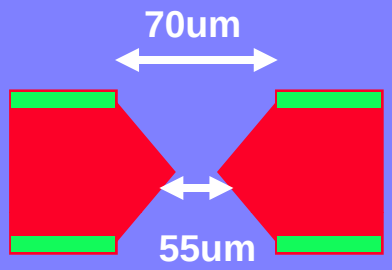
Large size MPGD production:
-GEM update
-read out board infos

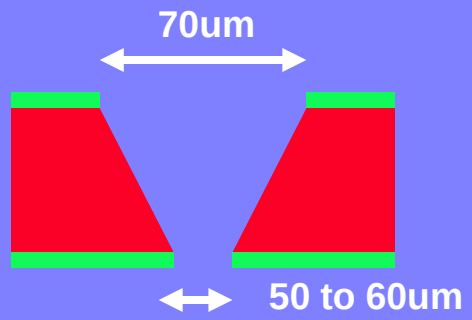
Rui De Oliveira

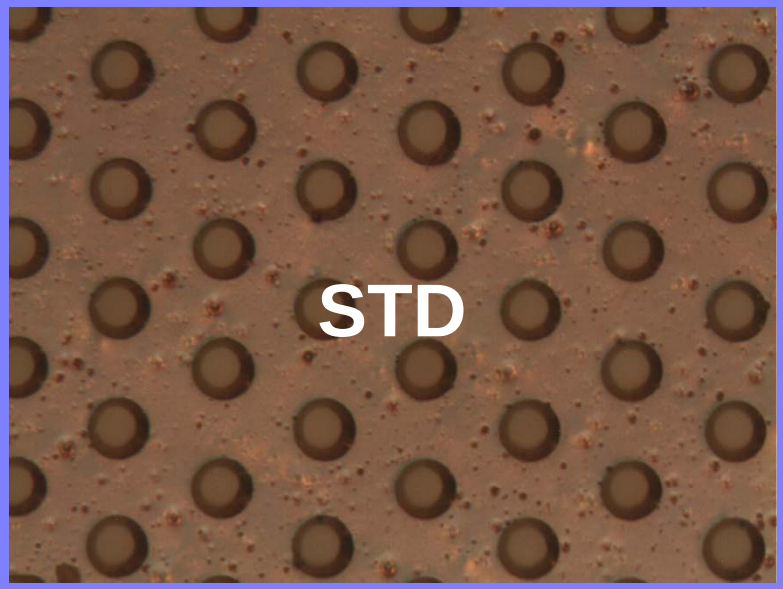
CERN 28/04/2009

GEM Goal

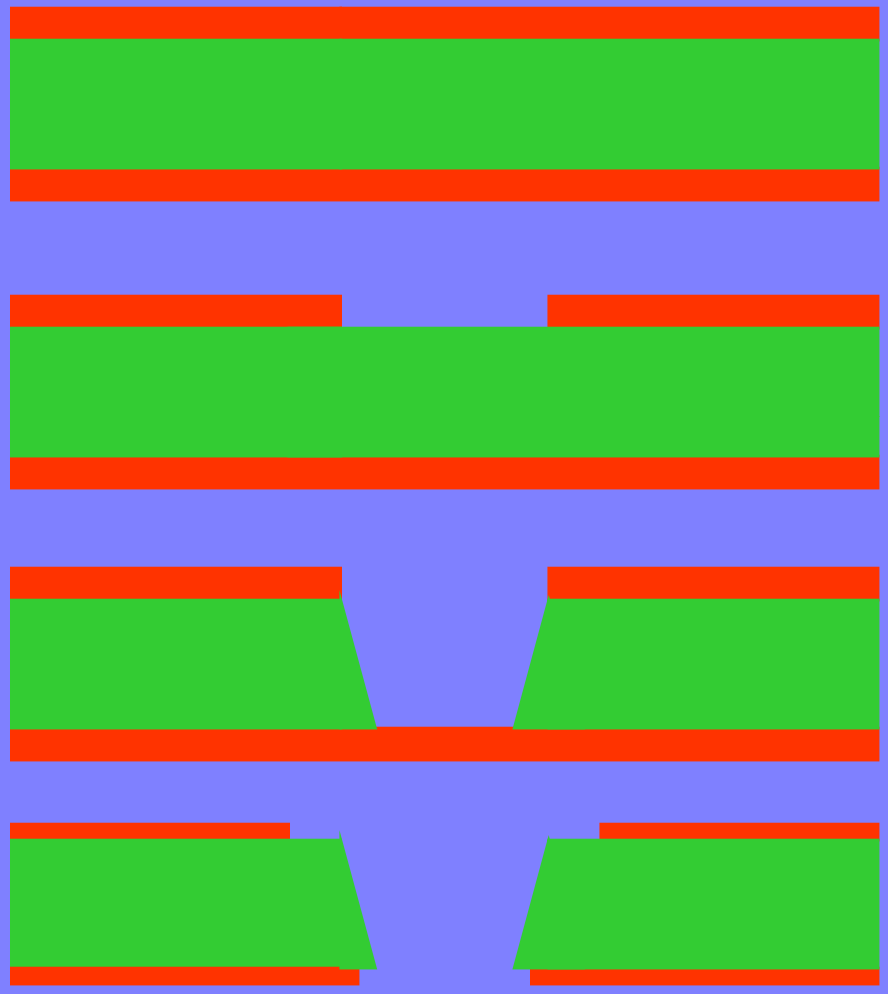
- 2 meter x 450mm GEM
- Single mask process (why?)
- 2um or 5um Copper on both sides







Main direction : Conical GEMs
This idea was found when we started making GEMs in 1996

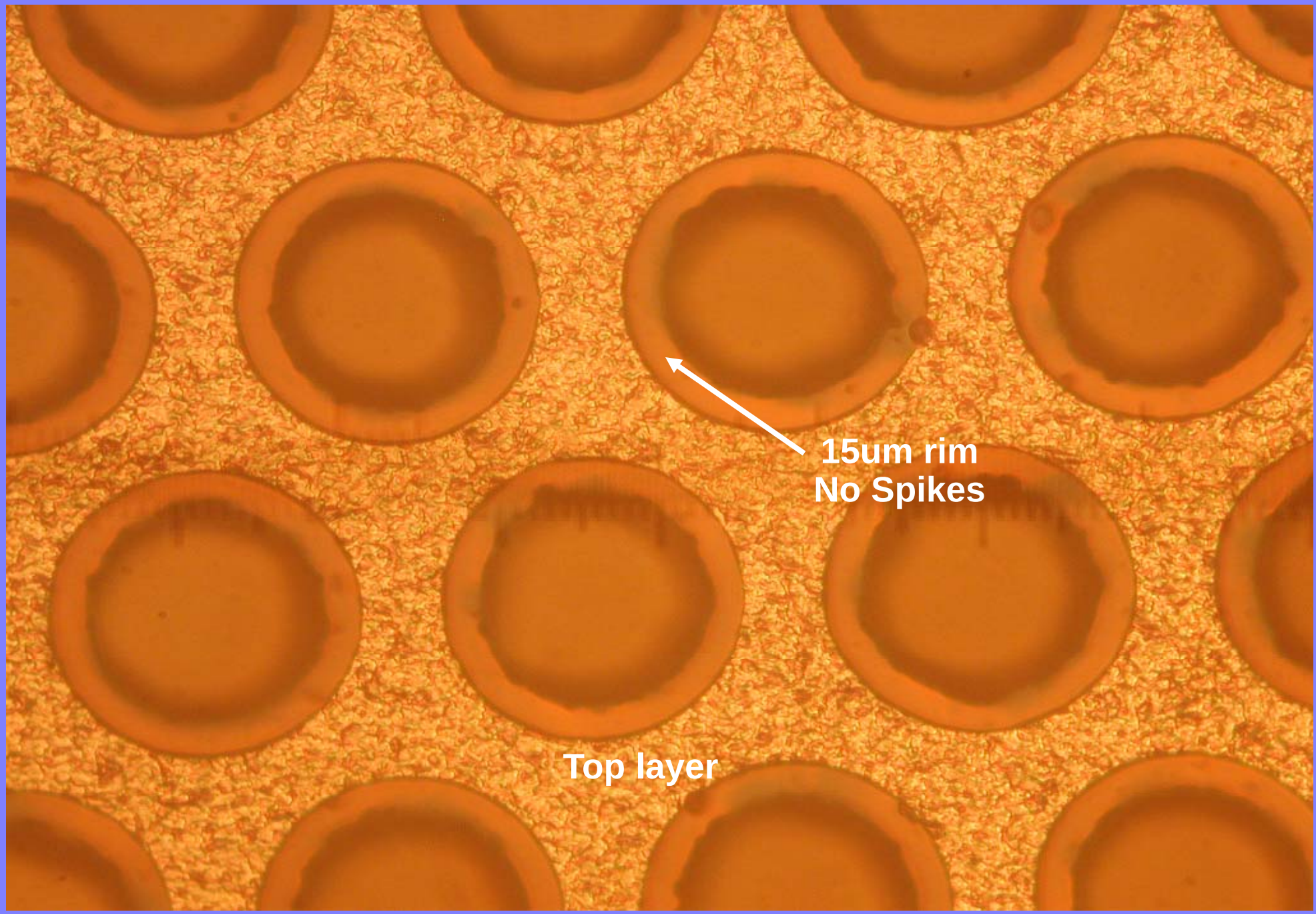


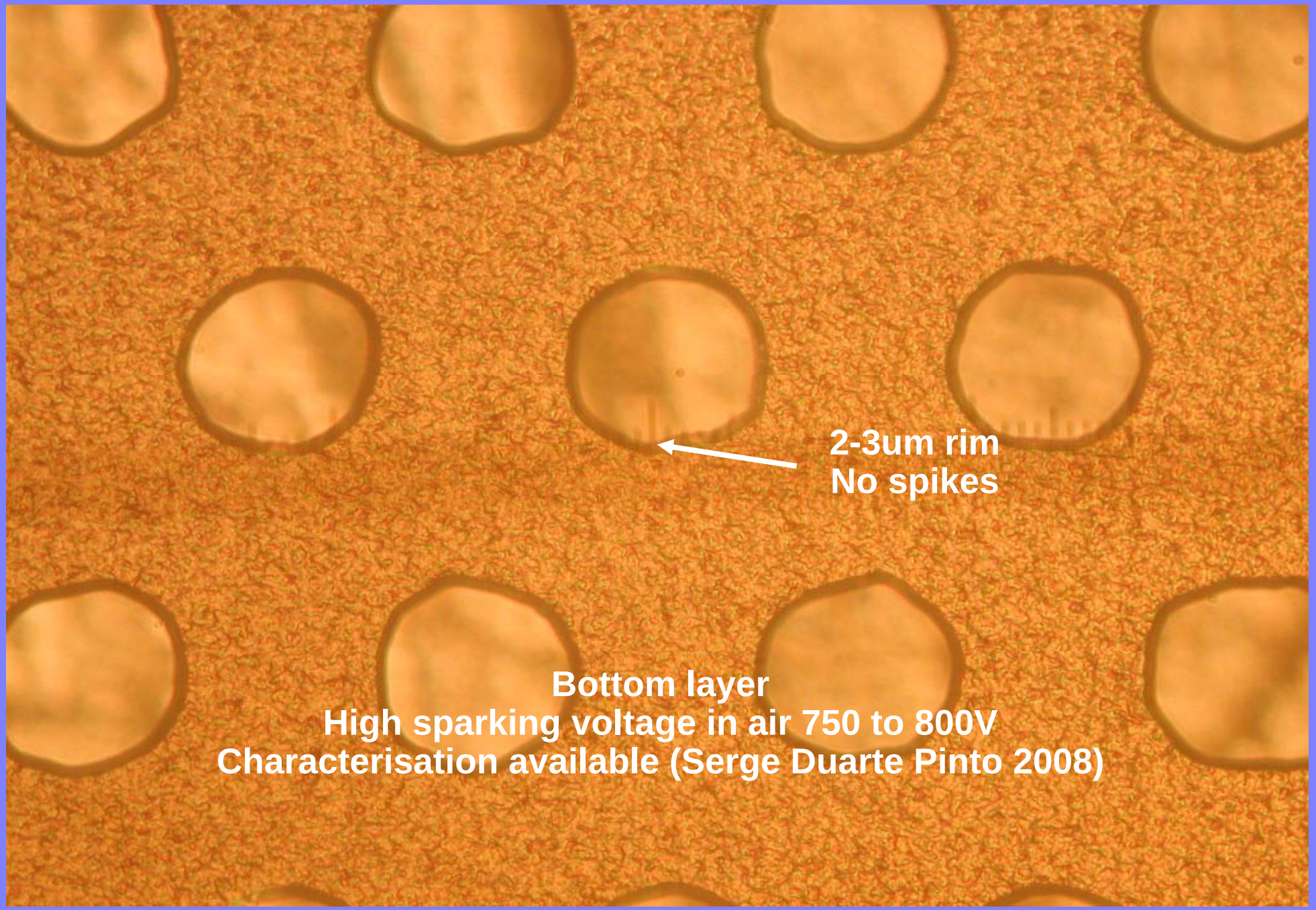
Raw material

Single side copper patterning

Polyimide etching

Copper differential etching


15um rim
No Spikes
Top layer


2-3um rim
No spikes
Bottom layer
High sparking voltage in air 750 to 800V
Characterisation available (Serge Duarte Pinto 2008)

- **Problems:**
  - Large rims on top
  - Yield in the differential etching step
  - Charging up
  - Hole shape too conical (70um top, 40um bottom best result)
  - Lower gain
  - GEM not symetrical (but perhaps not a problem)

- **Directions for improvements**
  - Holes more cylindrical
  - Remove the rims

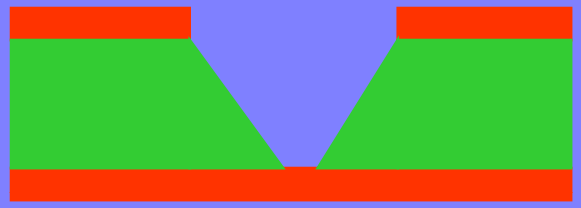
Holes more cylindrical → improve the polyimide etching

- Up to 30 different chemistries tested
- Ultrasonic bath tested
- Effect of temperature tested
- Spray etching still under test!

