Circular Ion Sources for pre-treatment, etching and ion assistance

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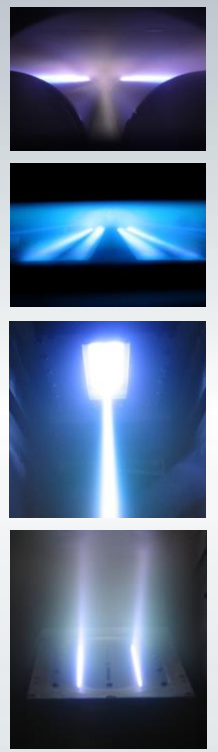
Gencoa, Liverpool, UK

- Introduction
- Ion Source Principles
- IMC75 Principle
- IMC75 Operating Range
- Power Supply/Feedback Control
- Etching Results
- DLC Coating Results
- Summary



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Gencoa IM75 plasma source for ***Research and Development***

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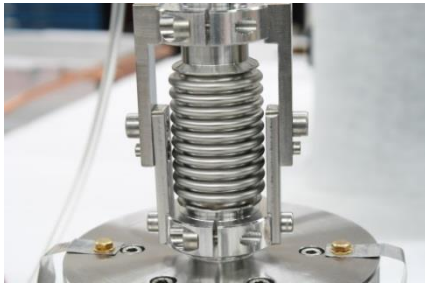
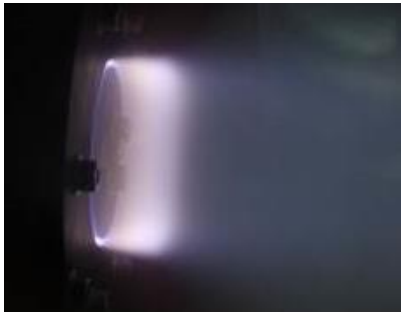
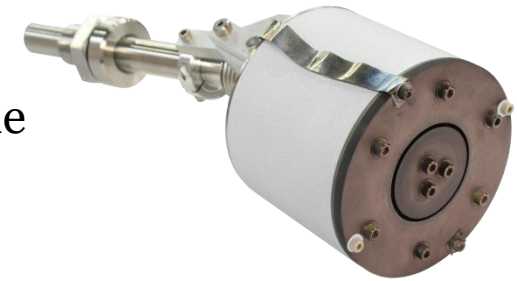
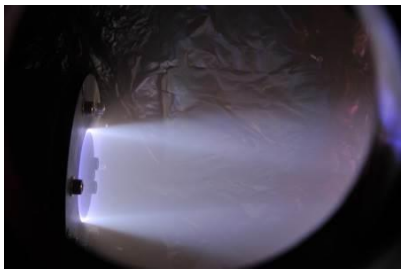
A multi-functional plasma beam



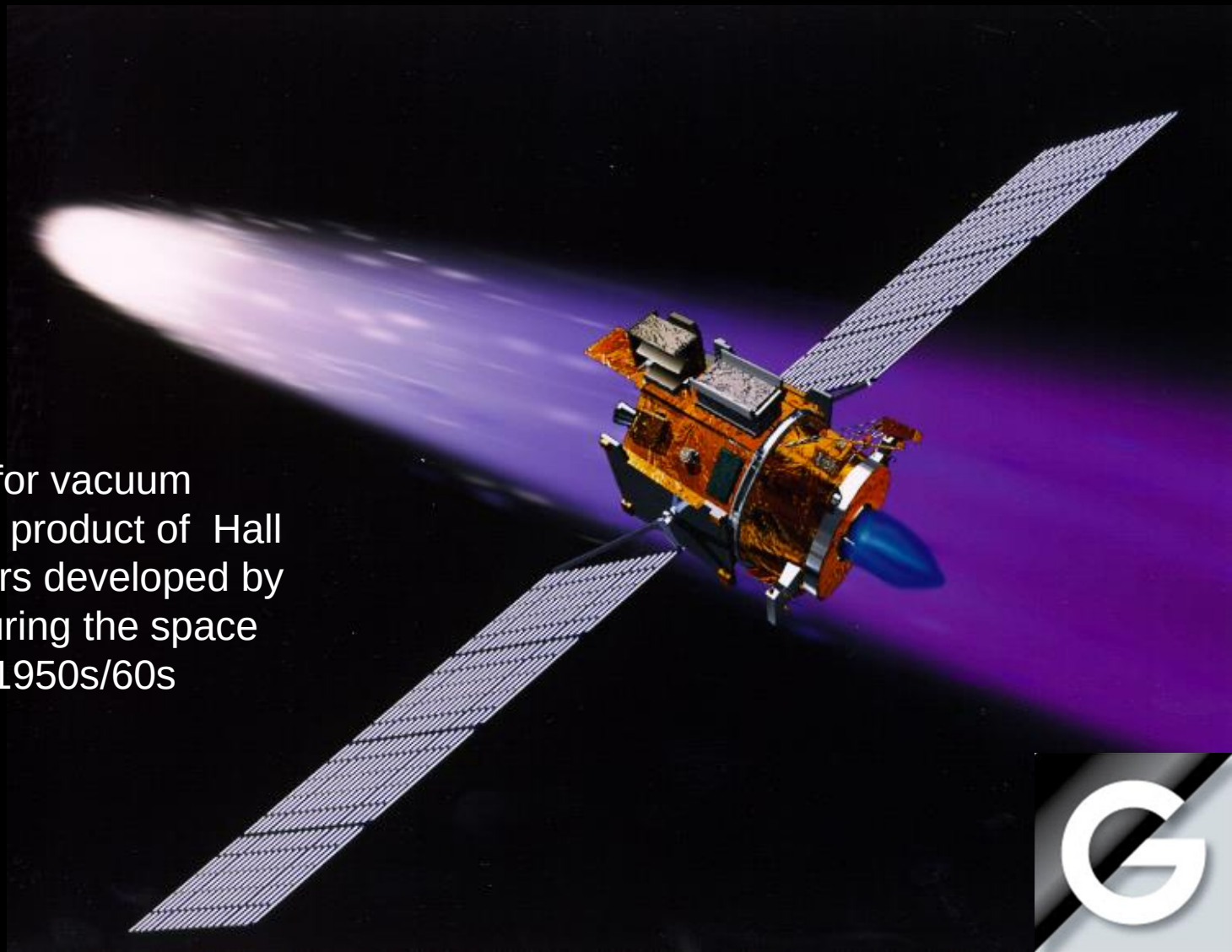


- A powerful new tool for thin film research.
- Fits into the space of a typical magnetron and has head tilt adjustment.
- Self neutralized plasma - no substrate surface charging.
- Variable plasma energy.
- Automatic gas feedback control via the IM300 power supply (any gas).
- Robust design with no maintenance.
- Can replace RF substrate etching.
- Multiple uses - ion assistance, patterning, pre-cleaning, coating stripping, PECVD



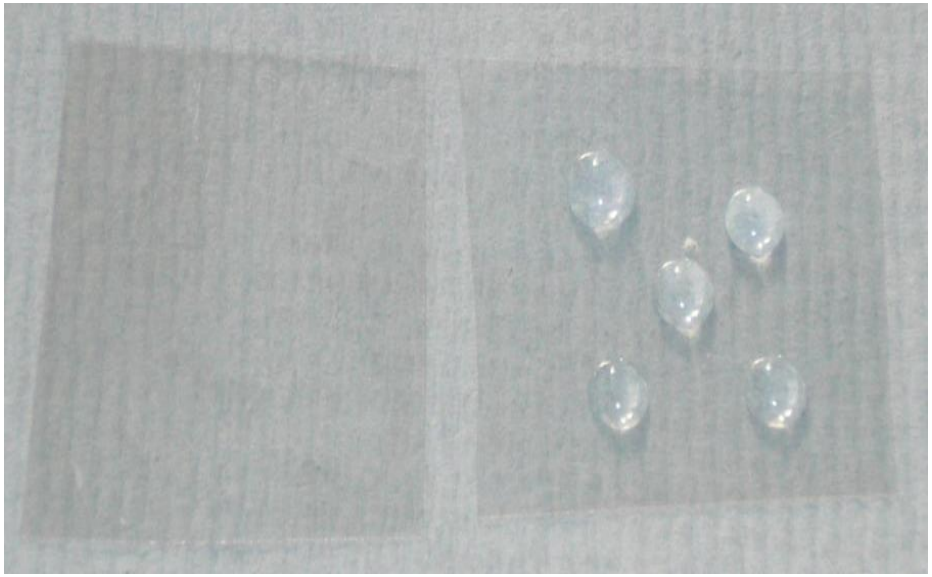


Courtesy of NASA



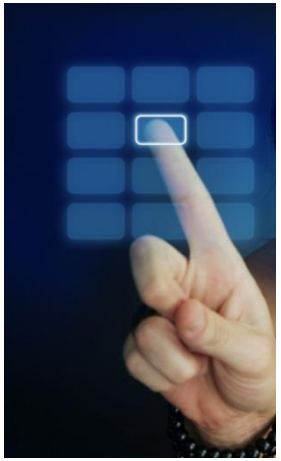
Ion sources for vacuum applications are a product of Hall Effect Ion Thrusters developed by USSR & USA during the space race of the 1950s/60s

