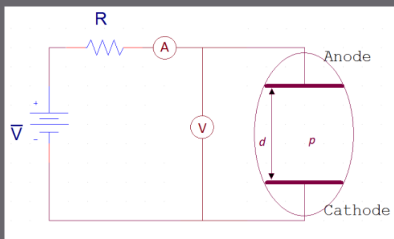
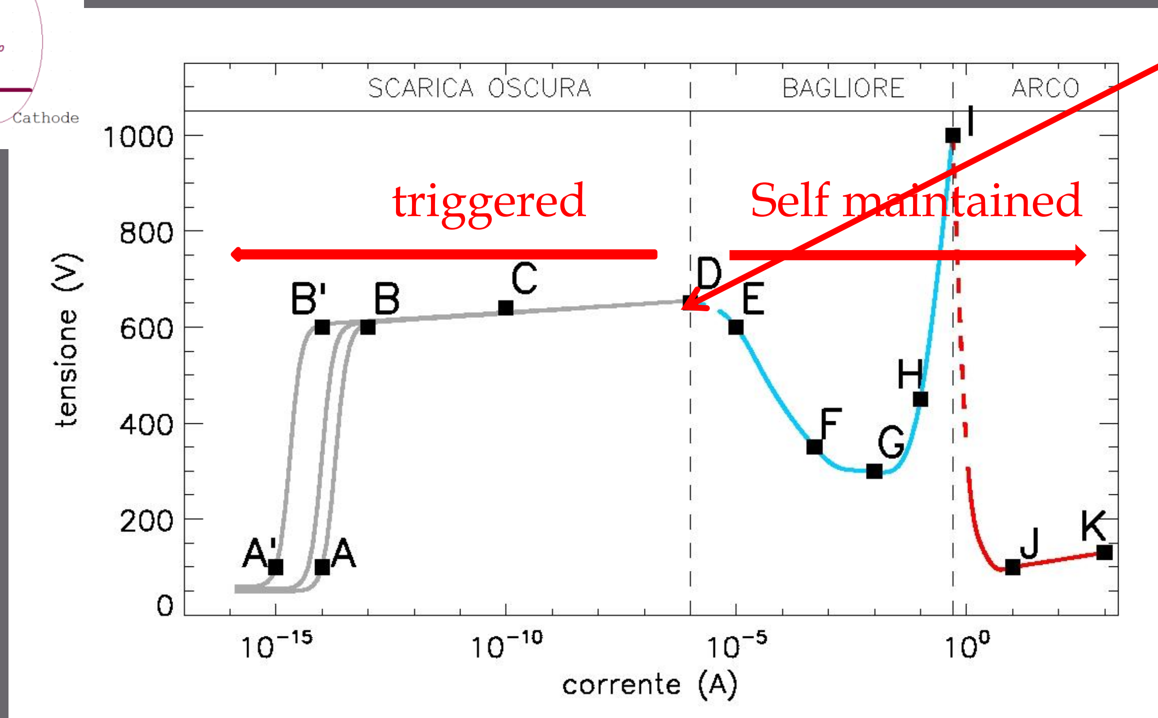
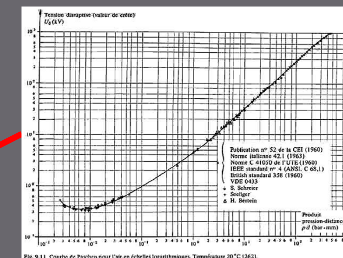
Sparks