We found 2 interesting chemistries

1

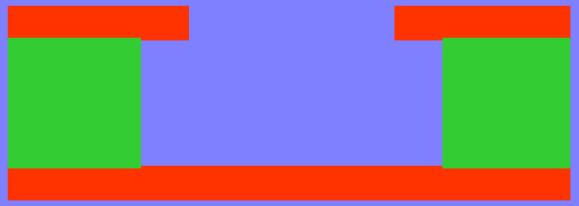
Strong isotropic conical etching stable from 7min to 15min

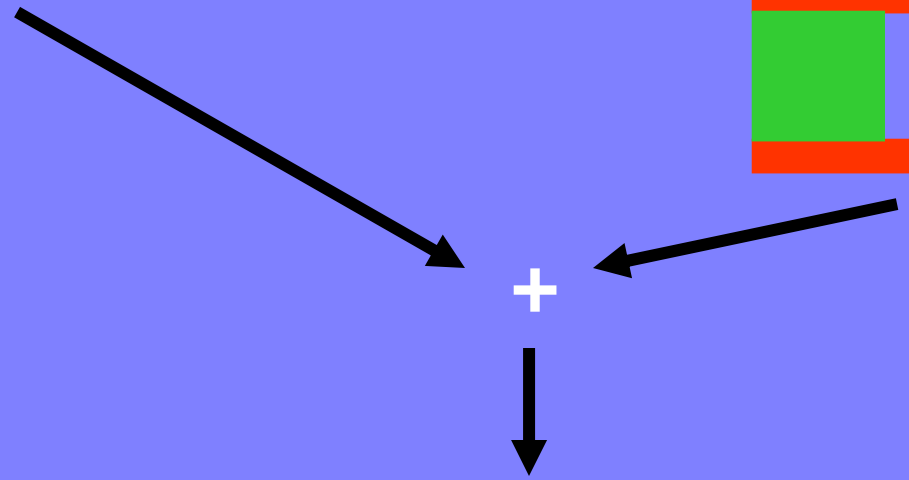


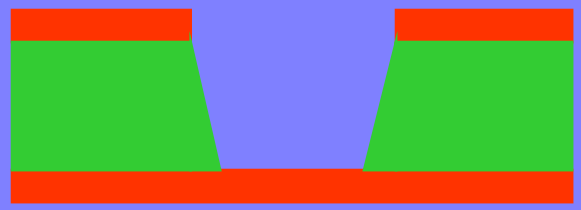
2

Anisotropic Cylindrical etching down to 25um @3min etching

isotropic etching down to 50um @5 min etching (lower quality)

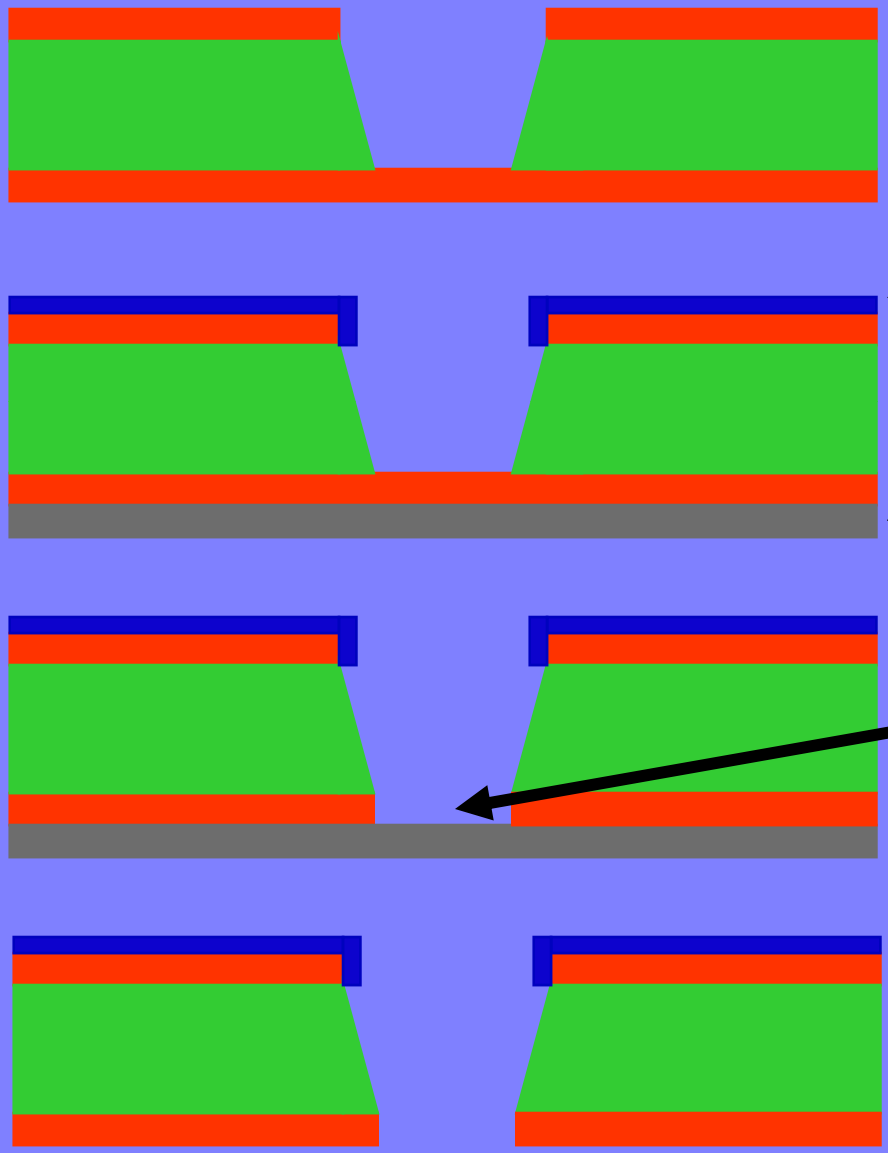






Mixed conical/cylindrical etching
7min +3min
70um top 50 to 60um bot
OK!

Removing the rims→ protect the metals



Chemical Polyimide etching

Au plating on top
Resist protection on bottom

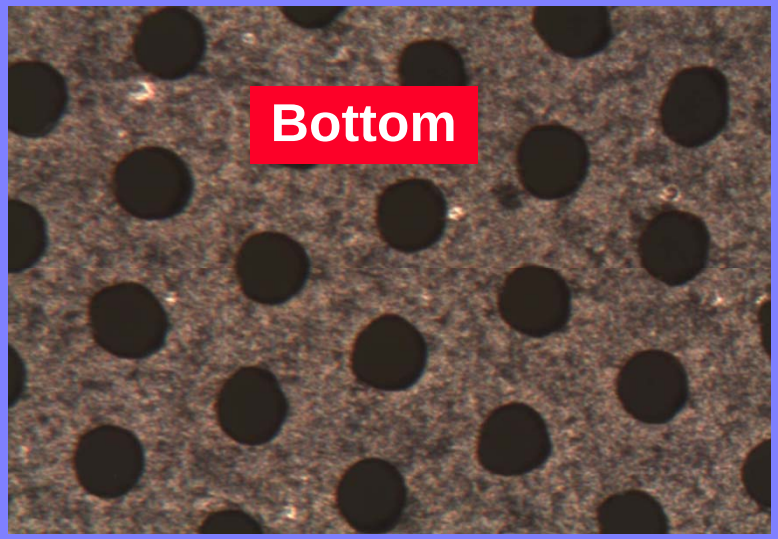
Conventional spray etching
of naked copper

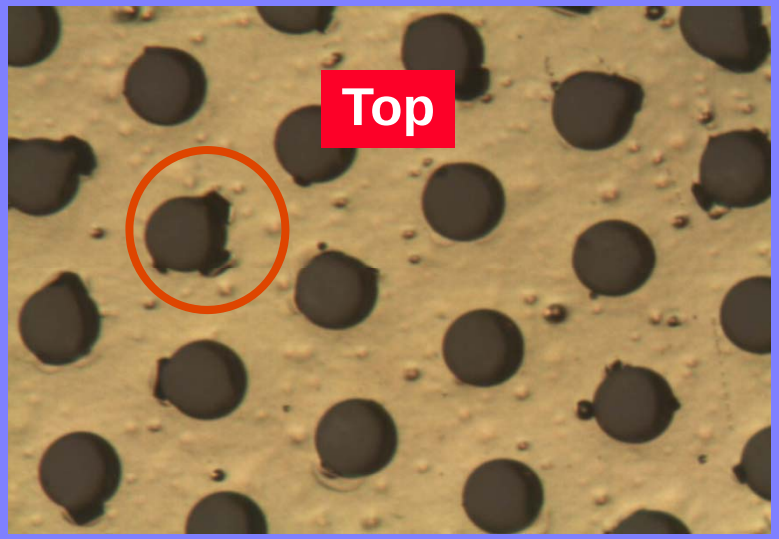
Stripping Resist on
bottom

Single Mask GEMs produced in january 2009 (100mm x 100mm)

Problems:

-Needs a protecting metal before second spray etch (cost)
-Still some delaminations on top layer due to spray etch
-how to strip the Au layer?
-uniformity seems good but need to be verified

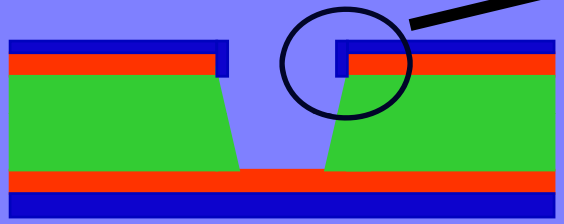


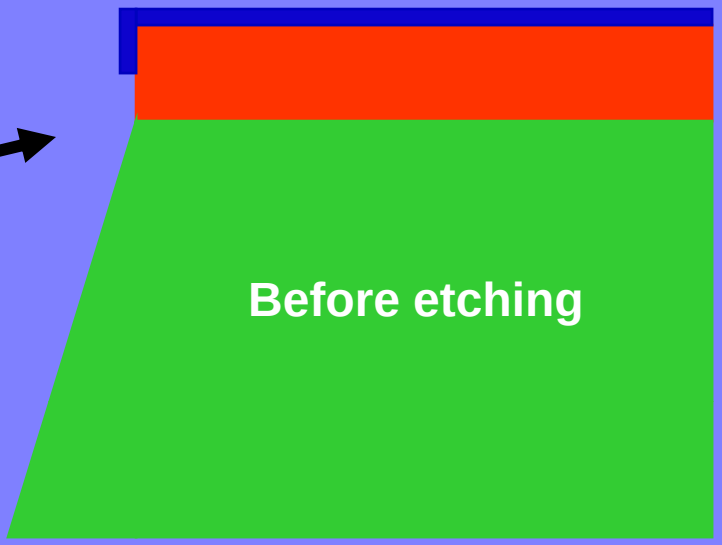


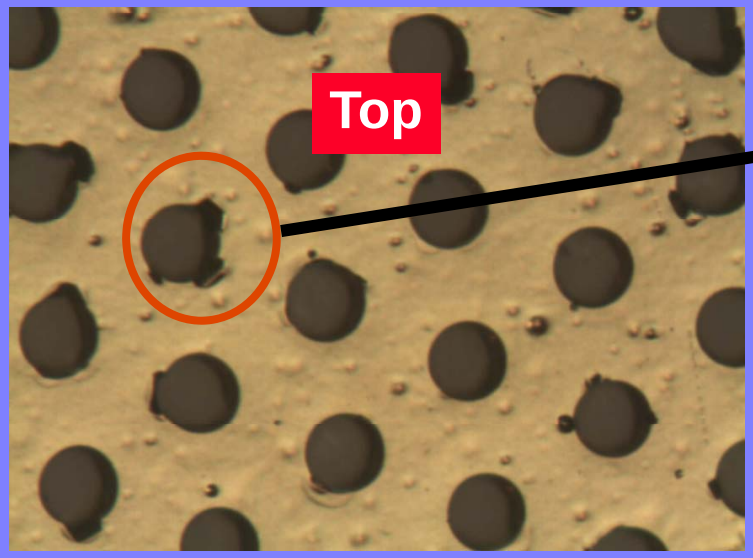
These pieces have been characterized by Giovanni Bencivenni
Result: good enough to make a detector!