Surface Modifications - Nanotexturing

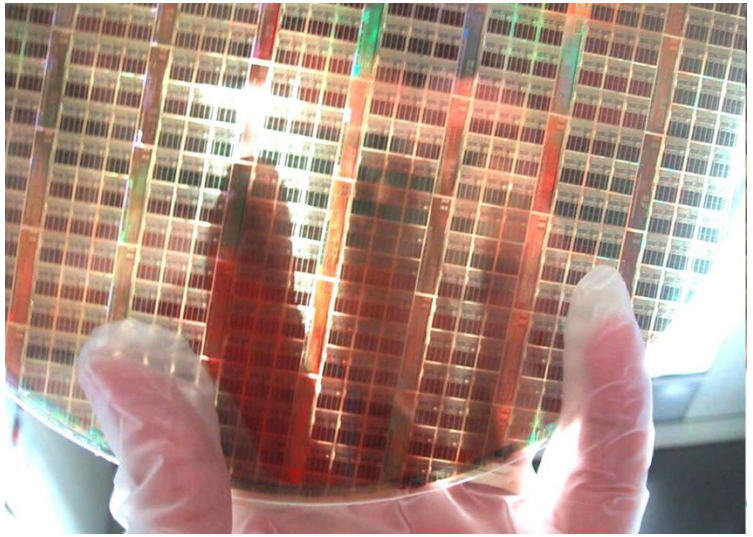


Coating removal

Improving Coating Adhesion

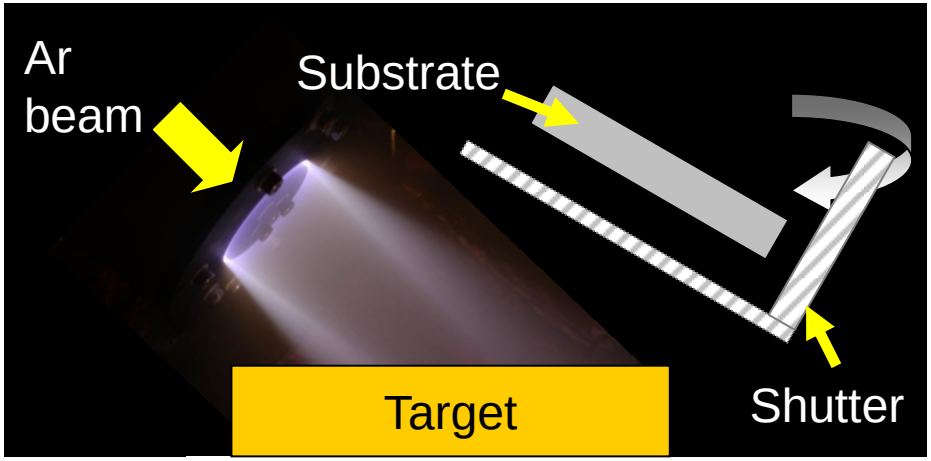


Etching prior to deposition on semiconductor applications

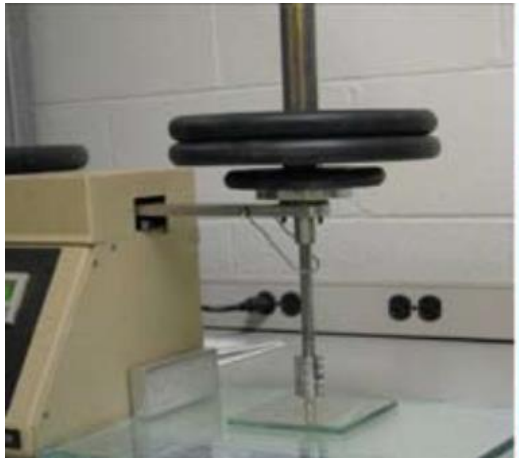


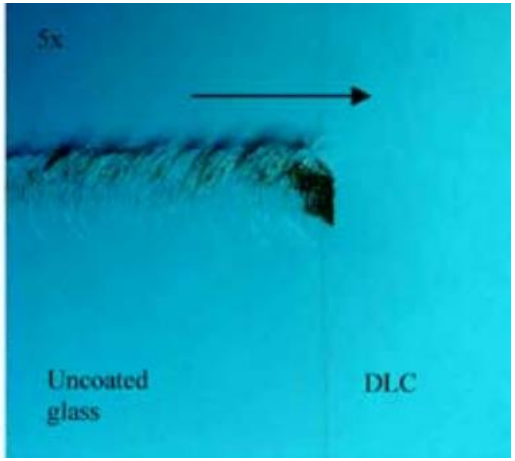
ITO &Silver Deposition Assistance

Ion Beam Deposition (IBD)

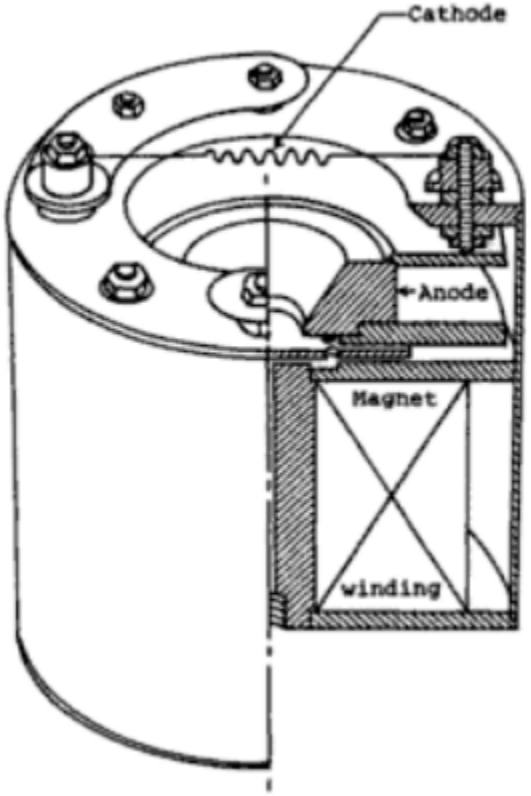


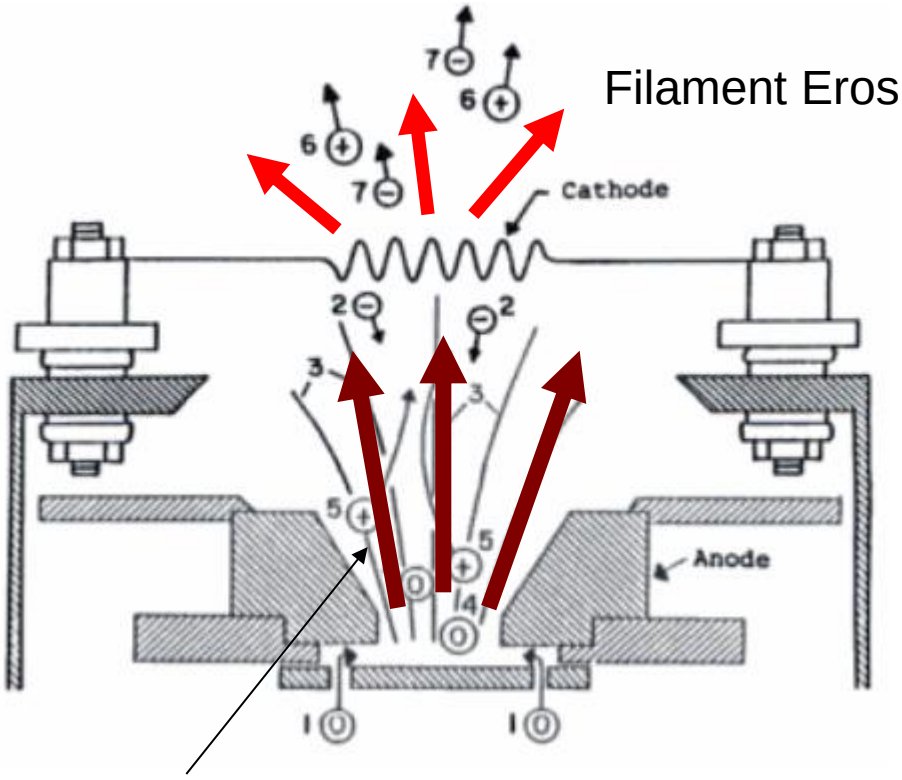
Scratch resistance test on uncoated and coated glass





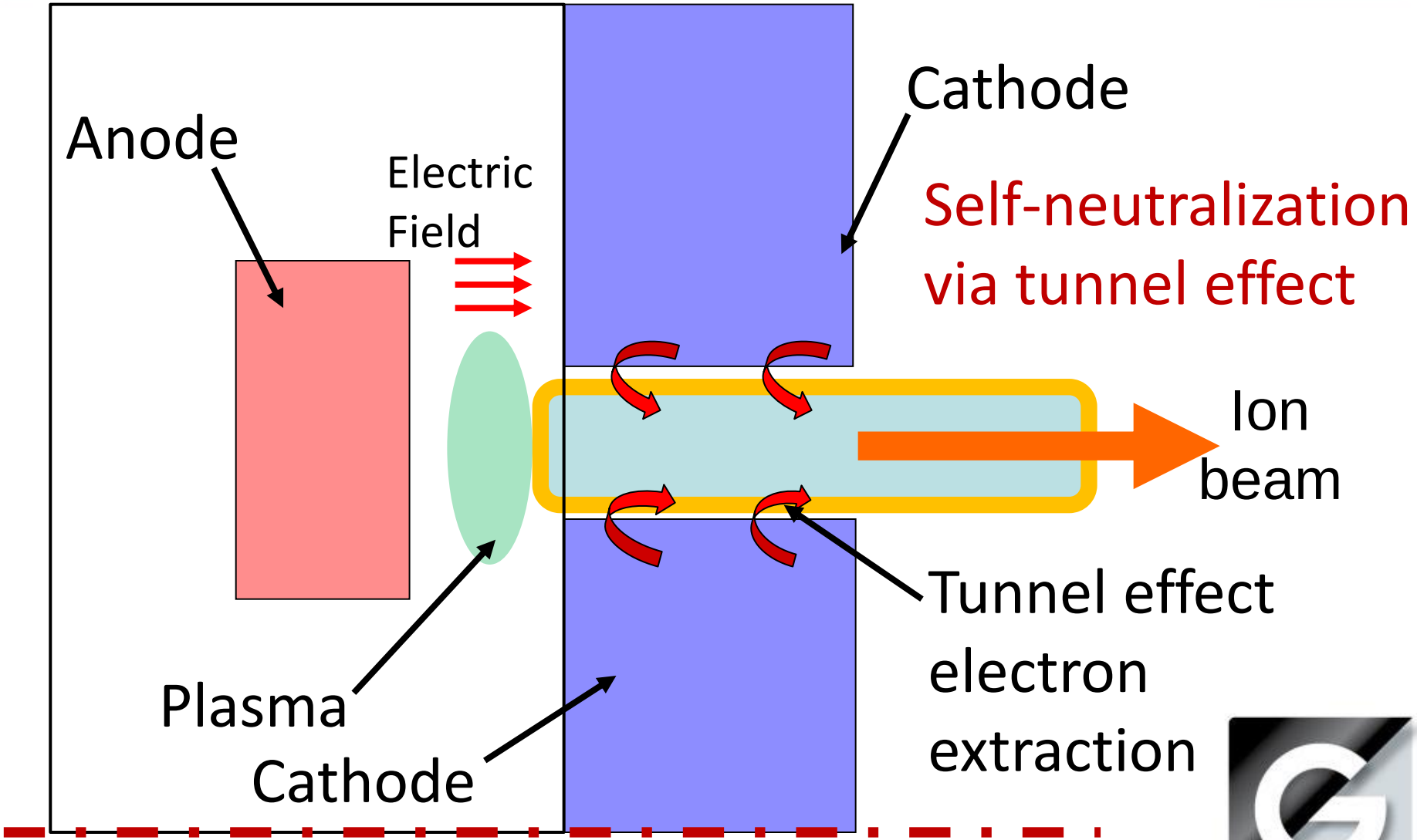
Source:
Guardian Glass
GPD 2009





- Filament erosion leads to sample contamination
- After a limited number of hours the filament needs to be replaced

IMC75 Self-neutralization Principle



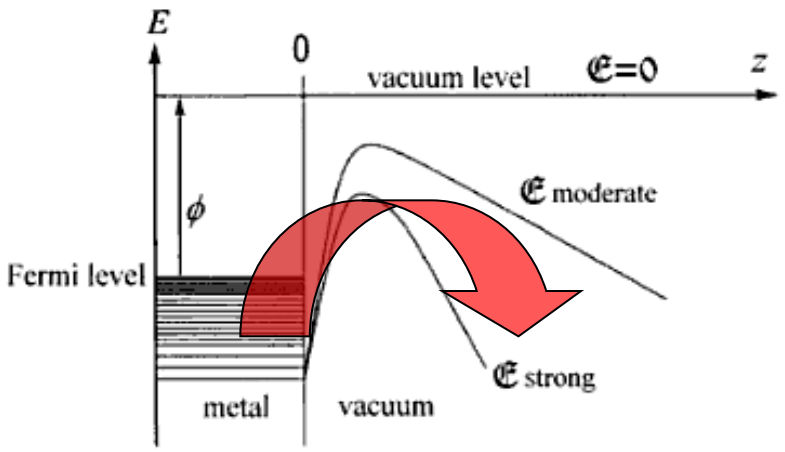


Fig. 3.5. Potential barrier at the surface of a metal: at very high electric field strength, its shape becomes a hill of sufficiently small width through which electrons can tunnel quantum-mechanically