Rui De Oliveira

Voltage/current characteristics of the DC electrical discharges



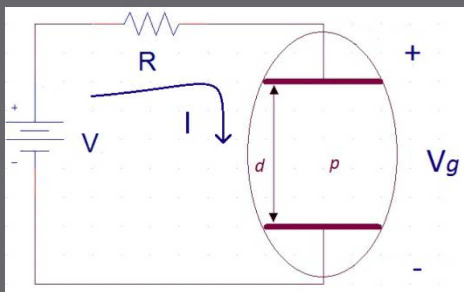




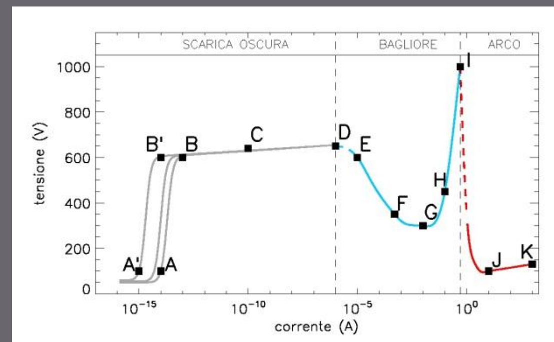
Gas Discharge Physics, Yuri P. Raizer

DC pulse-powered micro-discharges on planar electrodes, Yogesh B. Gianchandani

Working point : the load line method

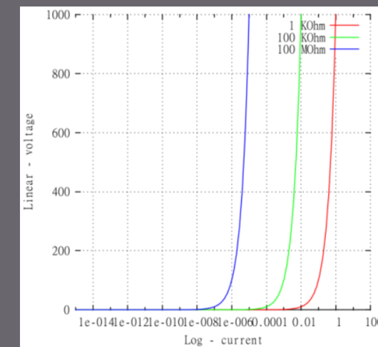