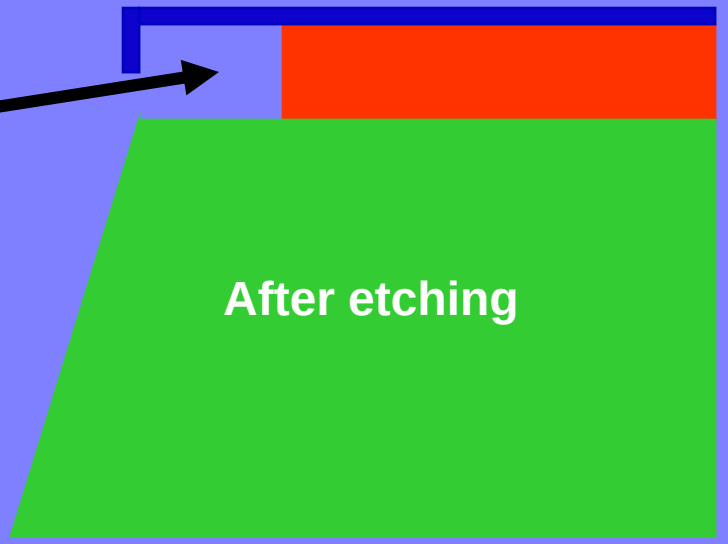
Most critical problem with Au or Tin protection

Sporadic defect : hermeticity
break at the copper
Polyimide junction

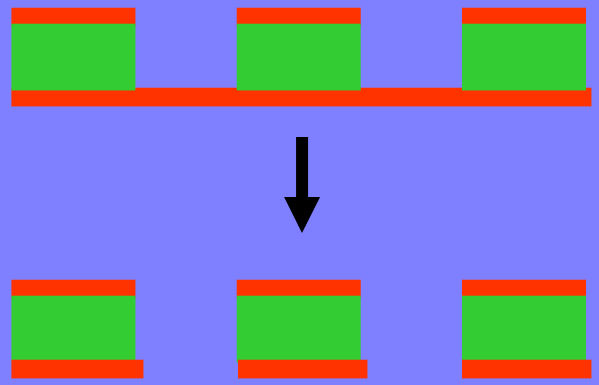








So what should we do now?
Our problem is to etch the bottom electrode without etching the top one
But both are made of copper



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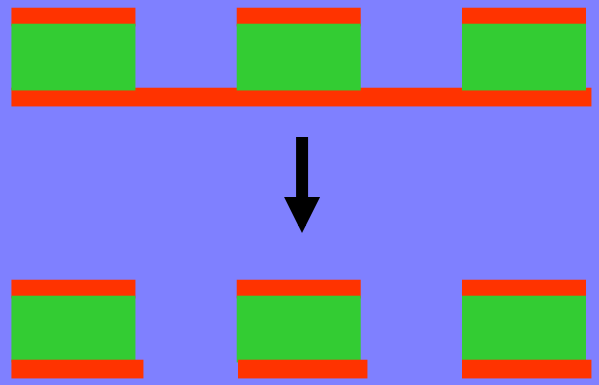
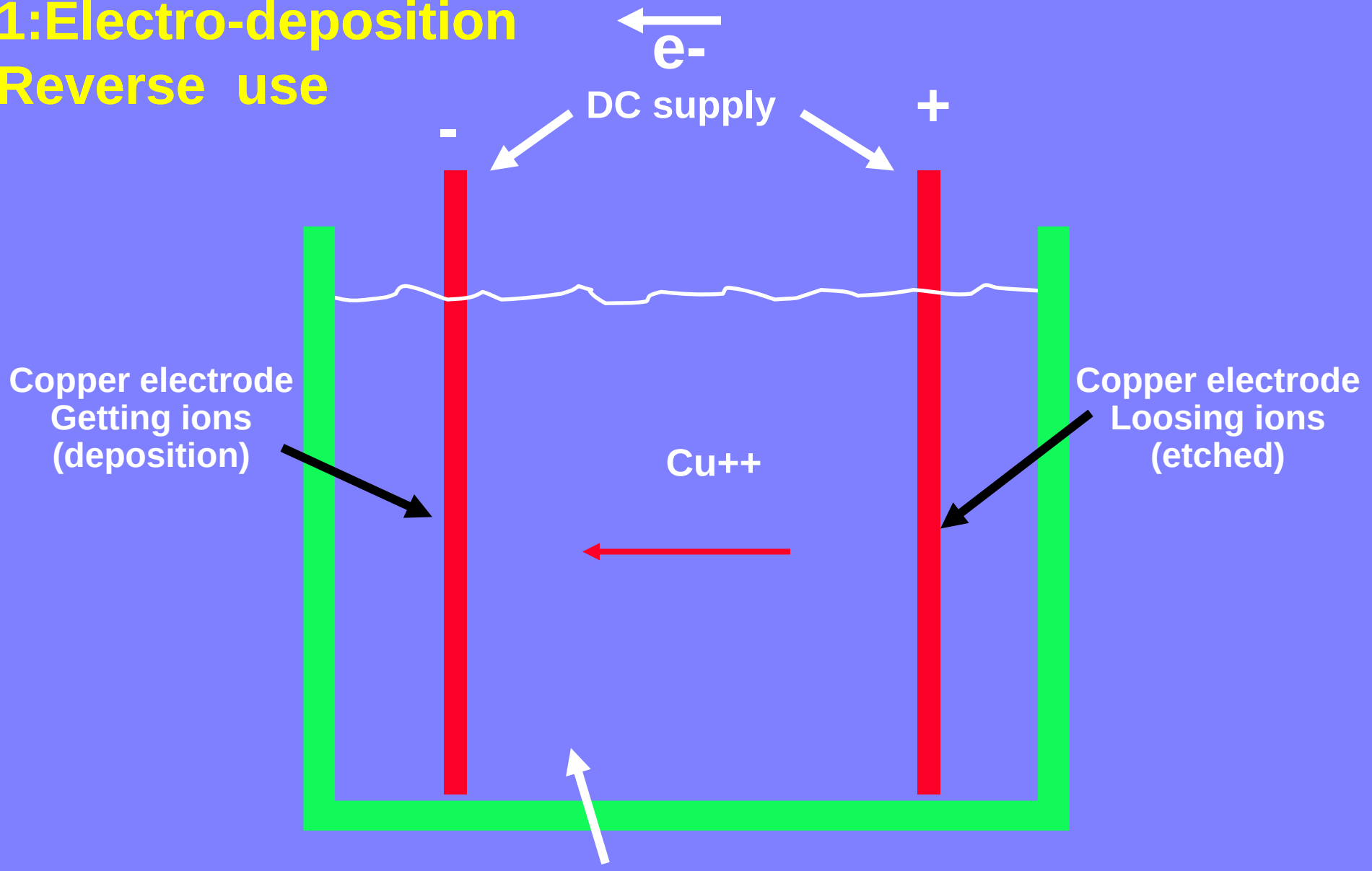
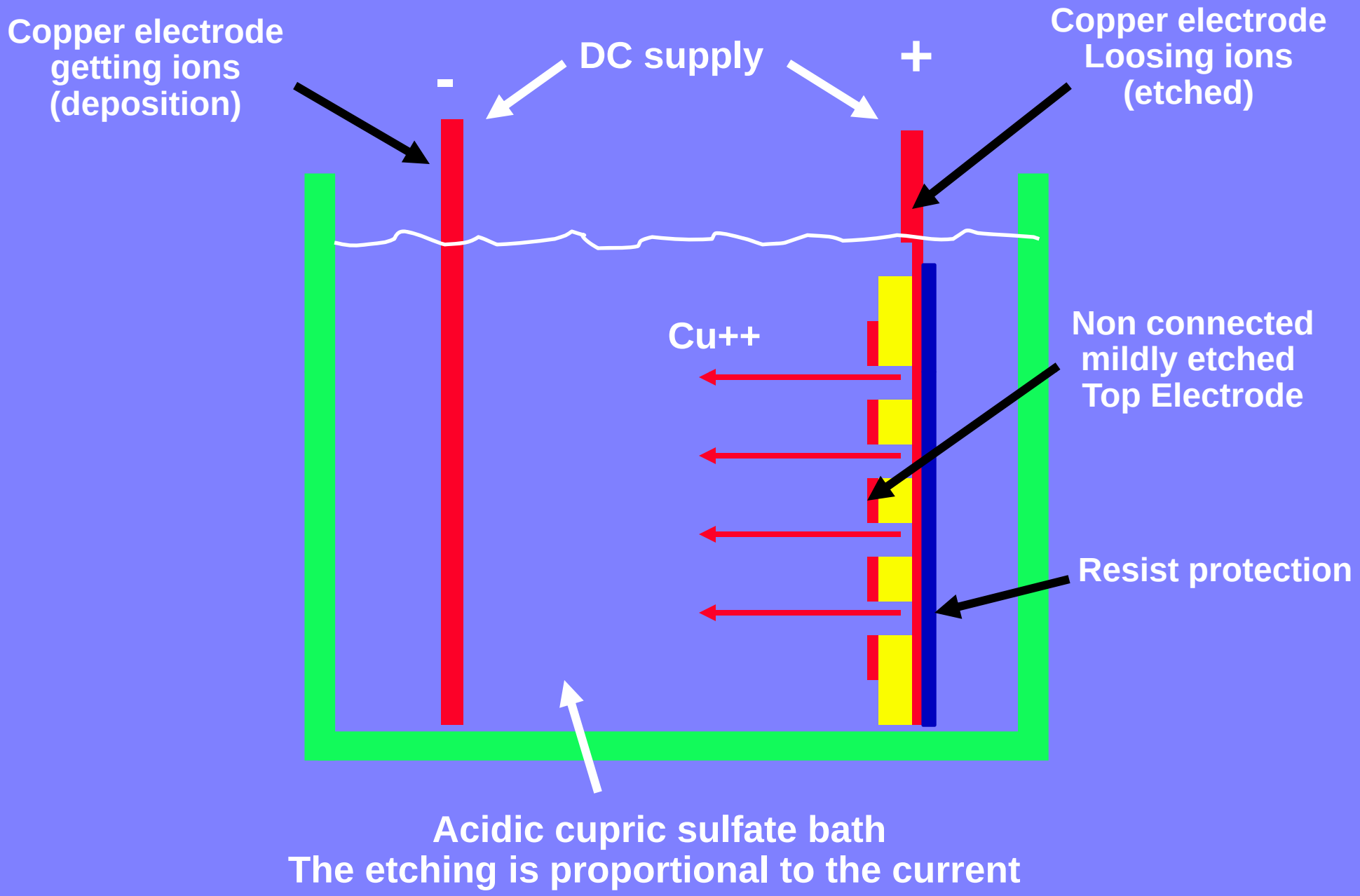


We went back to the electrochemical possibilities!