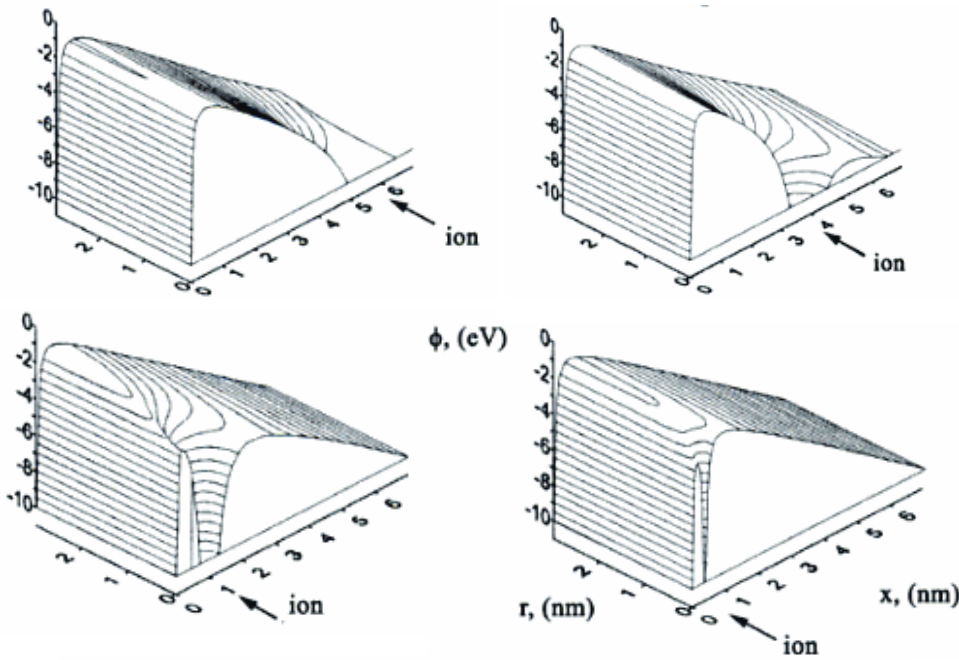


Fig. 3.12. Illustration of the time-dependent potential when an ion approaches a cathode, calculated for a Cu^{2+} ion and an average field of 1.4×10^9 V/m (adapted from Figure 6 of [31]); x is the distance from the surface, r is the radial distance from the projected impact location. At large distances ($x > 5$ nm), the deformation of the potential barrier by the ion is negligible, and at small distances ($x < 0.4$ nm), the ion captured one electron

Ions travelling near a cathode would deform the electric field. With a strong deformation electrons would be able to be extracted by tunnel effect.

Gencoa IMC75 plasma source neutralized beam via tunnel effect electron extraction

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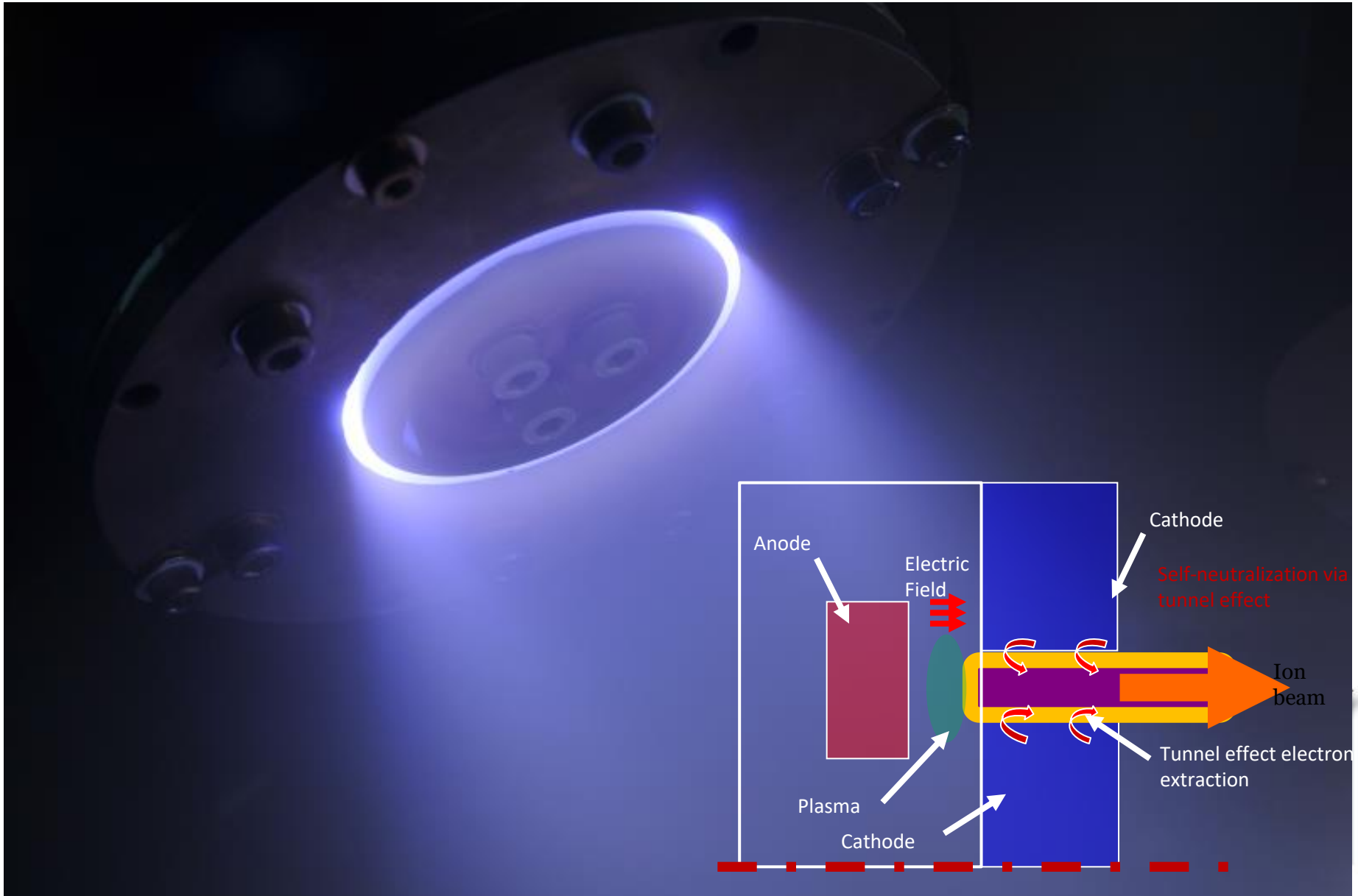
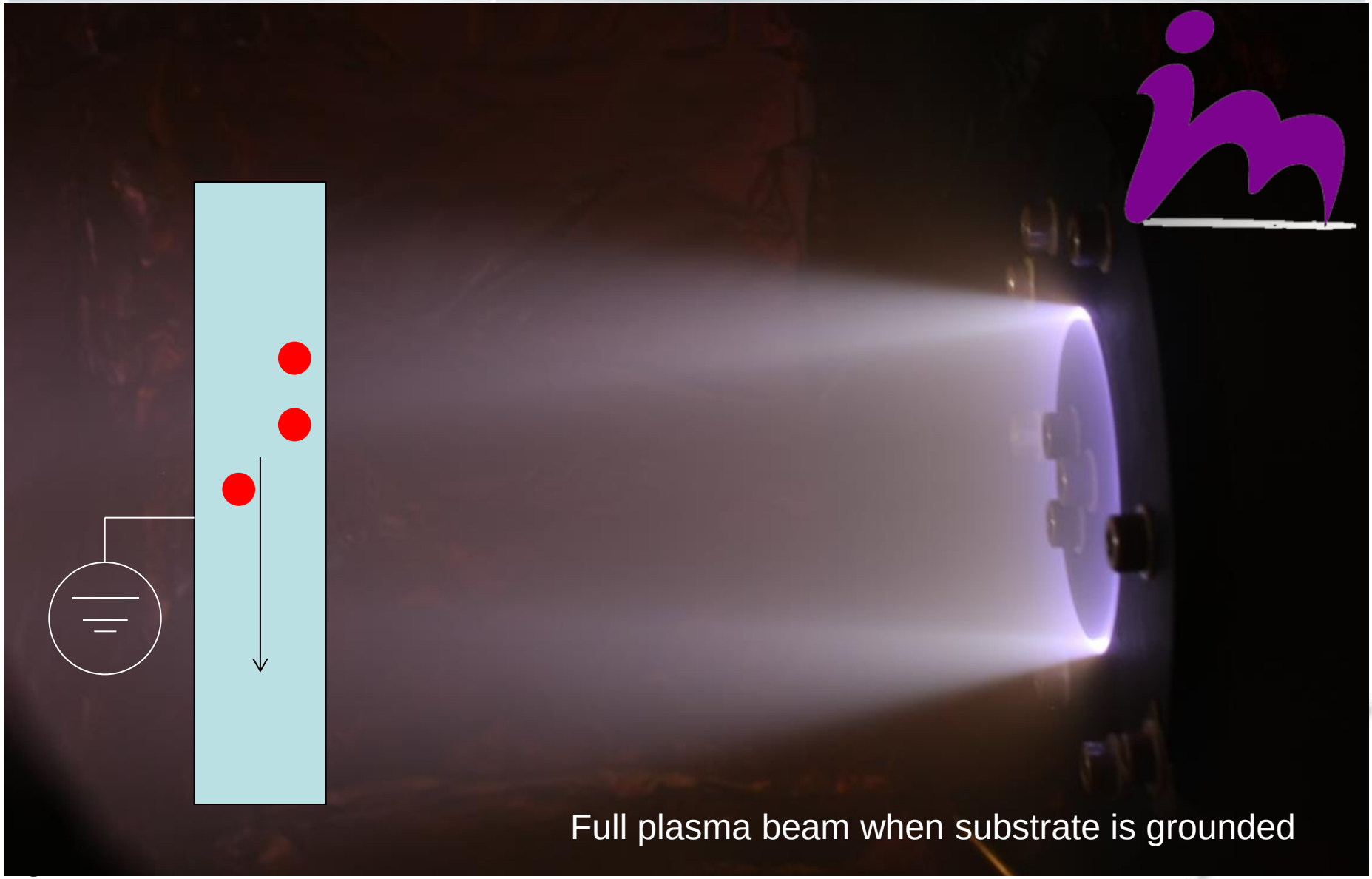
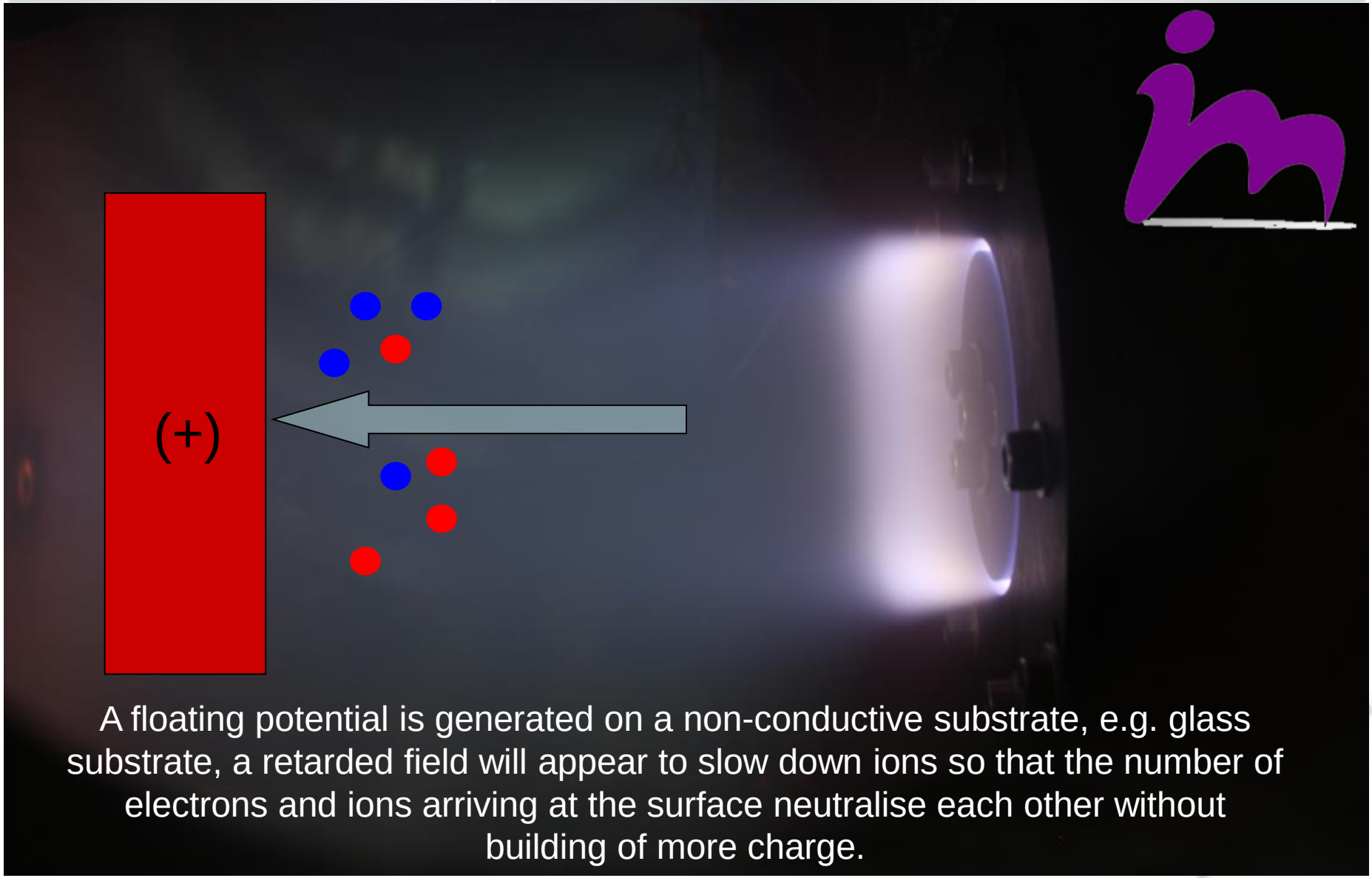