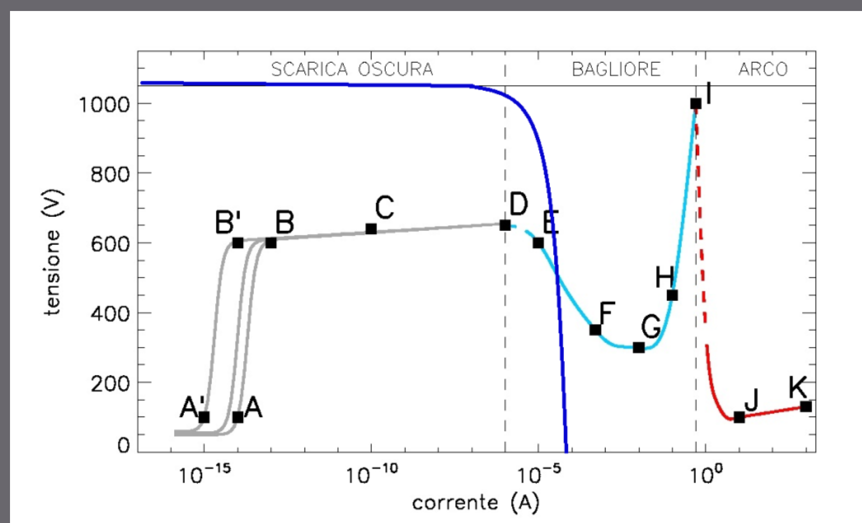
$$V - RI = Vg$$



$$V_g = f(I)$$

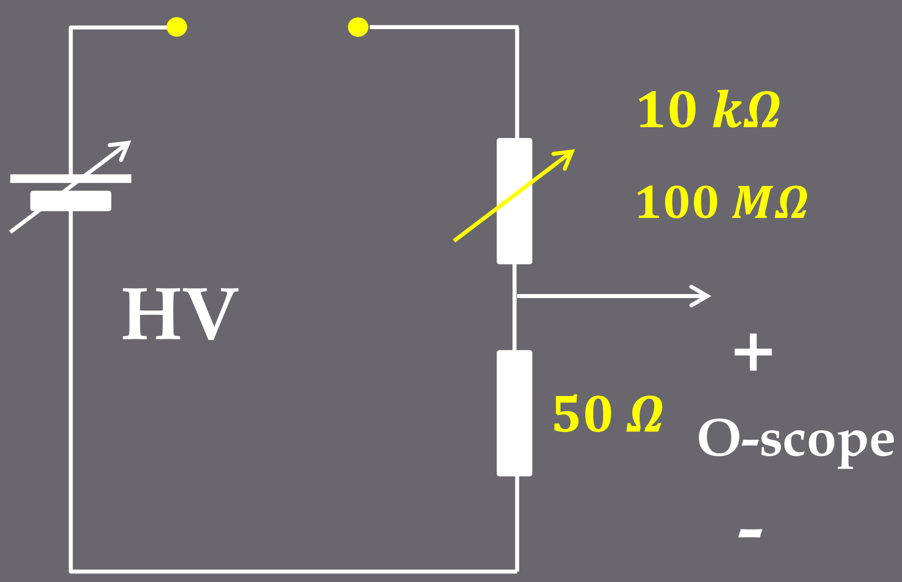
+

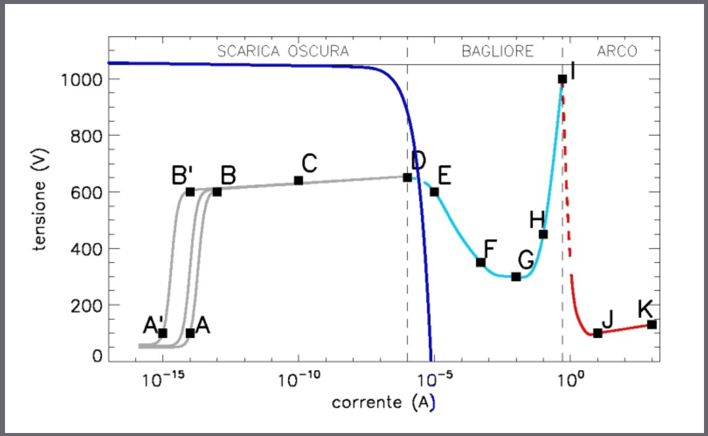


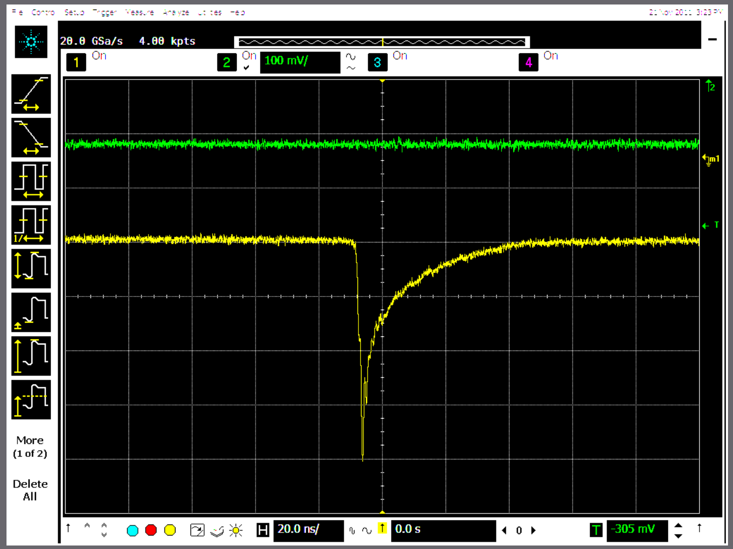


Sparks between two metallic tips in air

AIR, 1 atm **Low inter tips C**







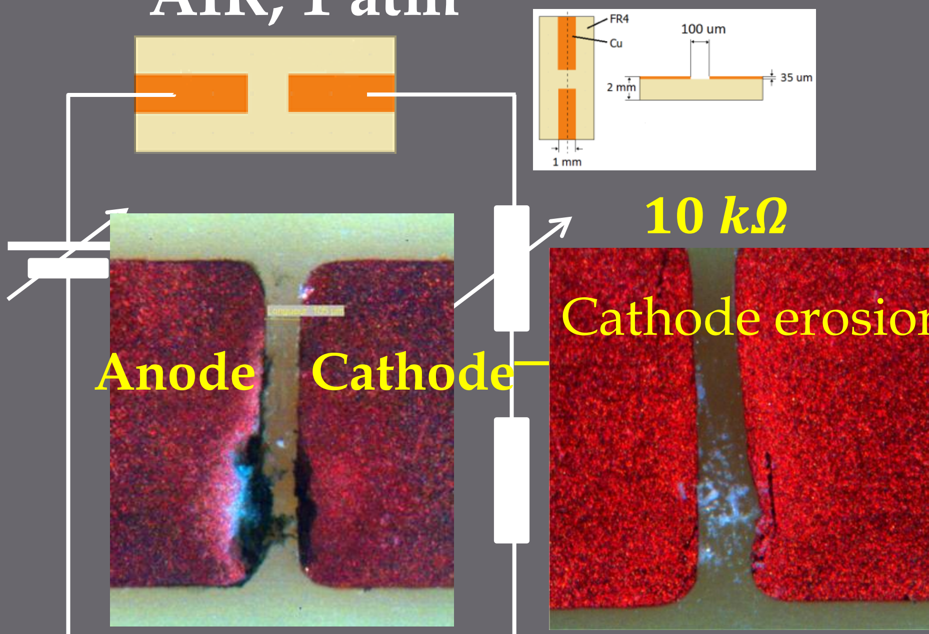
-No change is observed.