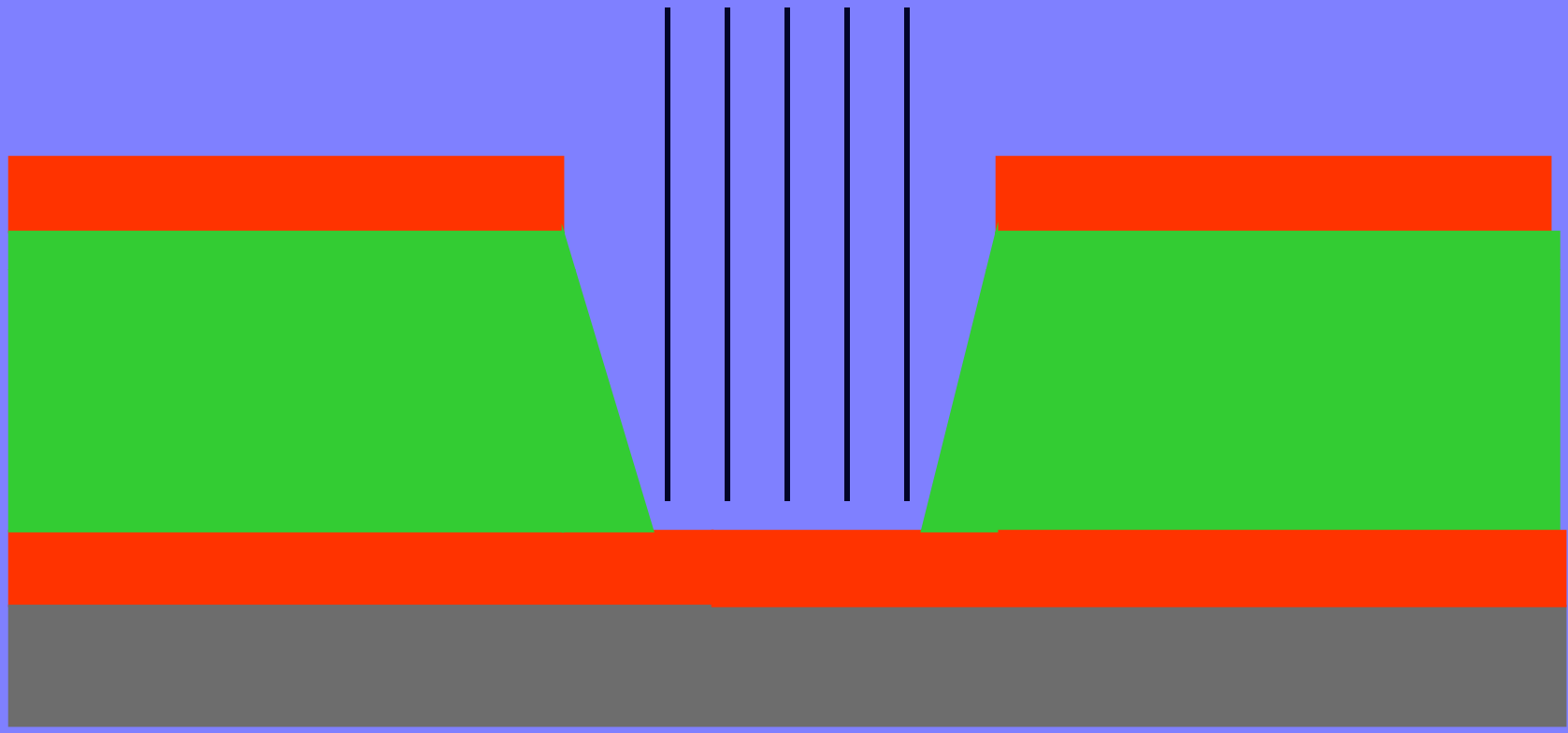
1: electro-deposition
2: active corrosion protection

1:Electro-deposition
Reverse use



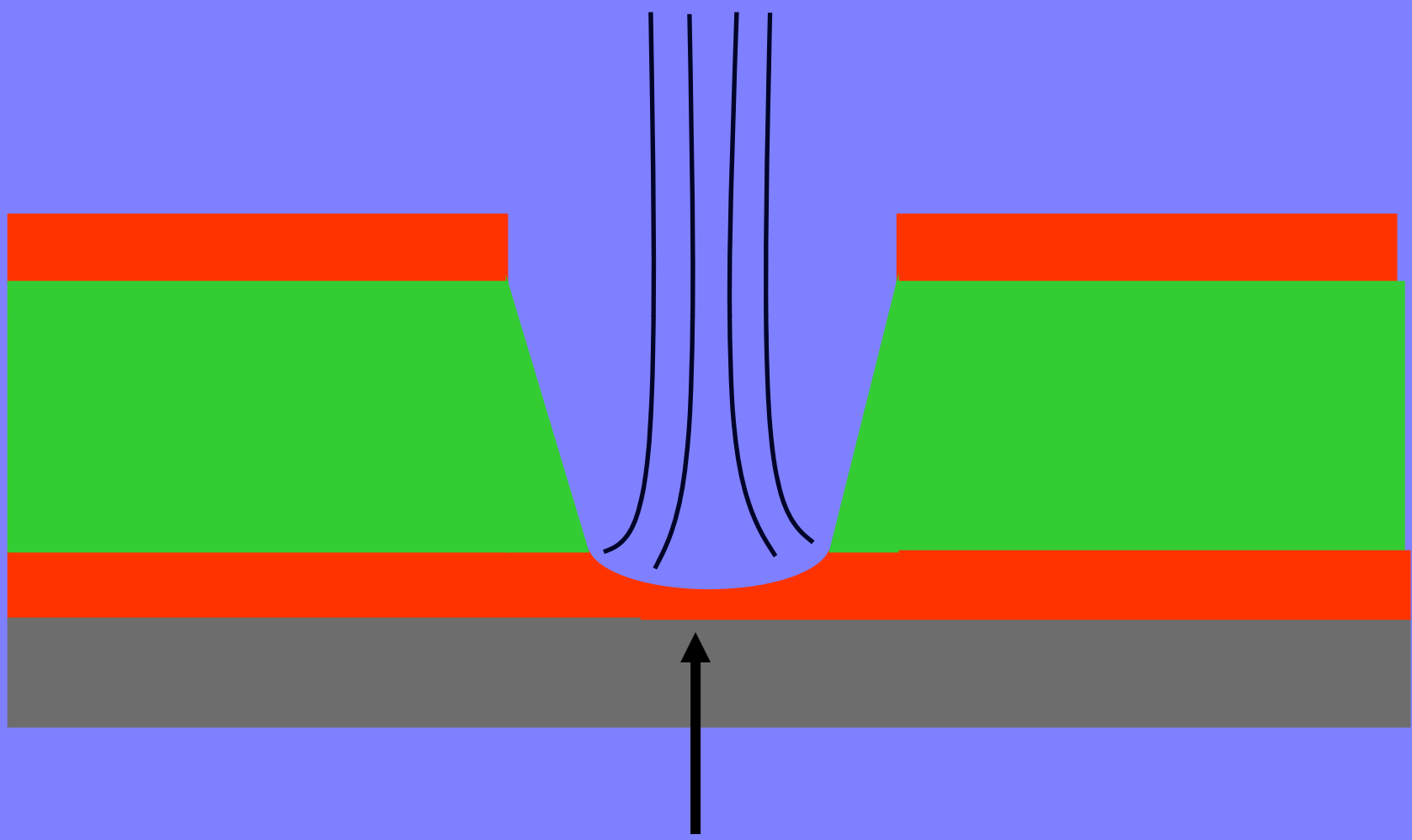

Copper electrode
getting ions
(deposition)
DC supply
-
+
Copper electrode
Loosing ions
(etched)
Cu++
Non connected
mildly etched
Top Electrode
Resist protection
Acidic cupric sulfate bath
The etching is proportional to the current

Current lines

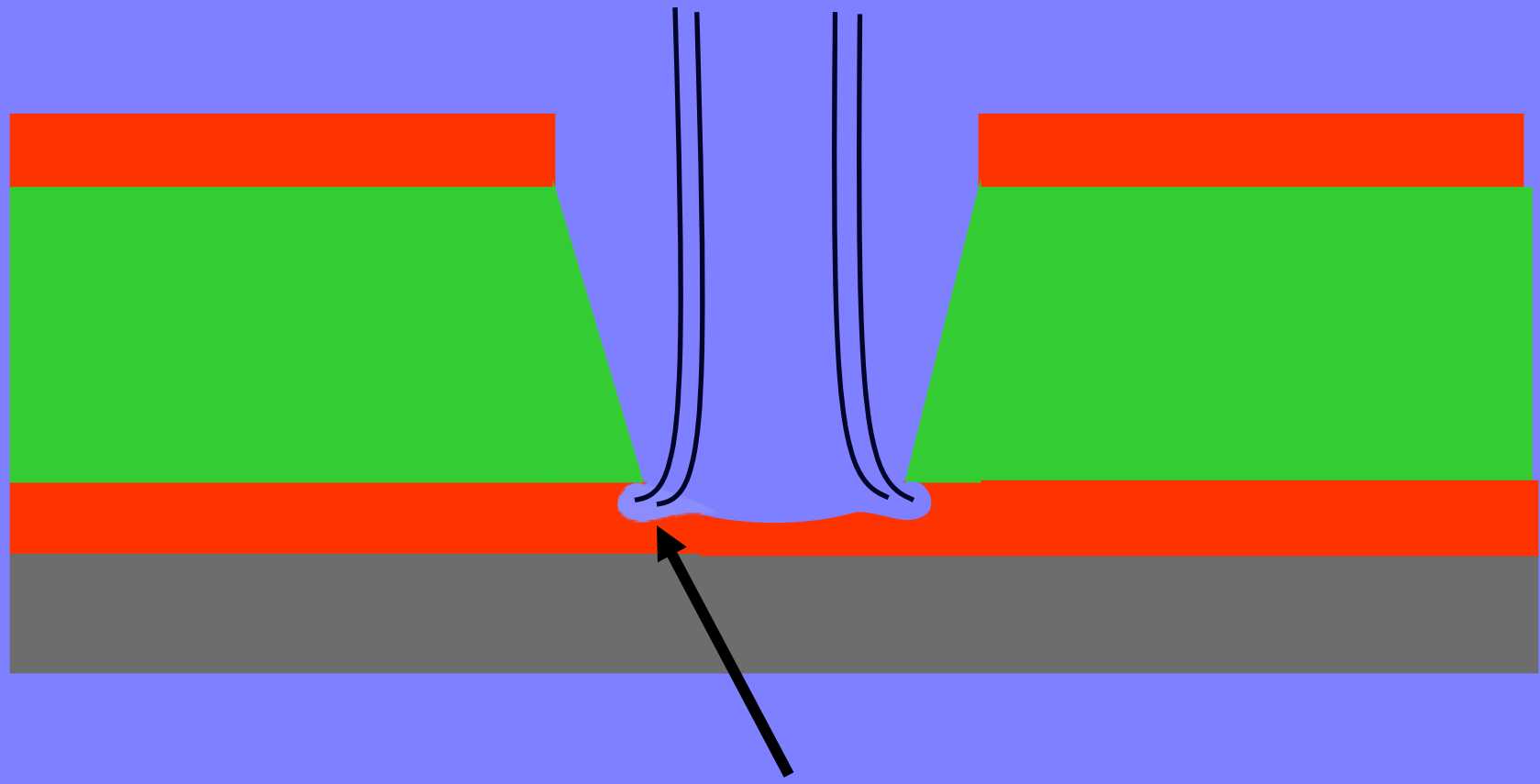


Starting structure

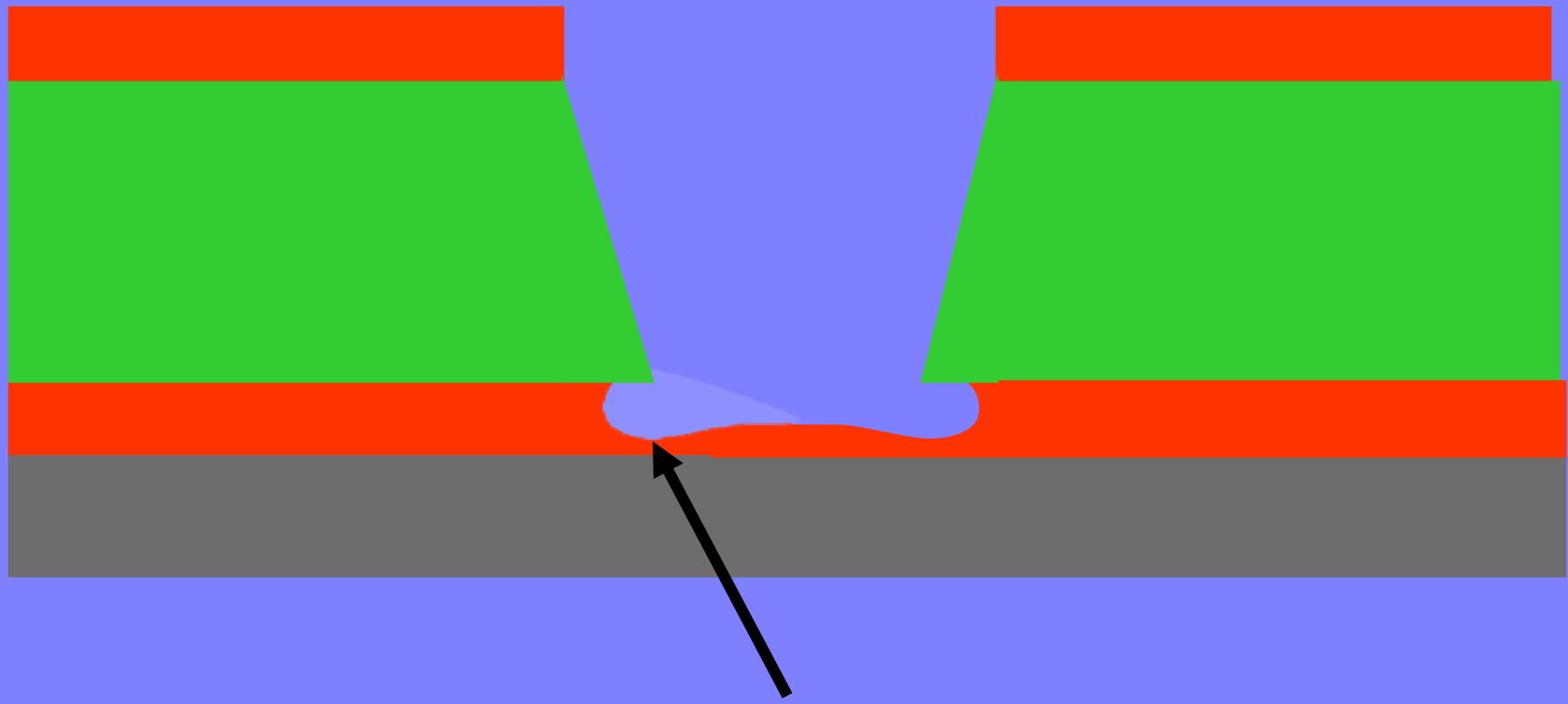
Current lines in the bath
Looking for the lower resistivity connection