IMC75 on Conductive Substrate





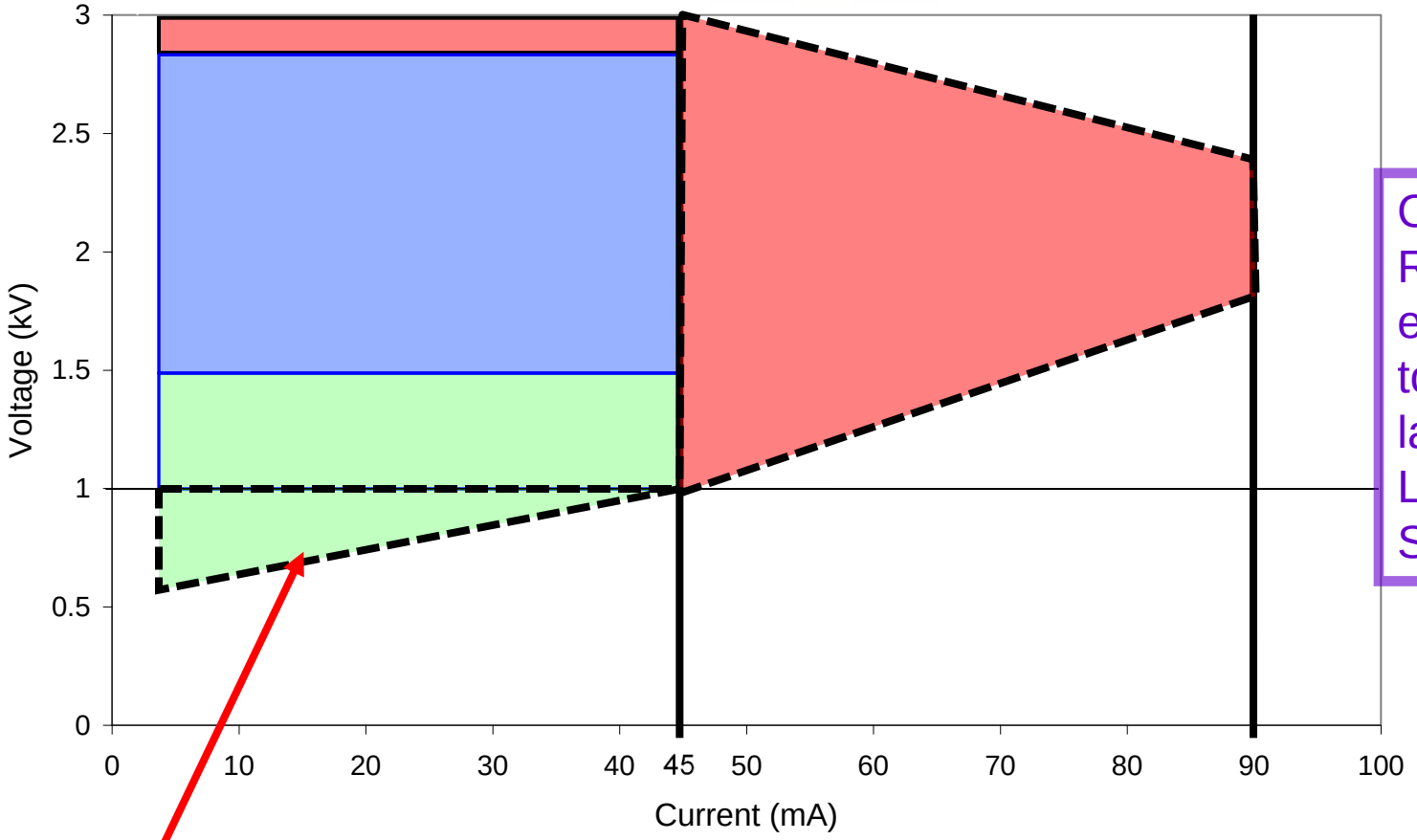
A floating potential is generated on a non-conductive substrate, e.g. glass substrate, a retarded field will appear to slow down ions so that the number of electrons and ions arriving at the surface neutralise each other without building of more charge.

IMC75 Characterization

IM75 on an Insulating Substrate

This type of ion source is specially suited for complex substrate as it will automatically adapt to the substrate electrical nature

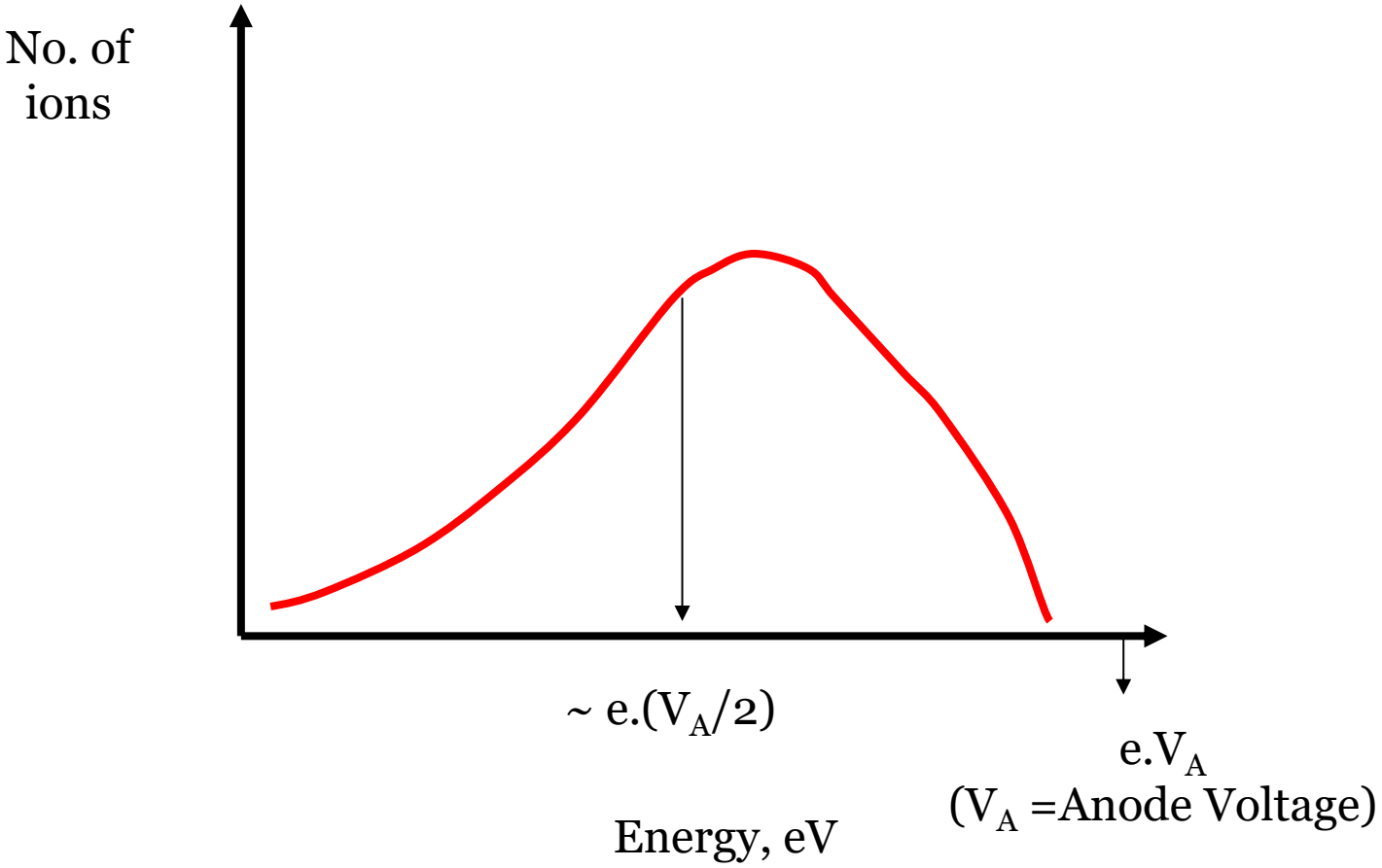
Operation Range for IMC75 Ion Source



Operation Range equivalent to industrial large area Linear Ion Sources.