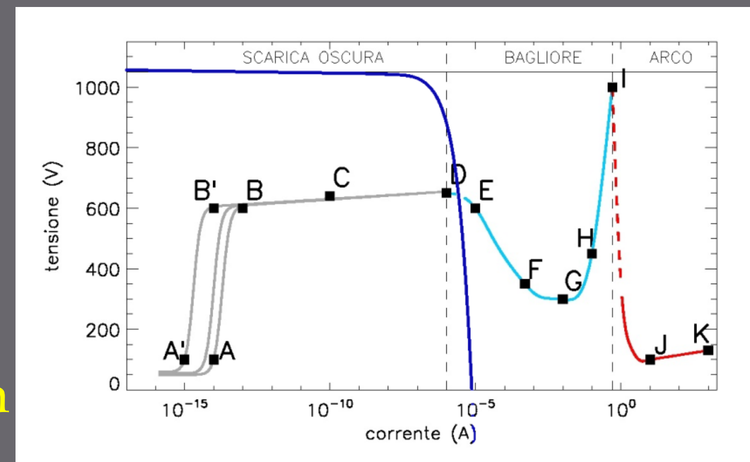
-The system is stably in one of the regions of the I-V characteristic.

-We can notice a little erosion of the Copper

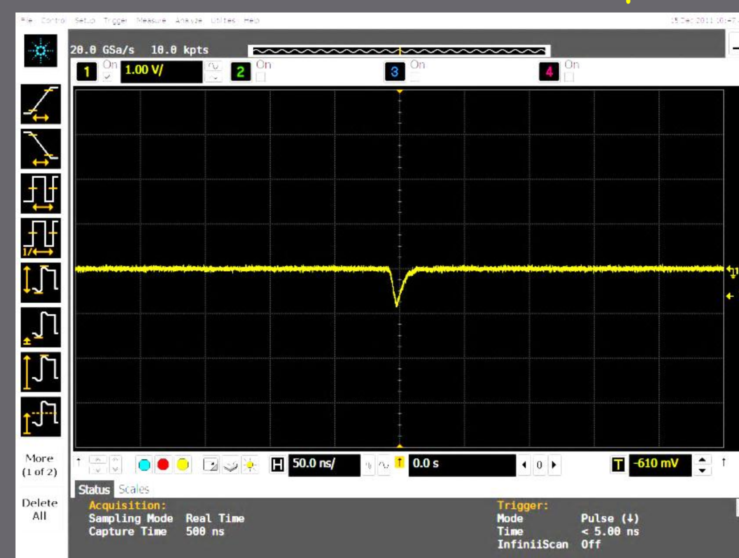
Sparks between copper lines on a PCB

AIR, 1 atm





At the end a DC current ~ μA

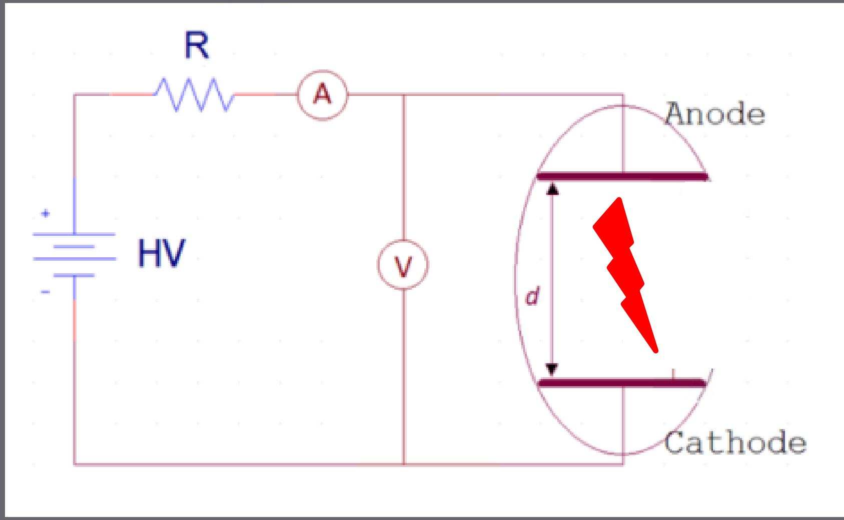


-During the sparks the growth of a layer is observed all around the impact point of the discharge, especially on the anode.