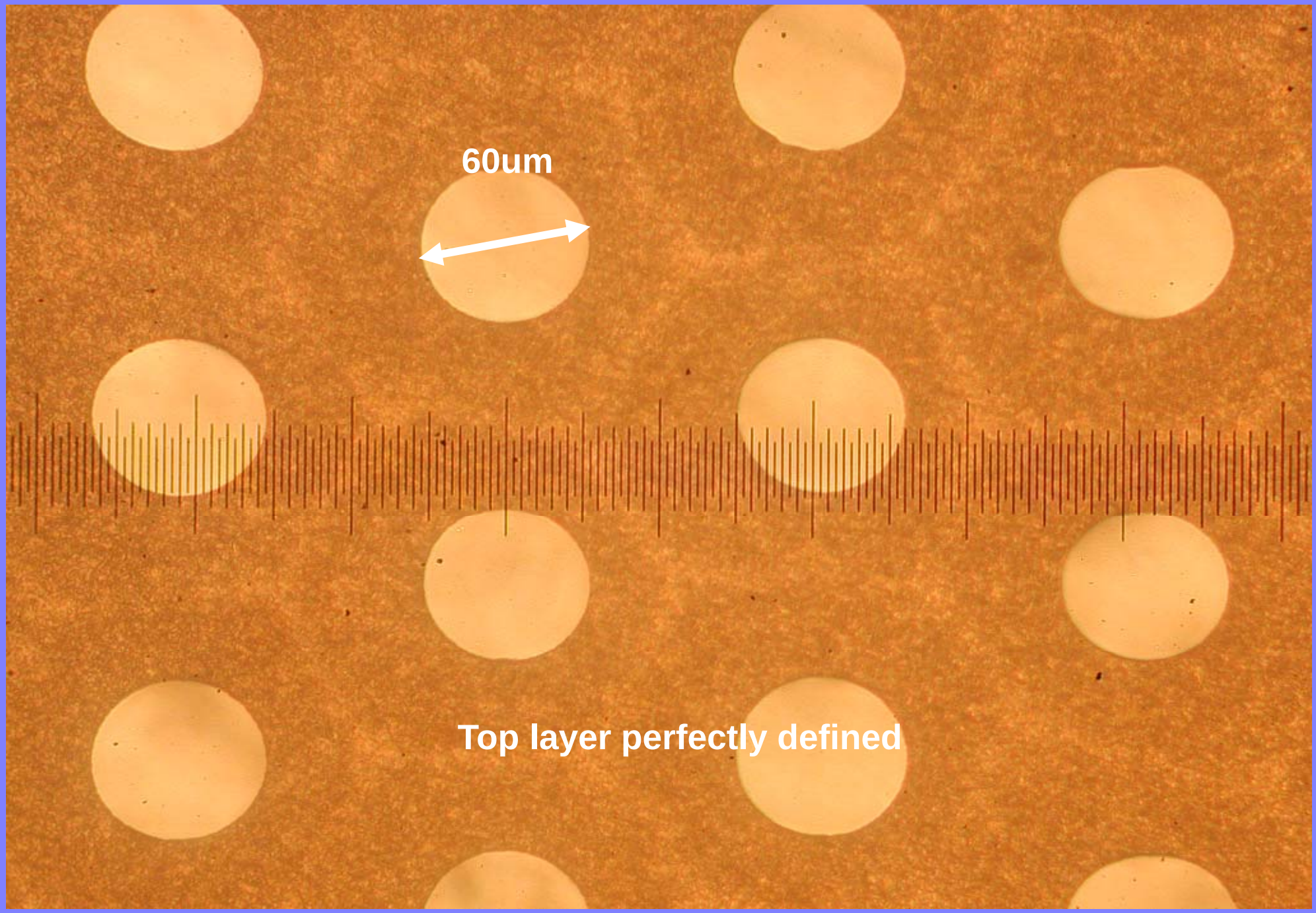
After a few minutes the copper is etched
and the resistivity starts to increasing locally at the center
The current density increases around the hole edge

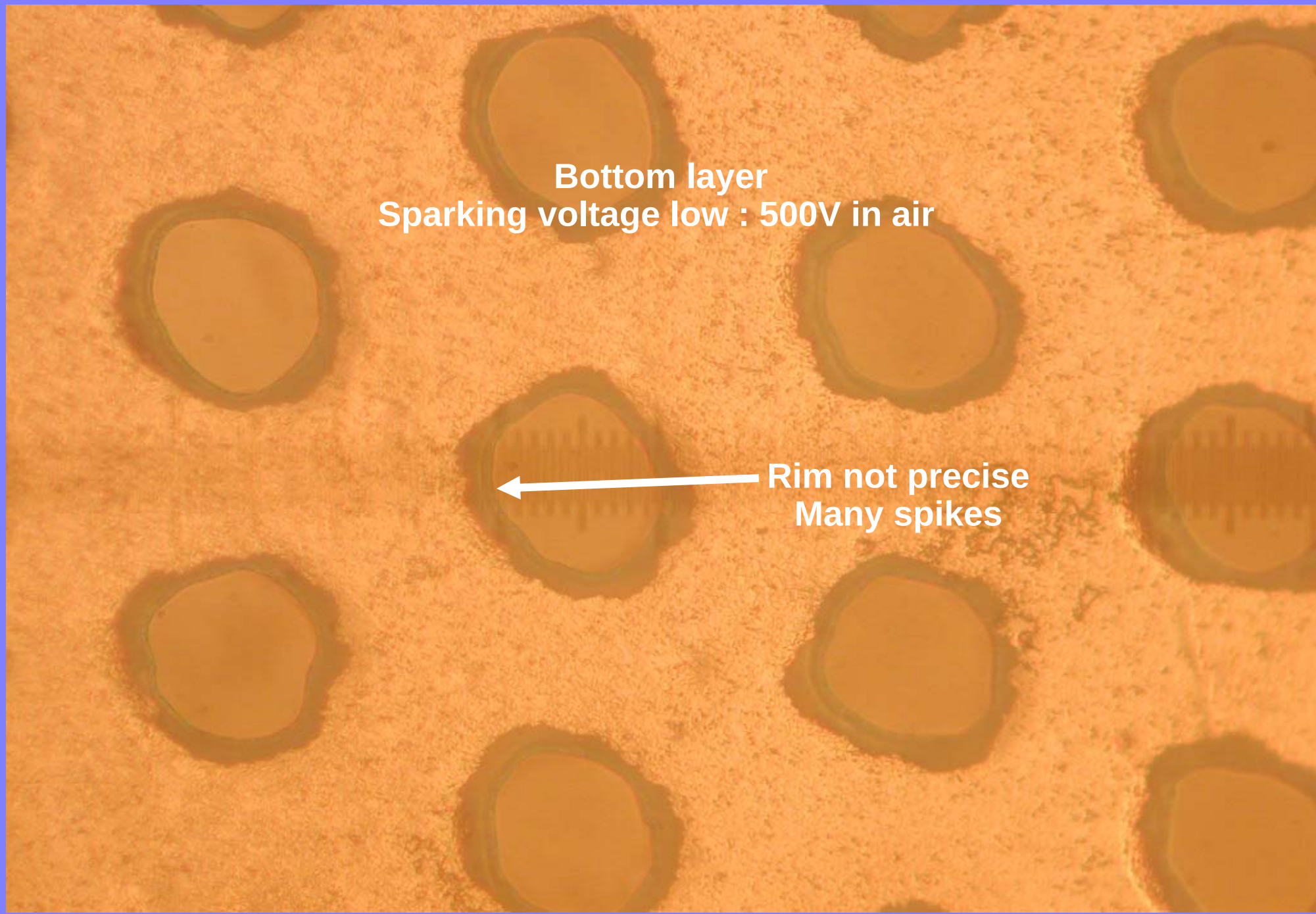


It induce an etching increase around the hole
The etching is directly related to the current density



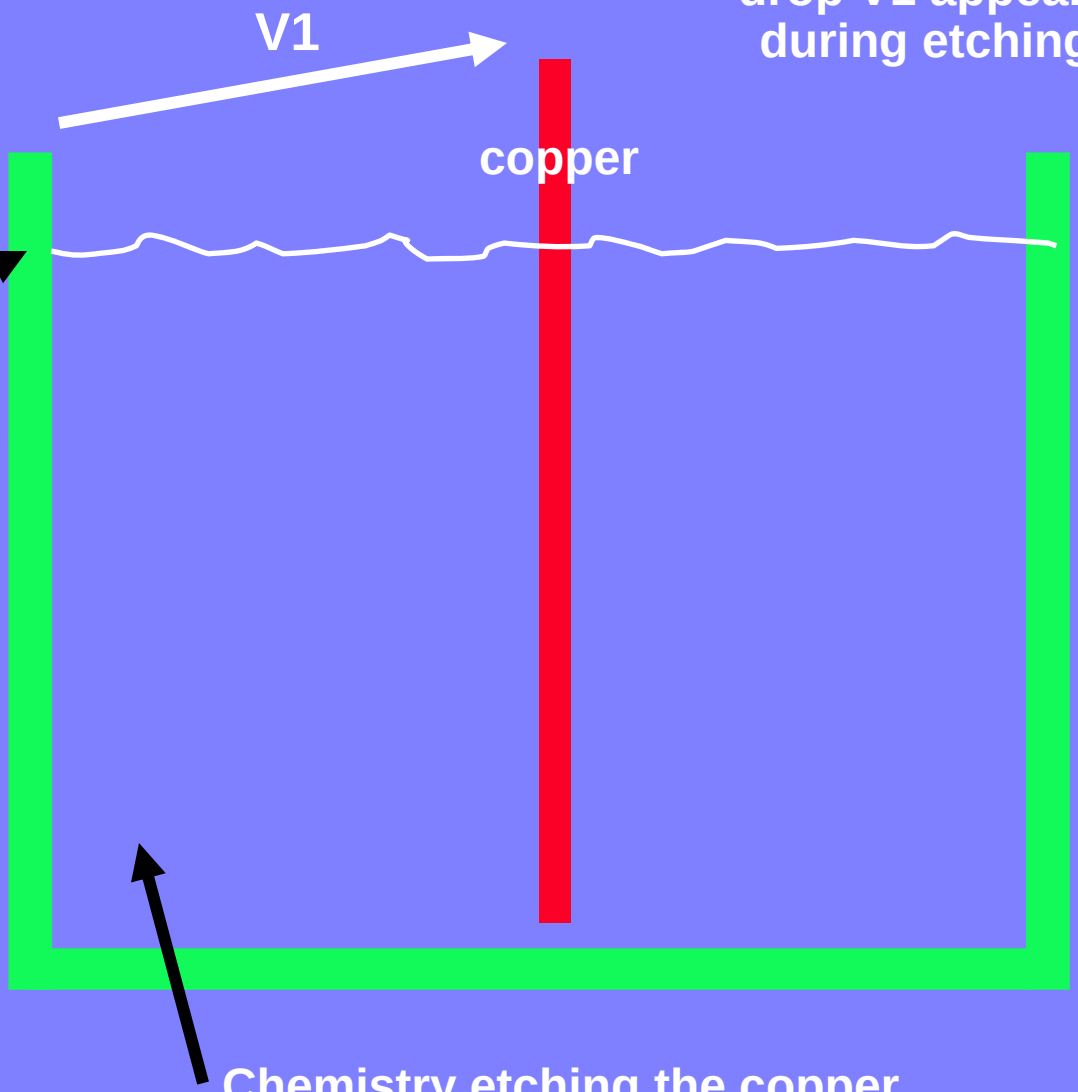
A thin copper layer is created, impossible to etch and leaving spikes
At one point the resistivity of this layer is too high to drive the current