This area required high flow and secondary plasma made it unstable

Normal operation area
Extended operation area
Low energy area
Very Low energy area


No. of ions
~ e.(V_A/2)
e.V_A
(V_A =Anode Voltage)
Energy, eV

IMC75 Feedback Control

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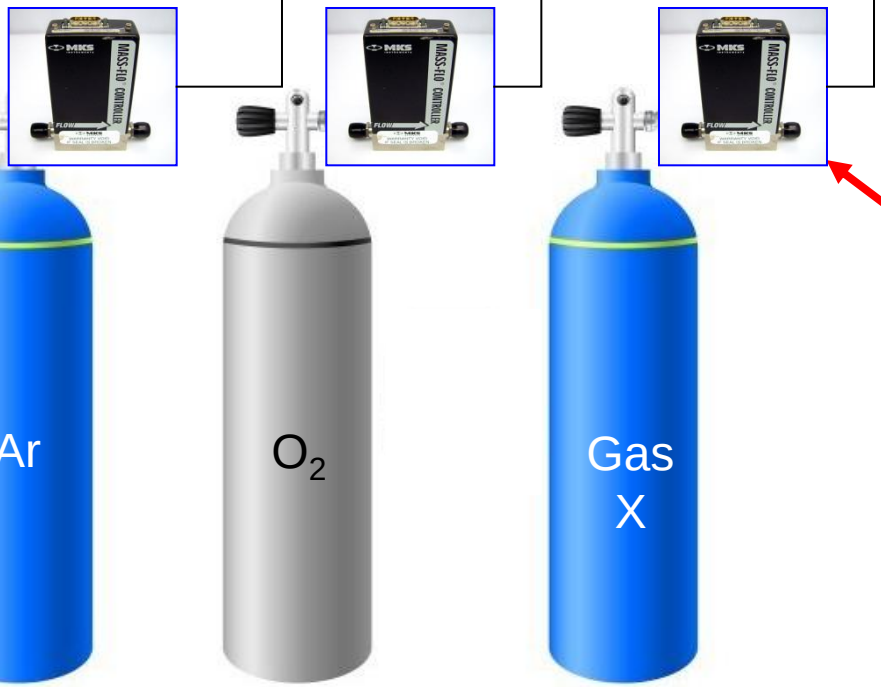
Speedflo mini - up to 3 different gasses

IMC75

V & I control

Beam energy control

IMC75 PSU
1 gas control



Speedflo
Up to 3 gases
Speedflo Mini
Up to 8 gases

speedflo™

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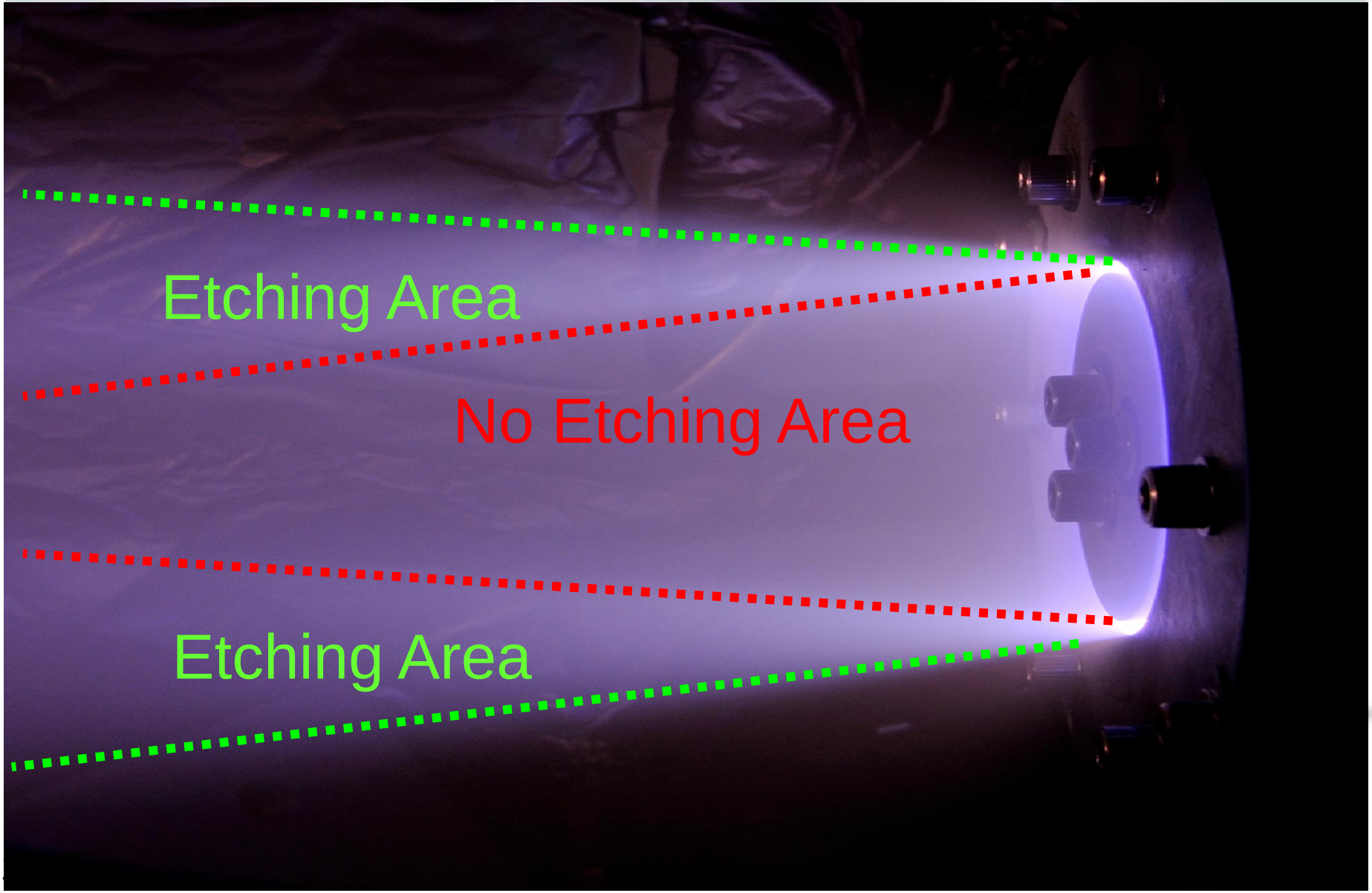
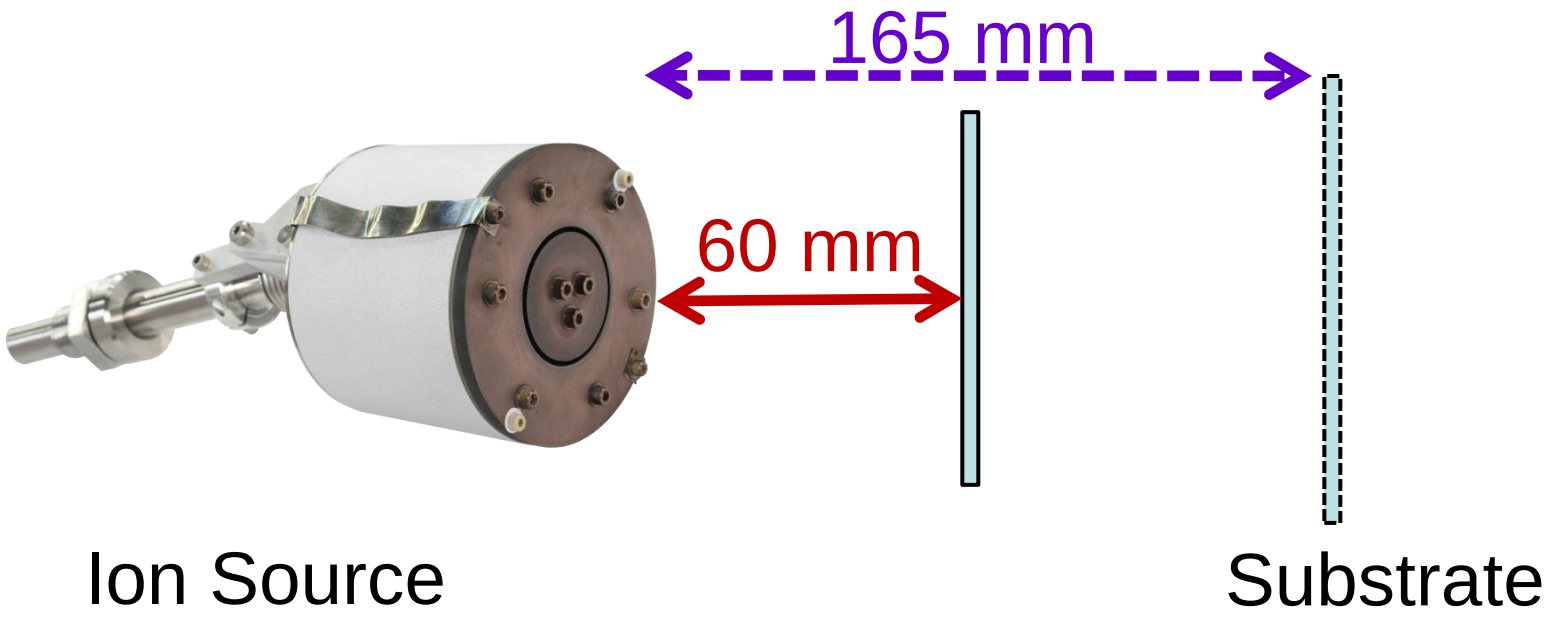
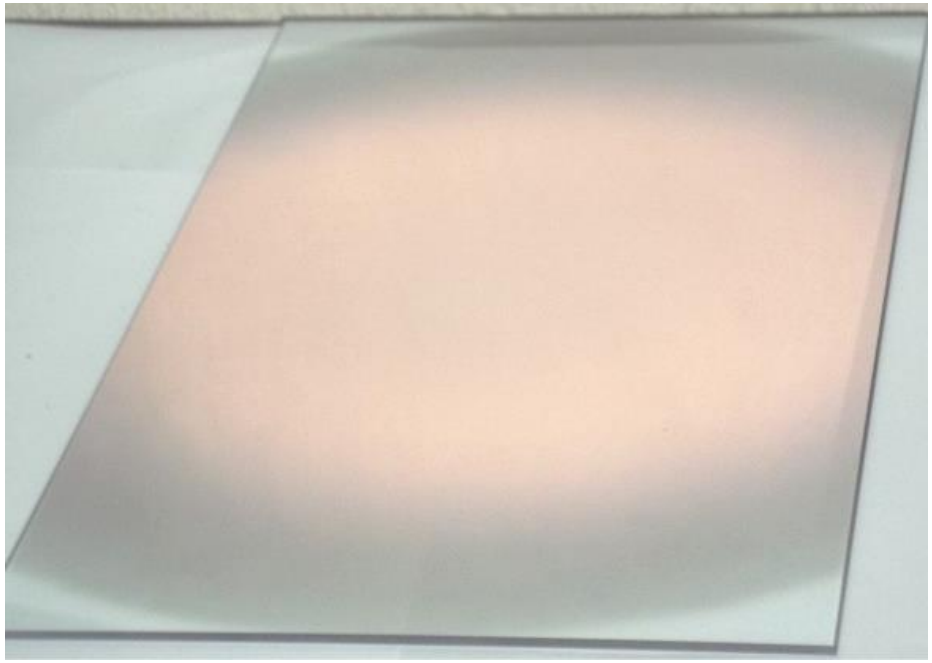
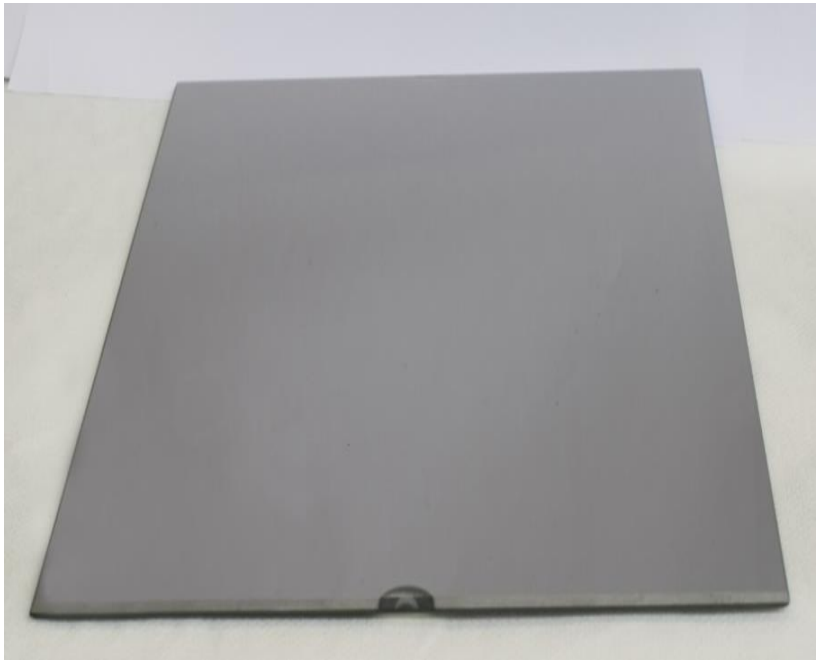