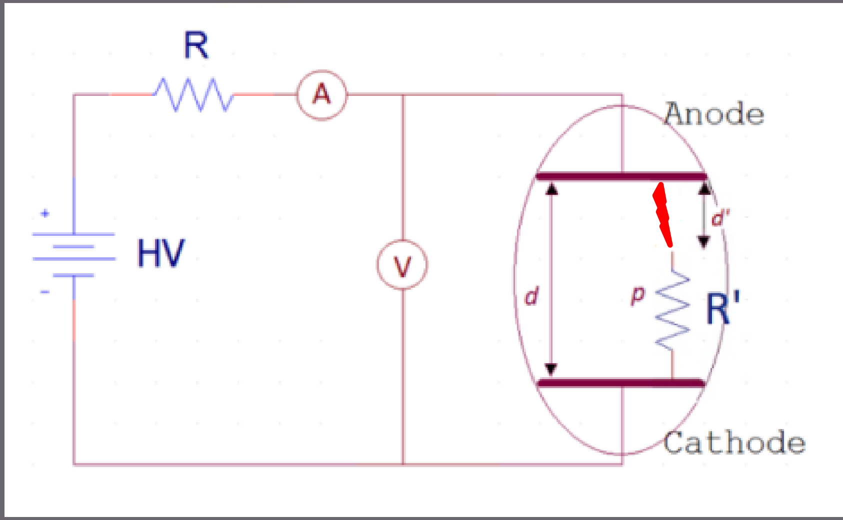
-We have also some erosion ofthe copper

-But the blue deposit is created by the epoxy

Introducing R′



Before

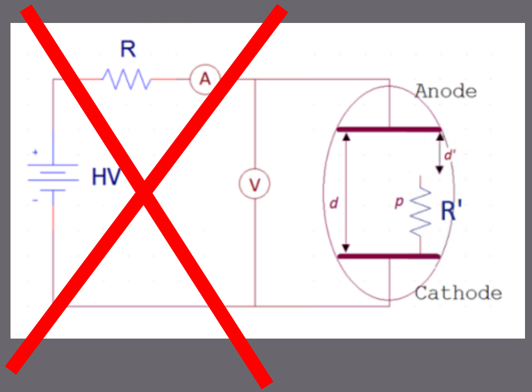


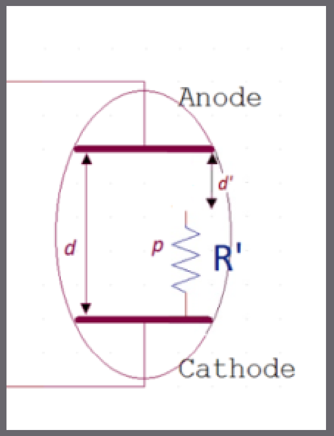
After

R′ is created

Voltage breakdown reduced :d′

Large capacity system





-If the capacity of the tips is high then this capacitor becomes the power supply for the spark
it can deliver more current than the power supply with no limitation