60um
Top layer perfectly defined

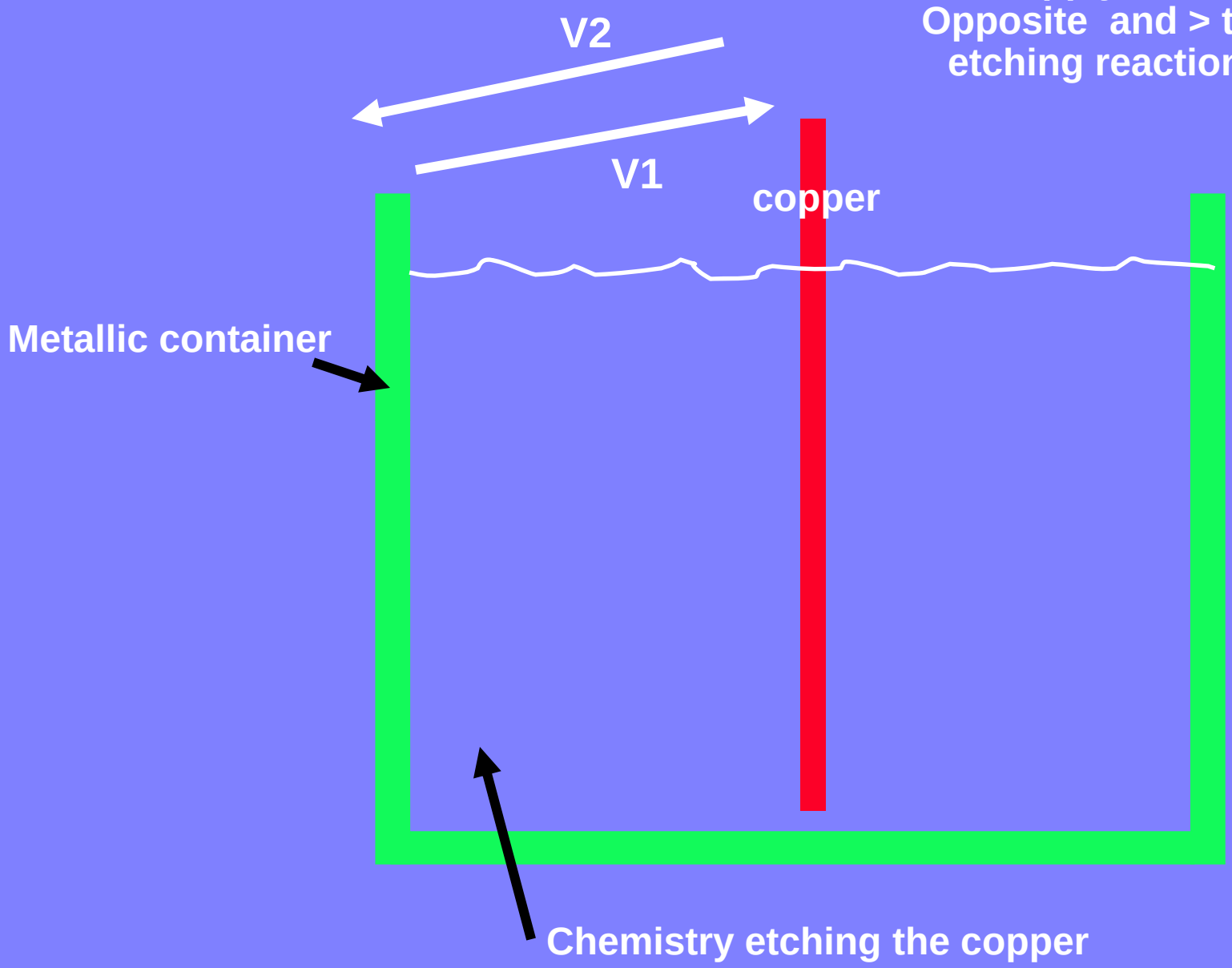

Bottom layer
Sparking voltage low : 500V in air
Rim not precise
Many spikes

2: Active corrosion protection

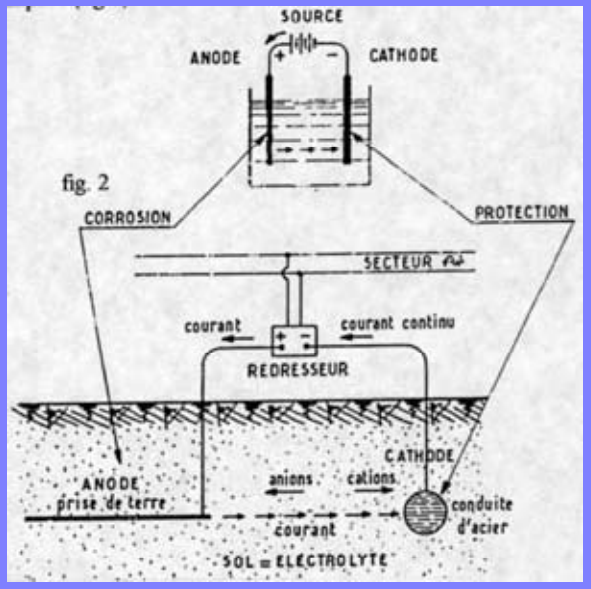
When the copper is immersed a voltage drop V1 appears during etching