Etching at different distances



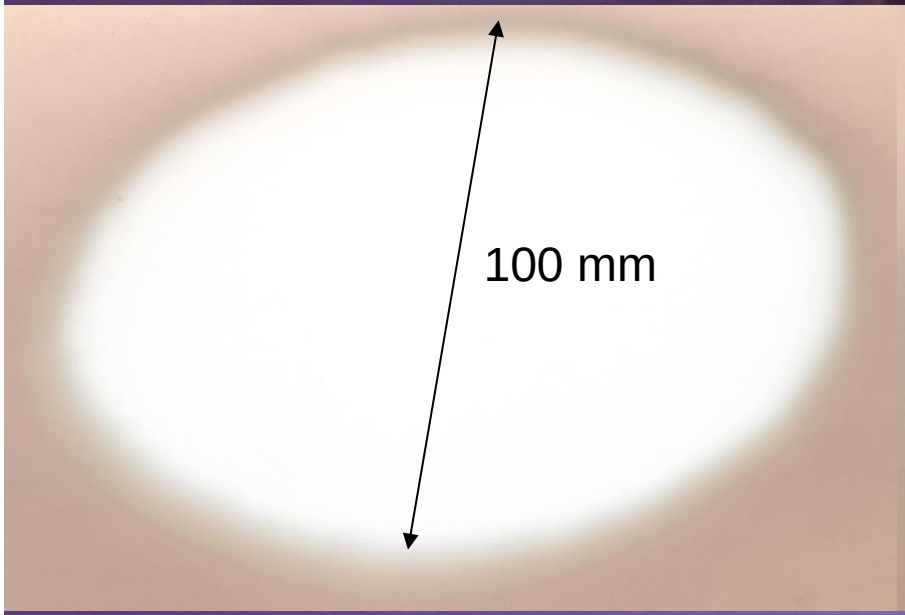




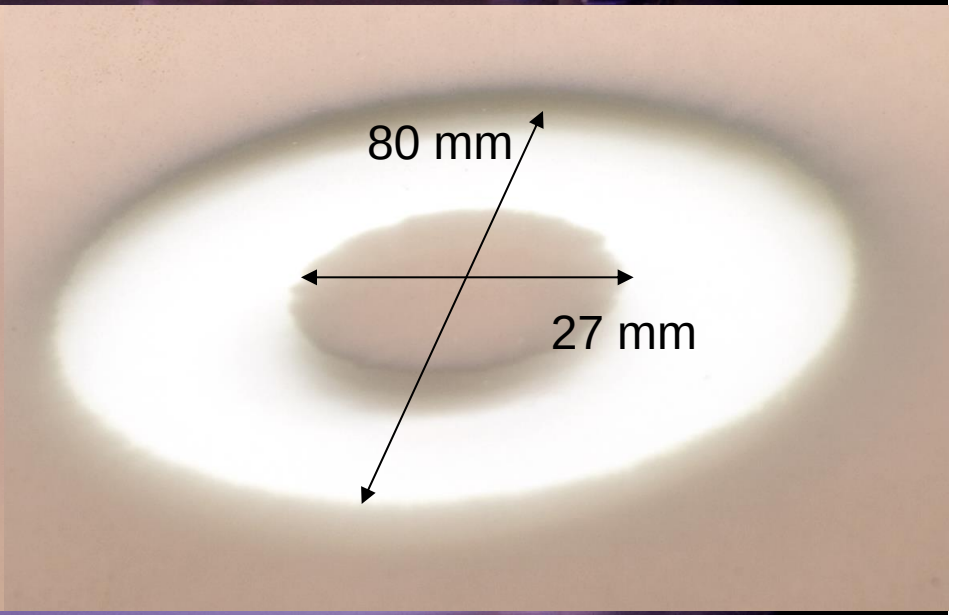
Copper on glass

StSt on glass

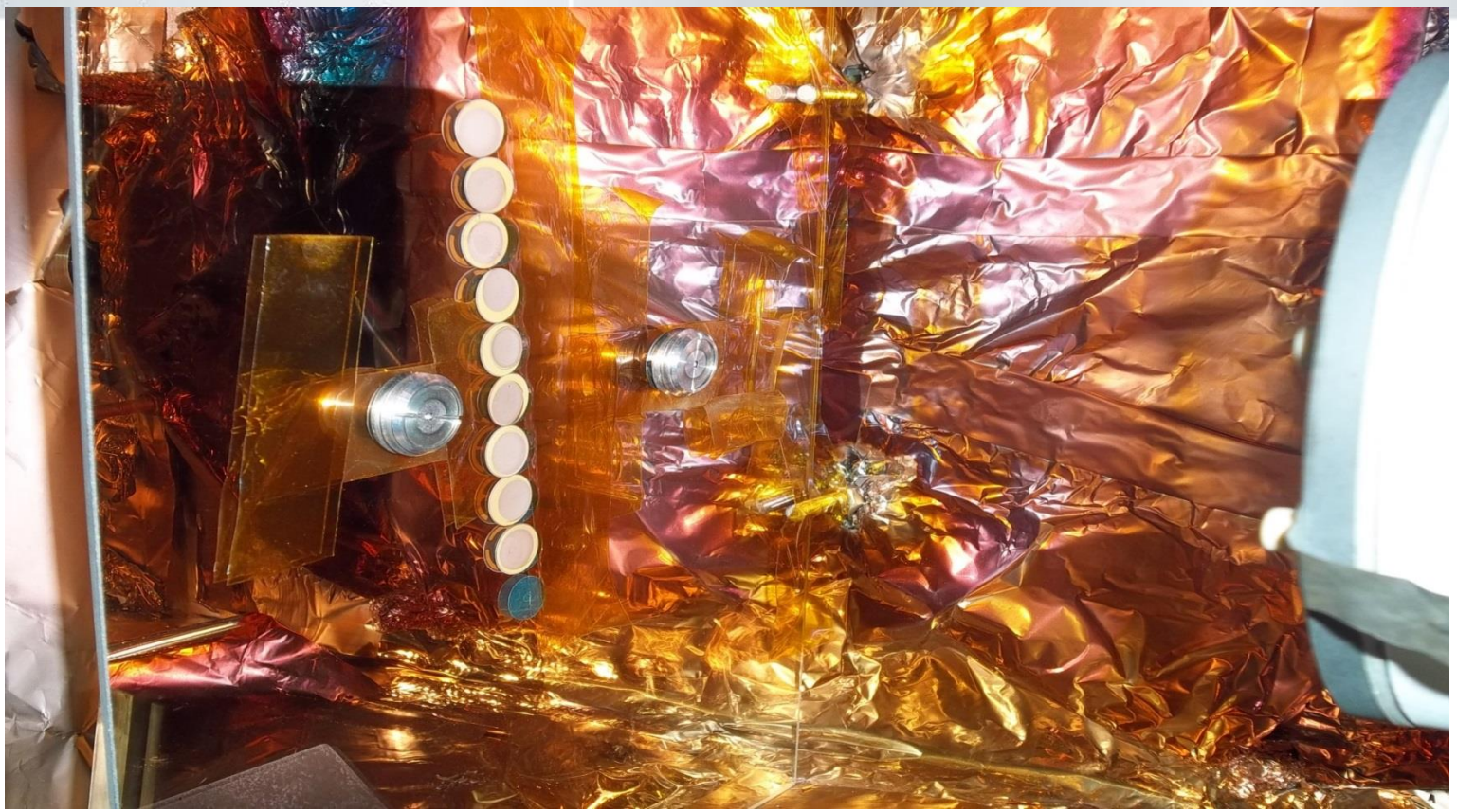
Source to Substrate distance affects the area of etching. The integrated etching rate is practically constant over a very large distance range



