent ink, Protein material, etc No special ink !

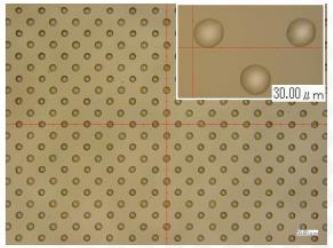
Patterning Example



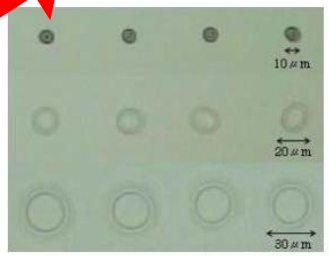
Silver ink, L/S=1 μm



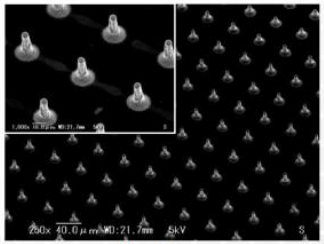
Circuit pattern



Microlens (resin ink)



Protein material (albumin)



Microbump
Diameter=5 μm, Height=20 μm

Micro QRcode (750 μm × 750 μm)

-We are now looking for MPGD concepts/ideas compatible with micro printing.

-The cost of this 50mm x 50mm patterning machine is moderate.

Conclusion

- There is a lot and good infrastructures/equipment to mass produce MPGD in industry. And most of the time more advanced technologically speaking than our present need.
- It is still difficult to access them easily because companies have a lack of knowledge of the MPGD field.
- Probably due to the lack of applications out of the research field, working most of the time in single shot mode.
- One direction to increase companies know-how and then keep it, could be to help groups developing detectors for industry/medical/portable applications . This is the only field (I think) where industry could create a solid ground with constant productions.

Thank you