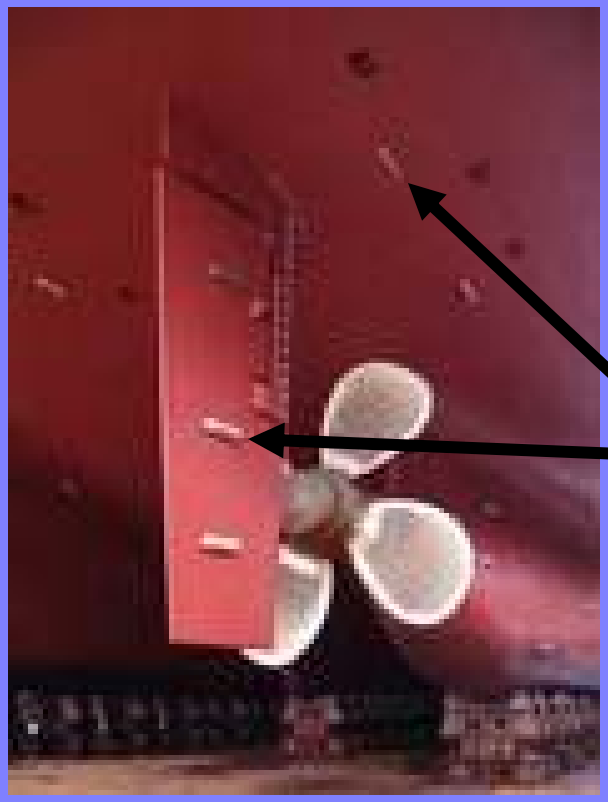


If we apply a voltage (V2) Opposite and > to V1 the etching reaction stops



Examples of application

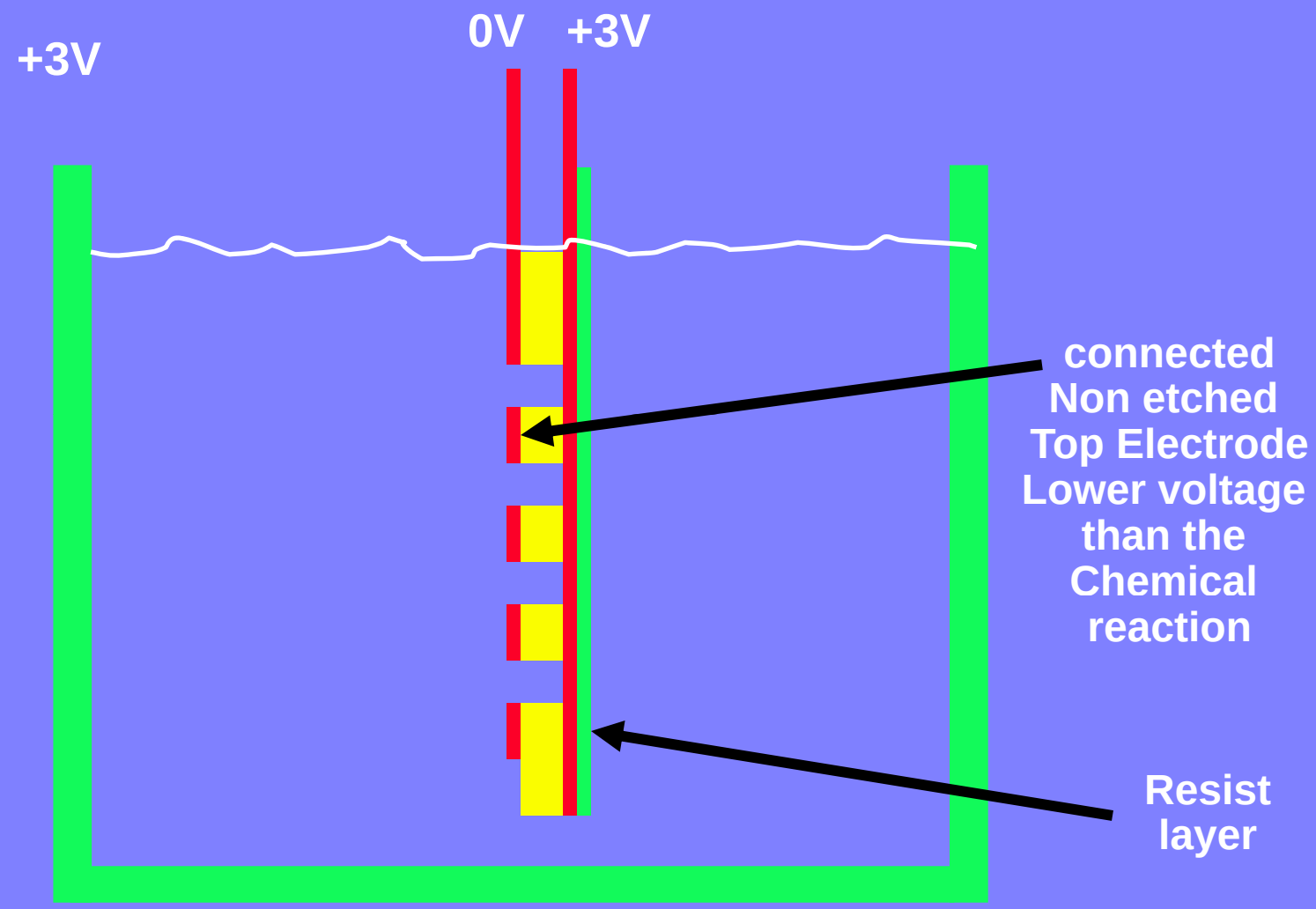




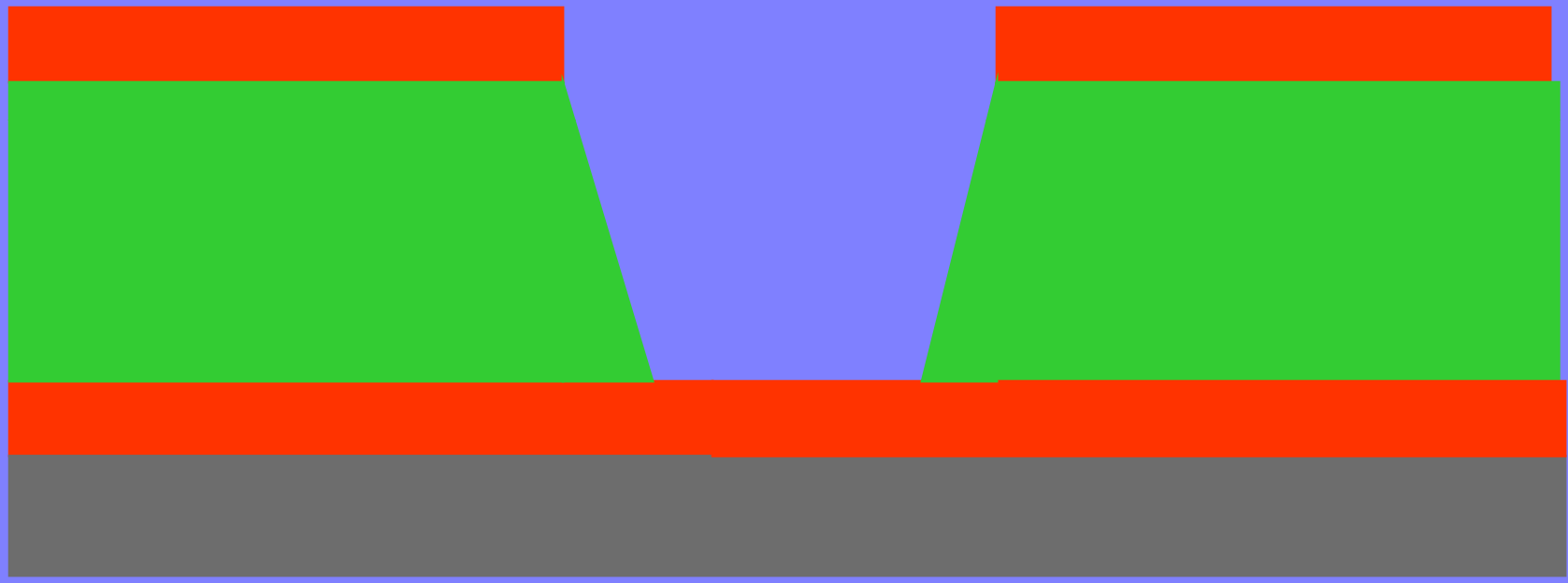
Electrodes to Polarize the water

Protection of boat hull against Sea water

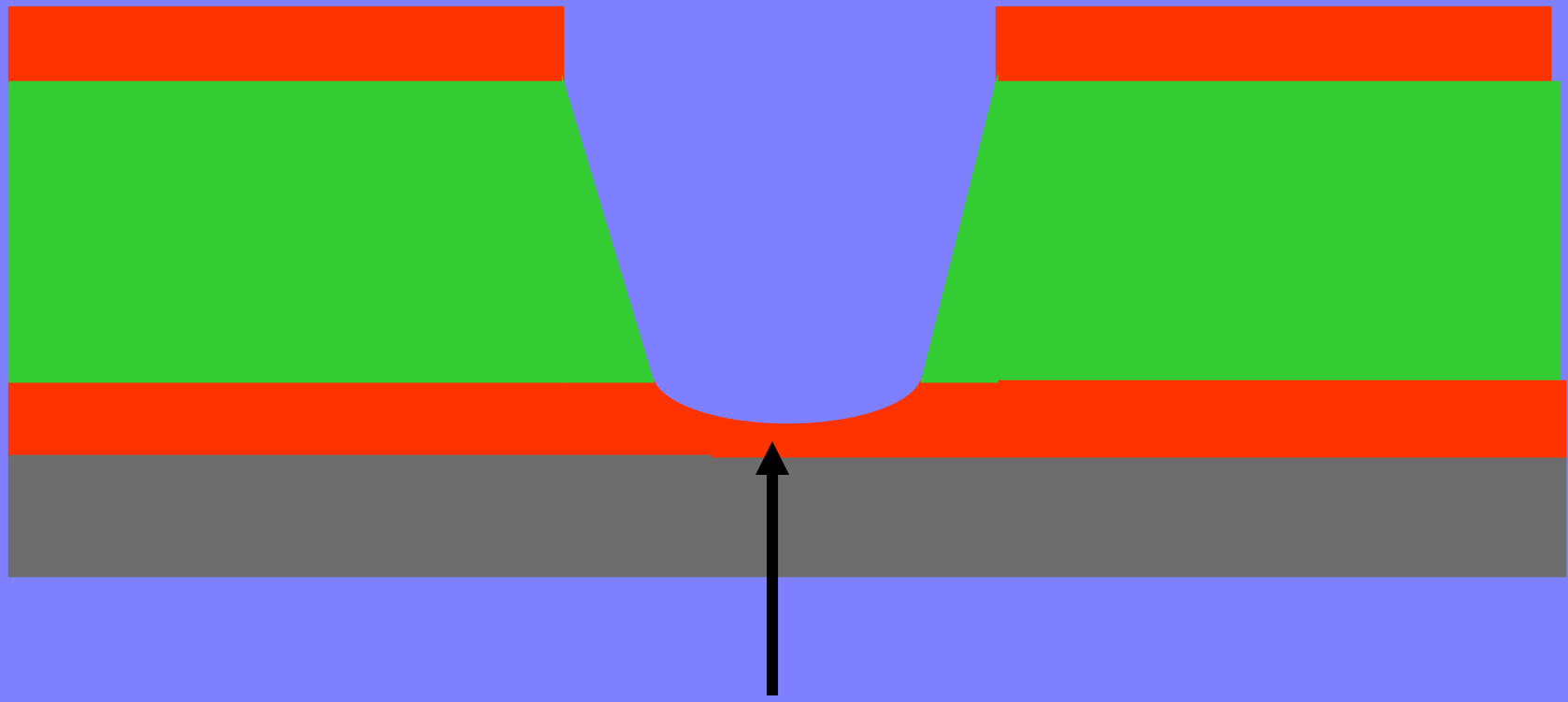
Protection of pipes against Humid ground corrosion



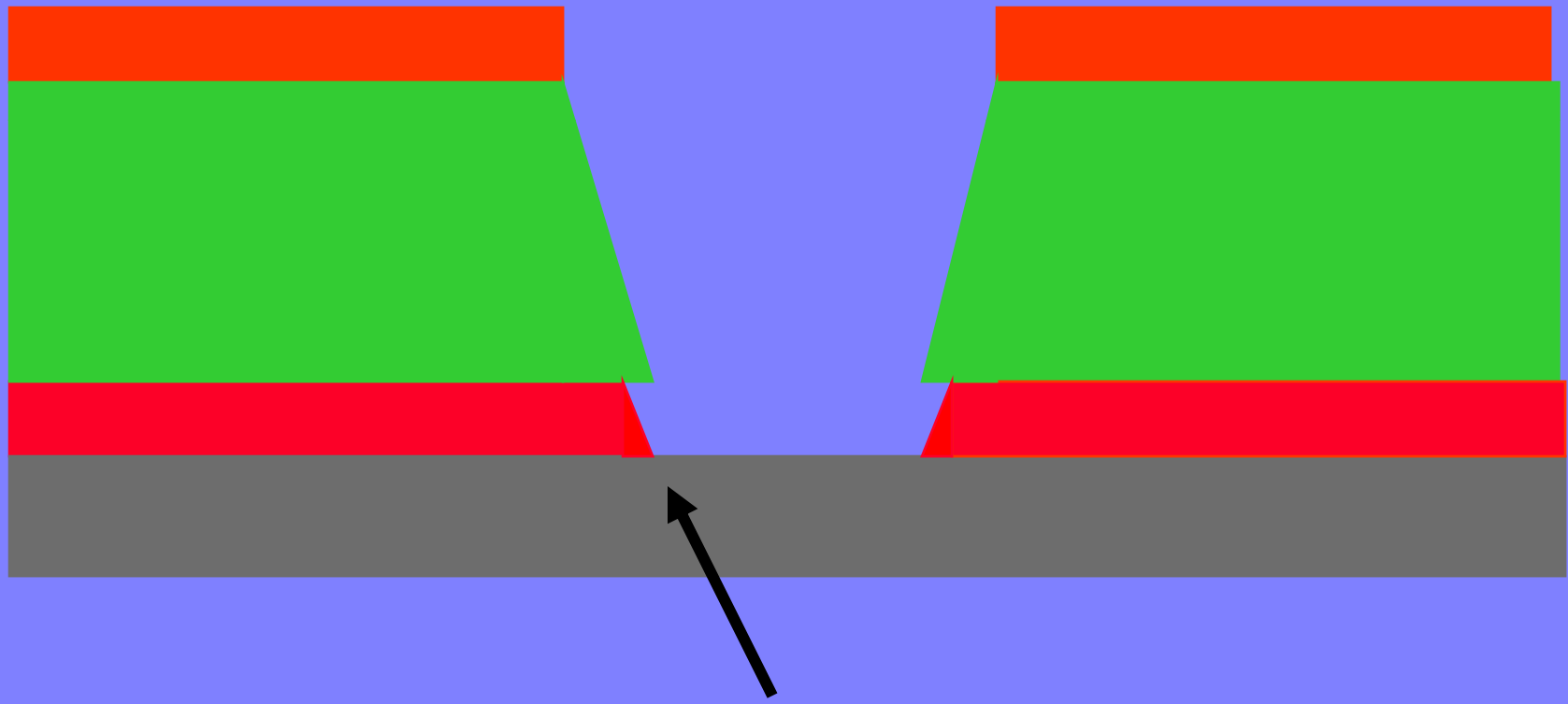
Bath at +3V
-everything at ground will be protected
-everything at +3V will be chemically etched
- An example of active corrosion protection