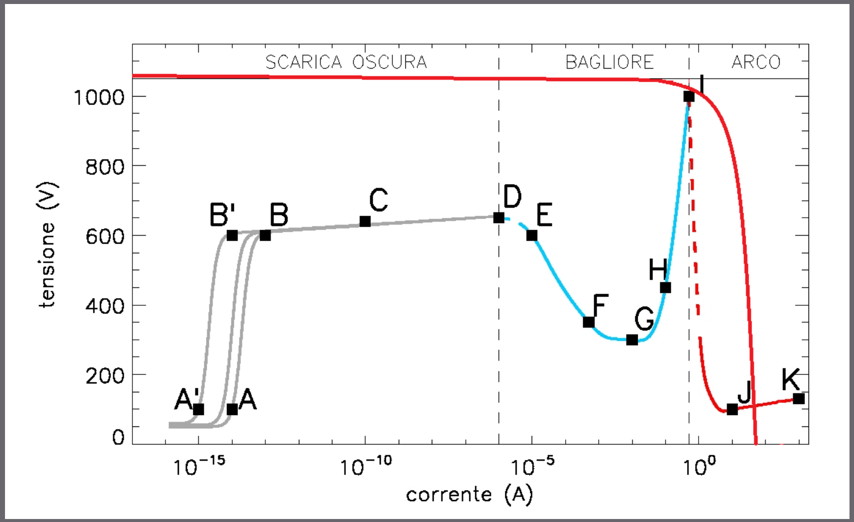
-The spark current is then practically independent from external power supply

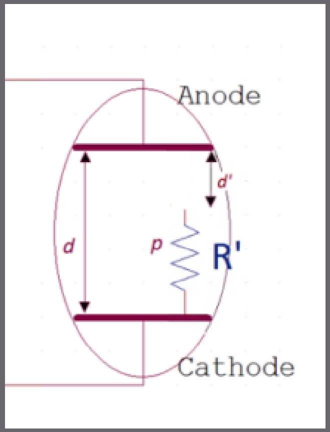
-The peak current only depends on: the capacitor value , R' and C voltage
(this current can not be measured in this configuration)

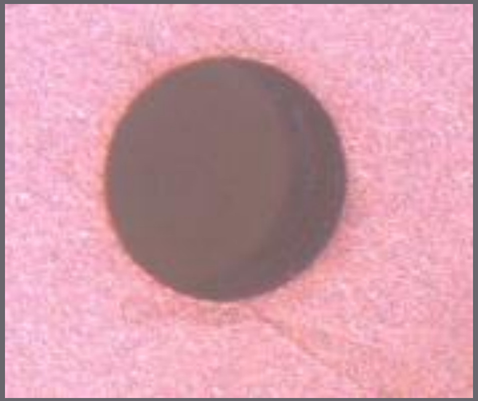
-The new Voltage breakdown will be define by d'

- The external power supply and R are just refilling the capacitor after a spark (defining the spark rate only)