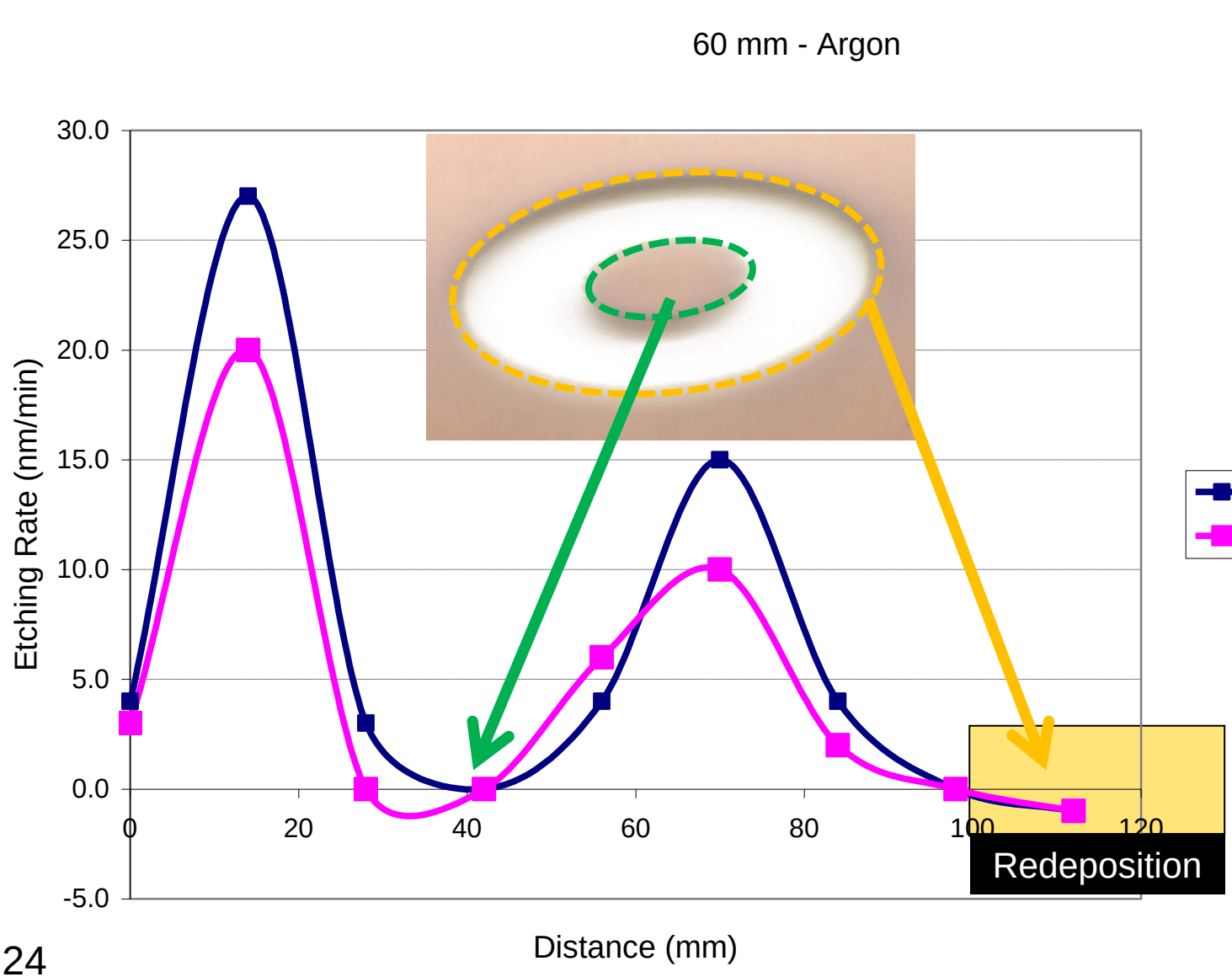
165 mm

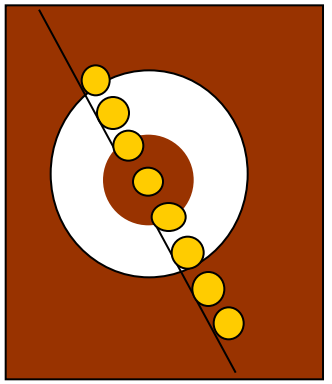


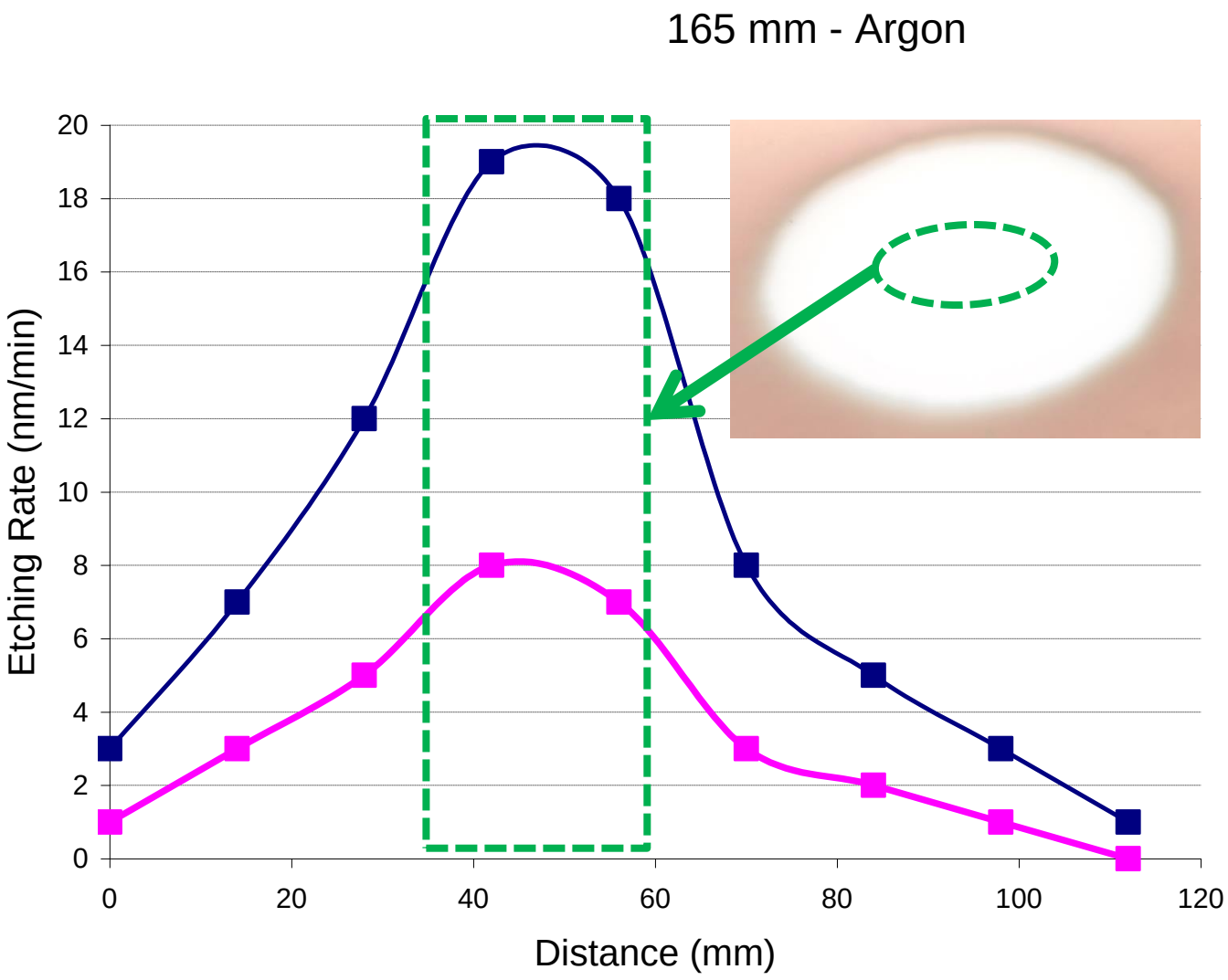
60 mm

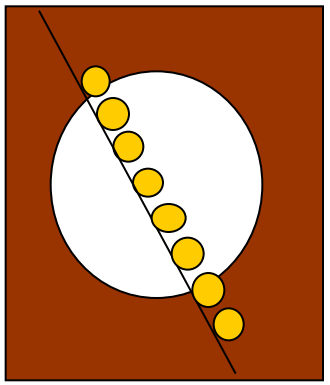


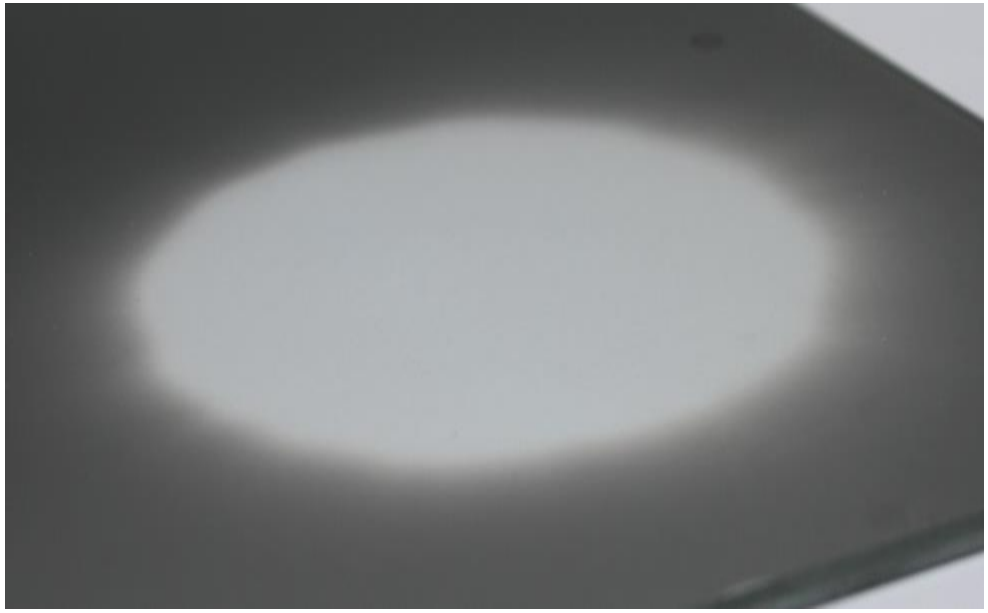
Crystal Sensors were coated with 1 µm Cu coating and arranged in a static array in front of the Ion Source. Etch rates were evaluated by the loss of Cu mass in different etching conditions

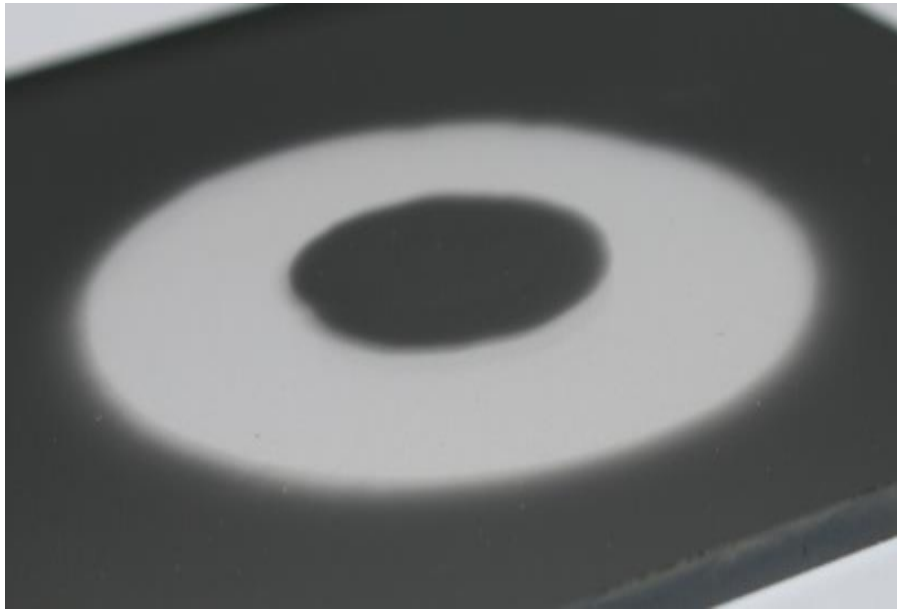

60 mm - Argon
Etching Rate (nm/min)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0
20
40
60
80
100
120
Distance (mm)
Cu etching rate at 2kV
Cu etching rate at 1.5kV
Redeposition




165 mm - Argon
Etching Rate (nm/min)
0
2
4
6
8
10
12
14
16
18
20
0
20
40
60
80
100
120
Distance (mm)
Cu etching rate at 2kV
Cu etching rate at 1kV