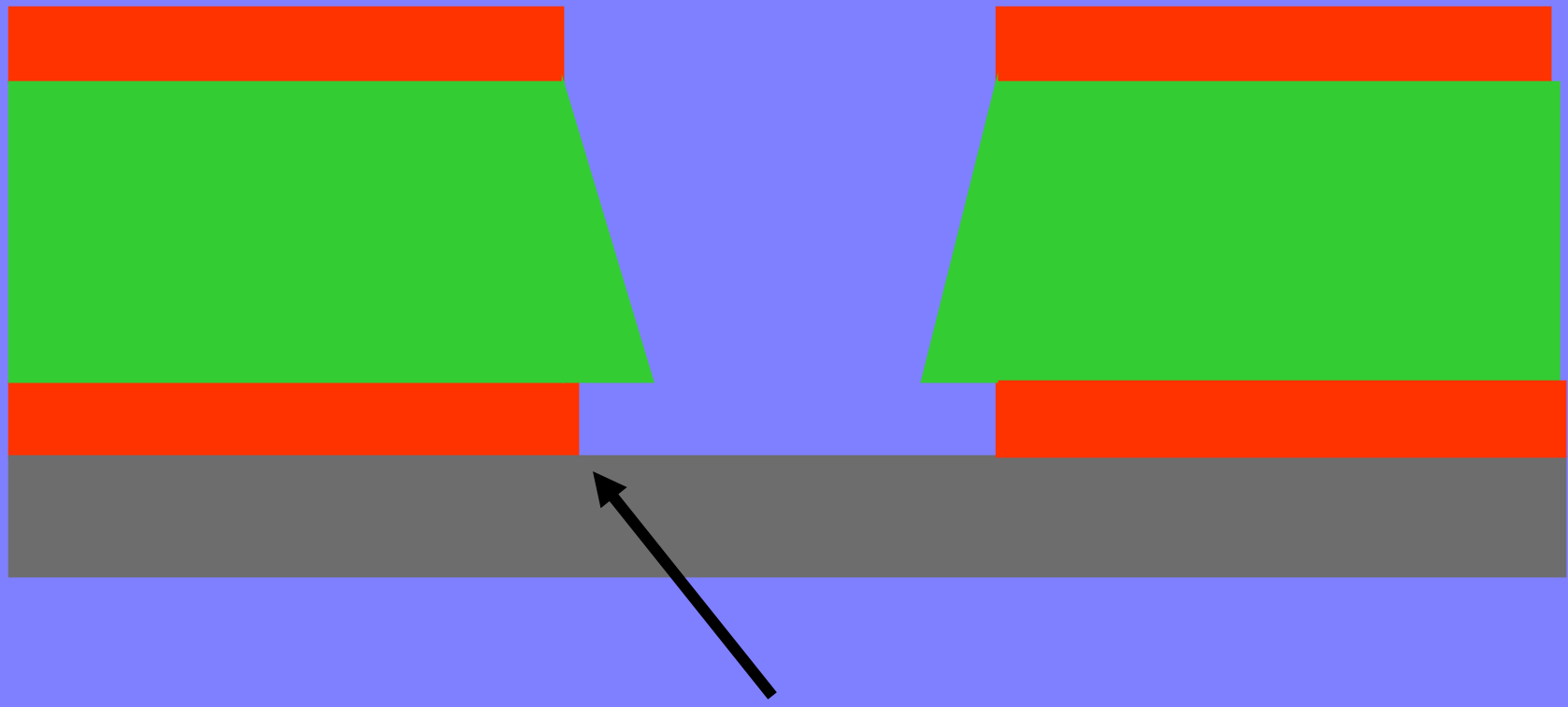
Starting structure

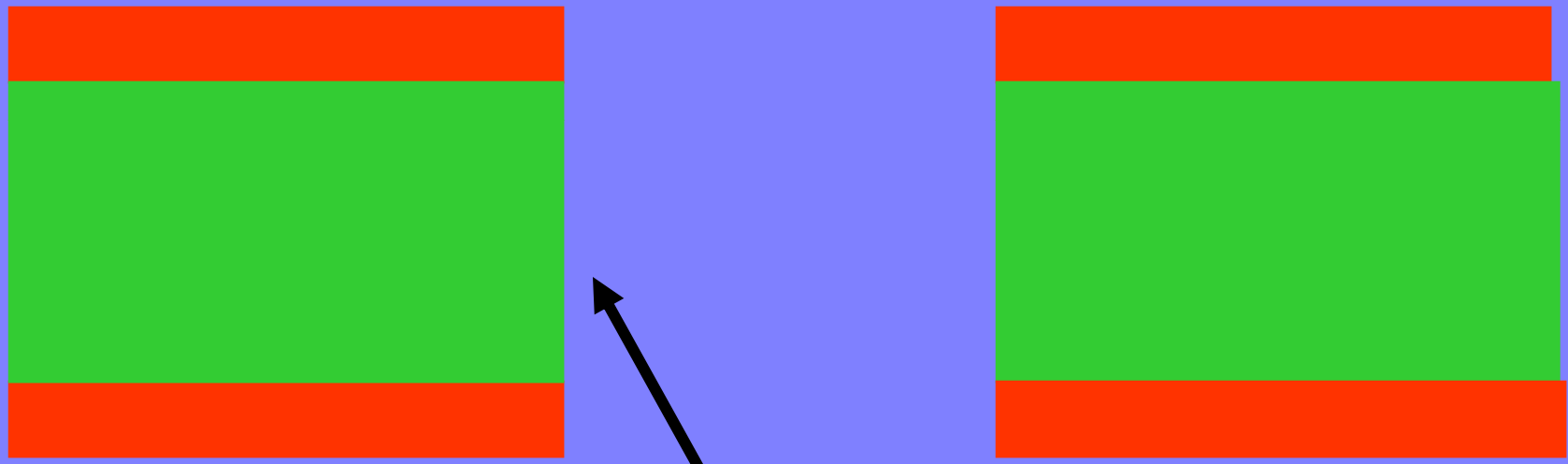


Conventional isotropic metal etching

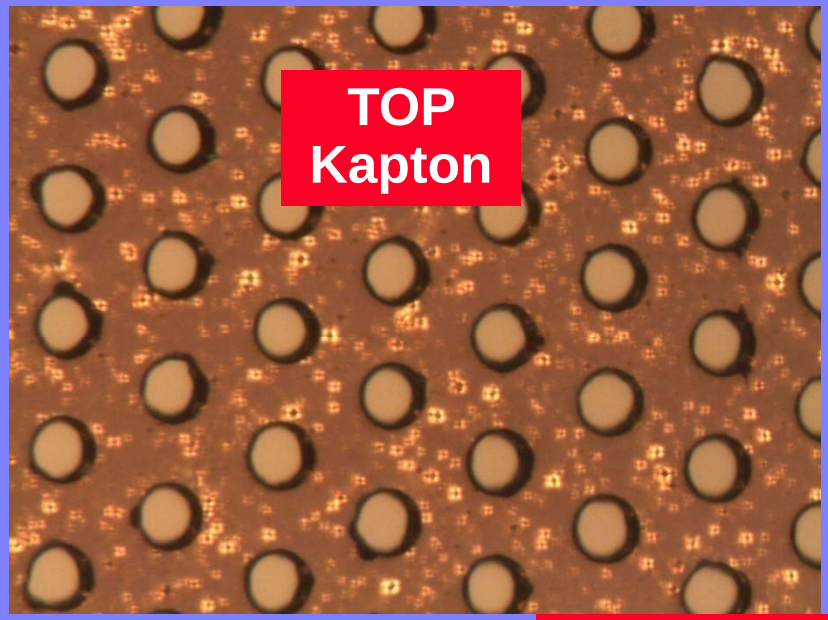


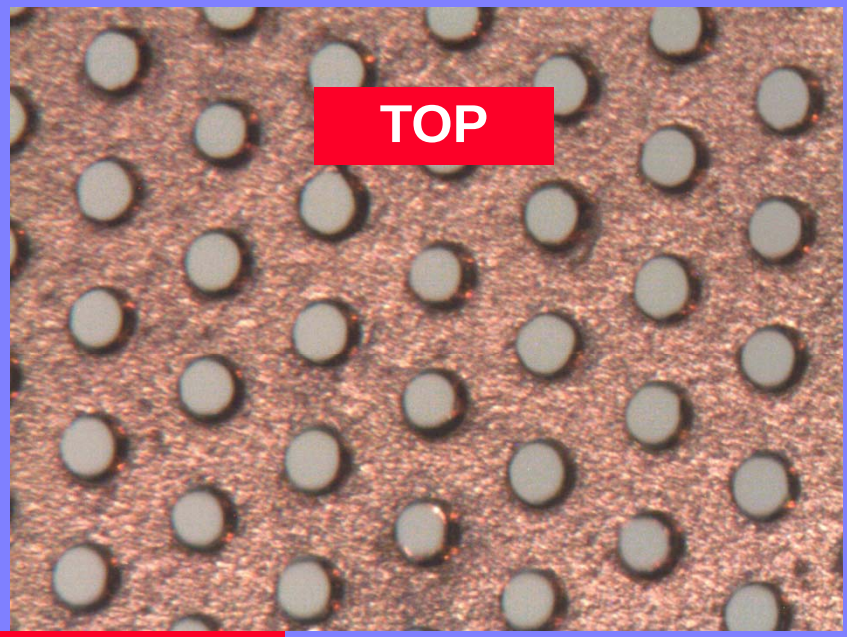
The hole is created but still an angle in the copper


With over etch

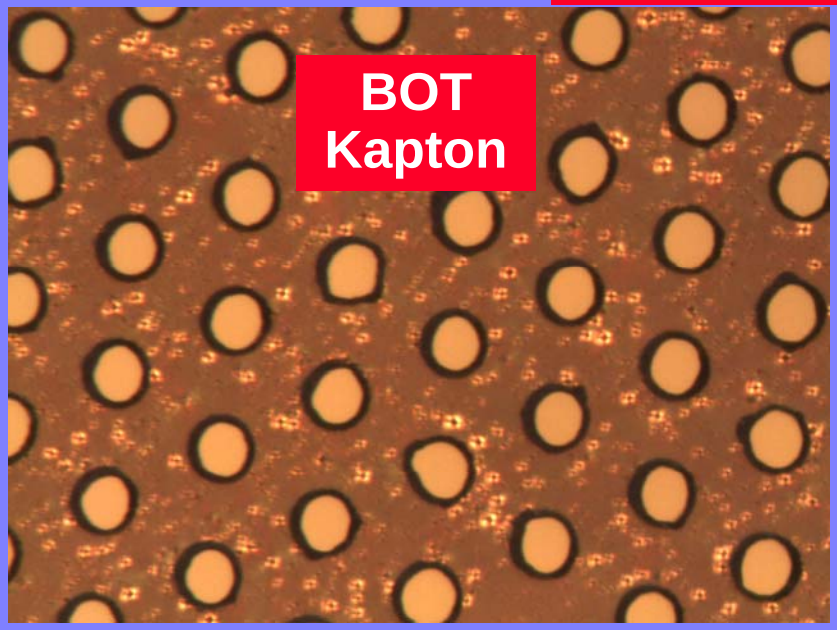


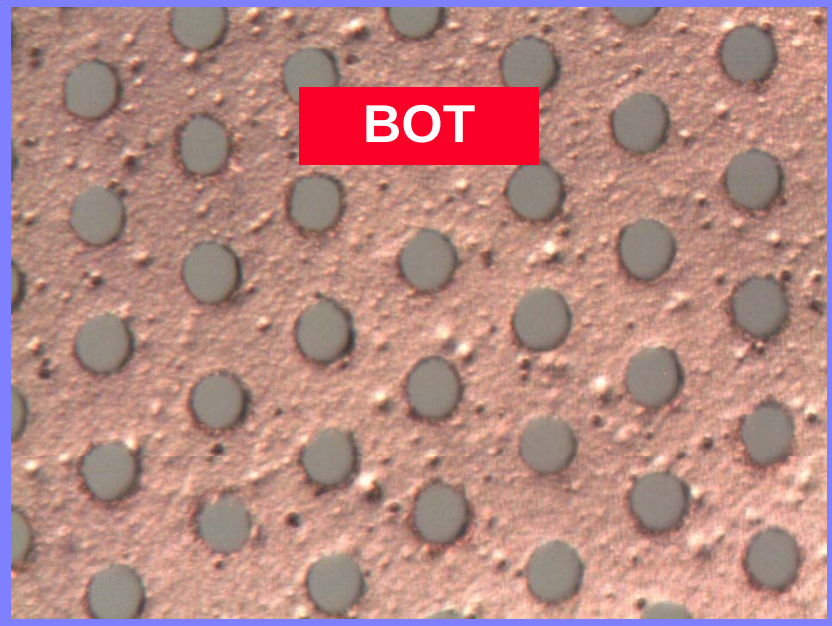
Going back to Polyimide etching for 30 sec
The hole become cylindrical

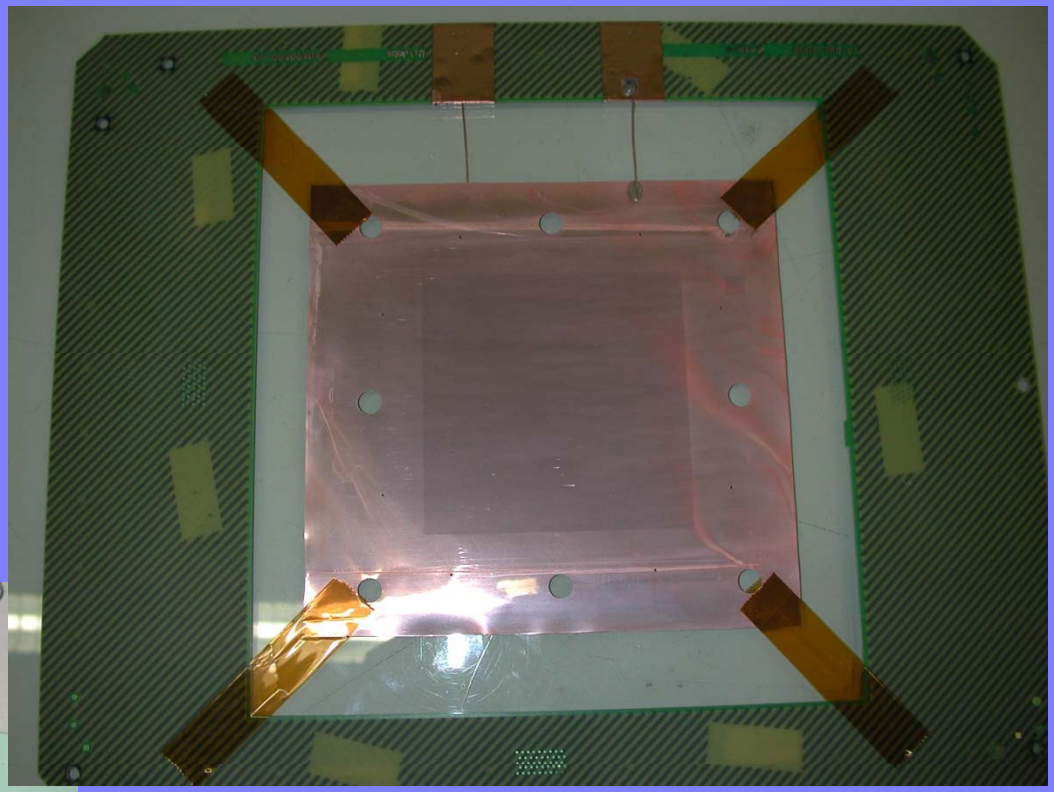




Sparking voltage 700 V in air







Test equipment
This technology is compatible with roll to roll process

Summary

- 12 GEMs Built middle of April (100% yield)
- 4 given to Giovanni Bencivenni
- 4 given to Serge Duarte Pinto
- 4 will be given to Bernd Voss

- Waiting for caracterisation

- Build a 1m x 33cm during May if results OK

Read out boards possibilities at CERN

type	complexity	Max size	Price factor (aproximative)	technology	drilling	plating
1D 1mm pitch	low	2m x 0.6m	1 x	Single sided board	n/a	no
1D 250um pitch	Medium	2m x 0.6m	1.5 x	Single sided board	n/a	no
2D 1mm pitch	Medium/low	1.4m x 0.5m	1.5 x	Double sided board	Mechanical	1 plating
2D 400um pitch	Medium/High	0.6m x 0.5m	3 x	Double sided board	Micro via	1 plating
2D GEM 400um pitch	medium	0.6m x 0.45m	2.5 x	Double sided flex	Mechanical or Micro via or no hole	1 plating Or no
3D 400um pitch	high	0.4m x 0.4m	5 x	5 layers	Blind via + Micro via	4 platings
PADs 5mm x 5mm	medium	0.5m x 0.5m	2 x	Min 3 layers	Blind via + Mechanical	2 platings
Pixel 0.5-2mm	High	0.4m x 0.4m	6 x	Depends on pixel. 6 to 10 layers	Blind via + Micro via	4 and more