THGEM test : initial situation

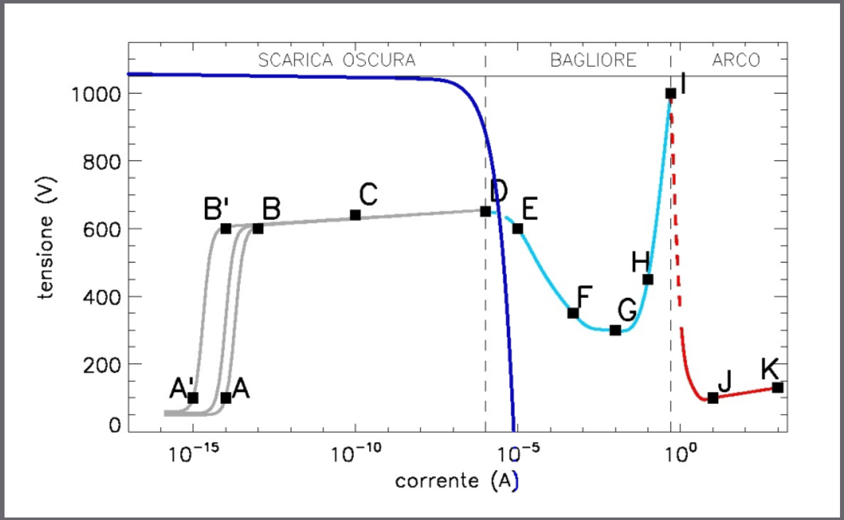


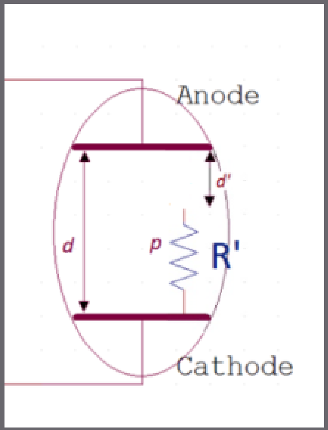


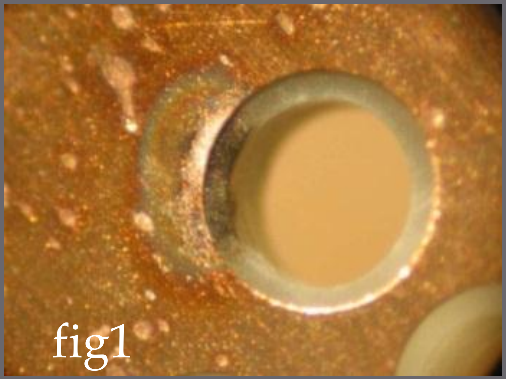


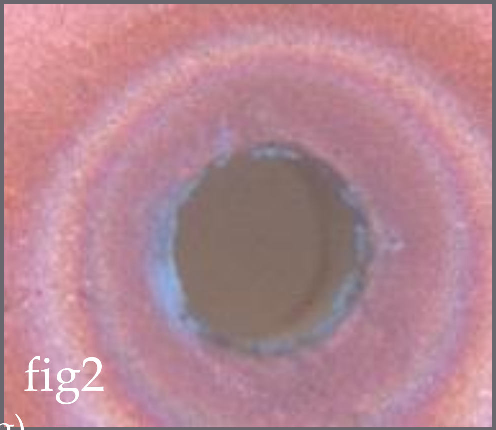
-At this stage R′ is only the copper surface resistivity (below 10 Ω)
- Working point in spark region
-High current discharge (define by C and R′)
-The system seems to be stable with repetitive sparks and average currents of few hundreds of nA (the rate of sparking is define by the capacitor value and the serial resistor after the power supply)

After spark → glow discharge









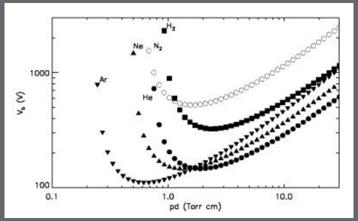
The repetitive sparks starts to create a deposit fig 1
-R′ is created and starts to grow (we think that the value is randomly changing)
- After many sparks the working point moves in the glow discharge region but still with pulsed current and with increasing rate.
-At one point the external power supply can deliver the current defined by the working point
-The system then moves in a stable mode and draws many micro amps DC current (the THGEM is dead)
-The DC glow discharge starts to grow a new deposit all around the hole. fig2

Ramping up the voltage slowly and limit the current

- In fact you are defining a working point exactly in the dangerous region of the device.
- Any dust can create the resistor R′
- The first action to do is to give enough energy to the system to evaporate all the dusts to have a working point in the spark region
- Usually leaving the system in the glow discharge region polymerize the dust and make it even more stable.

Preferred process

- Store the GEM in test in a low humidity environment (air with RH<35% or dry nitrogen)
- Look at the Paschen curve of the gas for 50um and 1 bar:
  - Air: 650V for 50um
  - N2: 600V for 50um



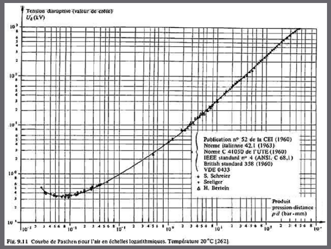


Fig. 9.11 Courbe de Paschen pour l'air en échelles logarithmiques. Température 20 °C [262]

- Apply directly Pashen voltage -50V with 2uA limitation for 100cm2
  - It gives a rate of spark in the 1 hertz range
  - Let the GEM sparks a few times to clean dust
  - After a few seconds the GEM should stop sparking
  - After 20 seconds the leakage current can be measured