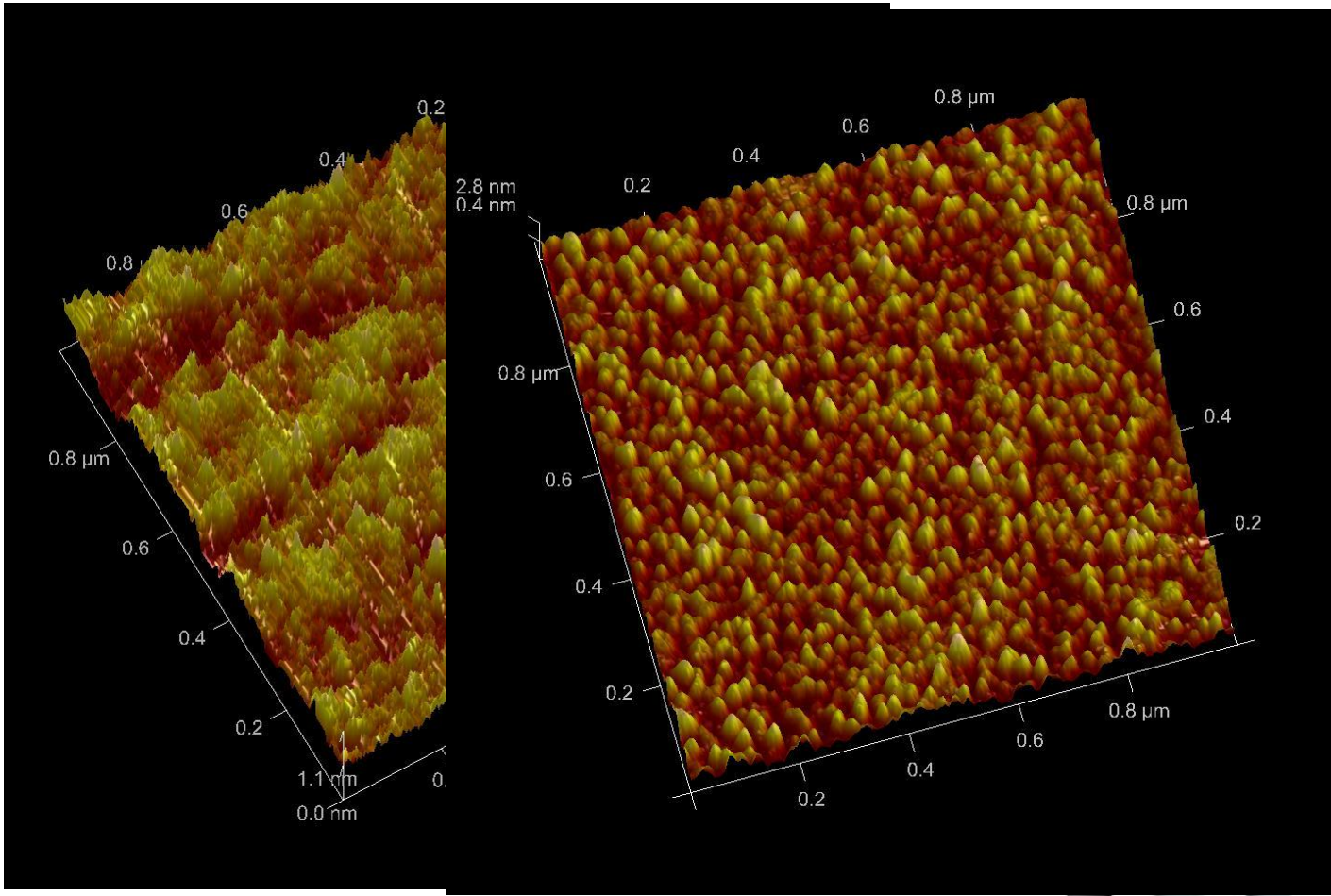
165 mm

60 mm

Untreated Zerodur

AFM was proven to be the best tool to visualize the effect of the ion treatment.

The sample here is as received with no treatment



Diamond-Like Deposition

Ethylene DLC

Gencoa provide a unique customer built power supply that automatically regulates two gas flow for ease of operation

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Output voltage	Up to 2500V (3000V ignition voltage)
Output current	550 mA
Output Power	1750W @ 2500V
Output polarity	Positive
Regulation Mode	Current 0-0.7A
Output connector	Fischer, type 105, 10kV rating for RG213 coax cable
Weight	3kg
Cooling	Forced air cooling
Working temperature	15-35° C

Active Front Panel - Touch screen display ,240x 128 pixel
Automatic voltage tracking by dynamic flow adjustment for constant voltage (requires MKS 1179A MFC) (VT) - 2 channels ,analog 0 to 5V , supply +-15V ,max supply power 10 Watts.
Input 240 AC or 115 ac switch selector inside max 500va
Size 3UI rack mount L=480mm H=178mm D=300mm
CE Mark

Schematic of the ion source with power supply and automatic gas regulation

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Removes beam variation – I & V regulated

IM300 Power Supply

Power Cable

MFC cable (for MKS's MFC), D9-D15 Shielded

Chamber

GENCOA IMC75

Pump

MKS MFC

Gas

MFC Spec:
MKS 1179A
Db15
±15V

IM75 Feedback Control for 3 or more gases

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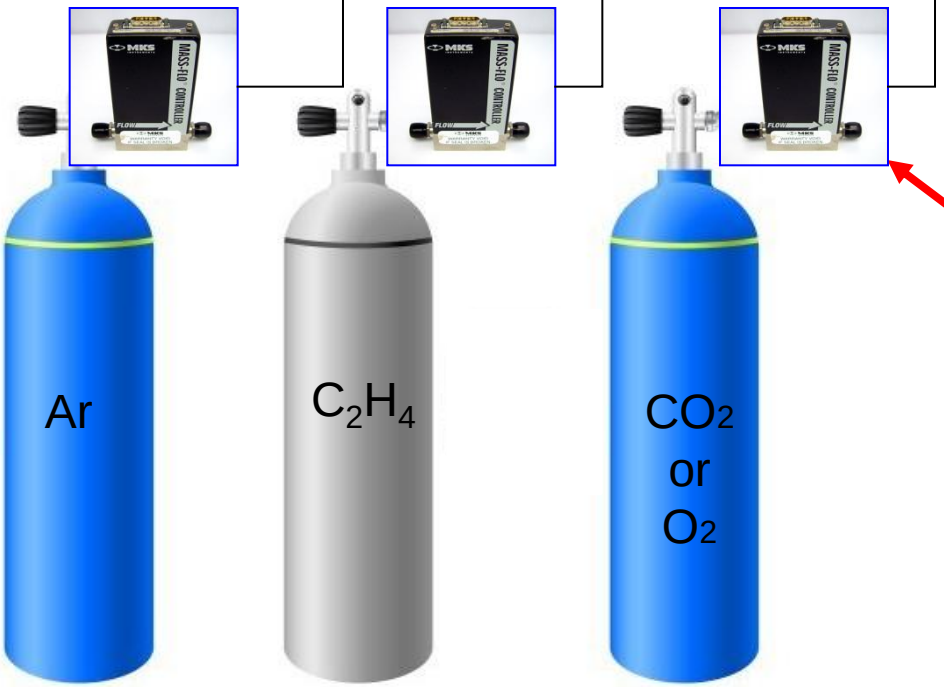
Ethylene DLC

RG142 cable
(power)

DB25 to BNC cable
(V feedback)



Oxygen could also be added to the process in order to harden the DLC in a more sp^3 structure

IM600 at 300mA - gas Ar - Example of voltage tracking feature via auto control of gas

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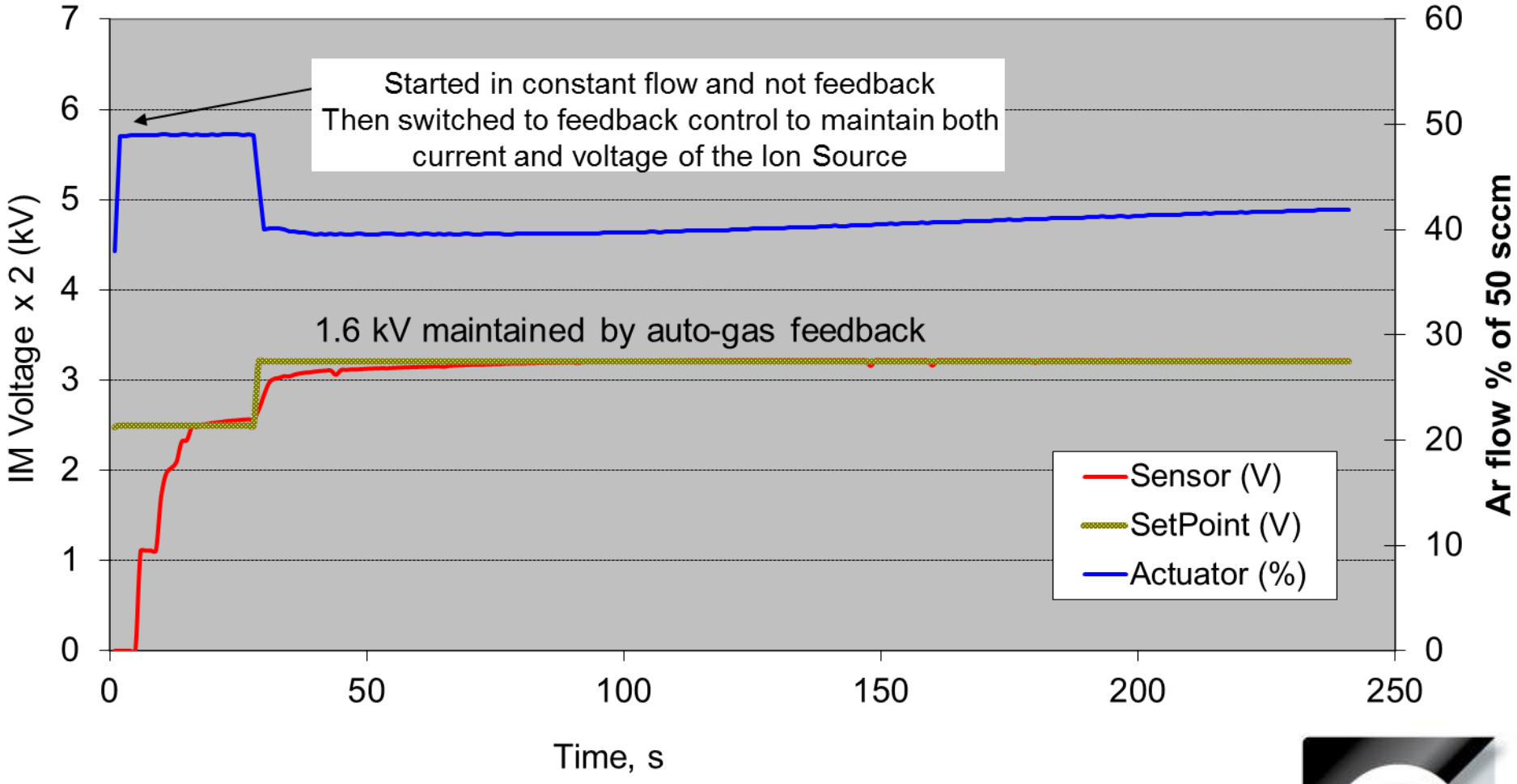
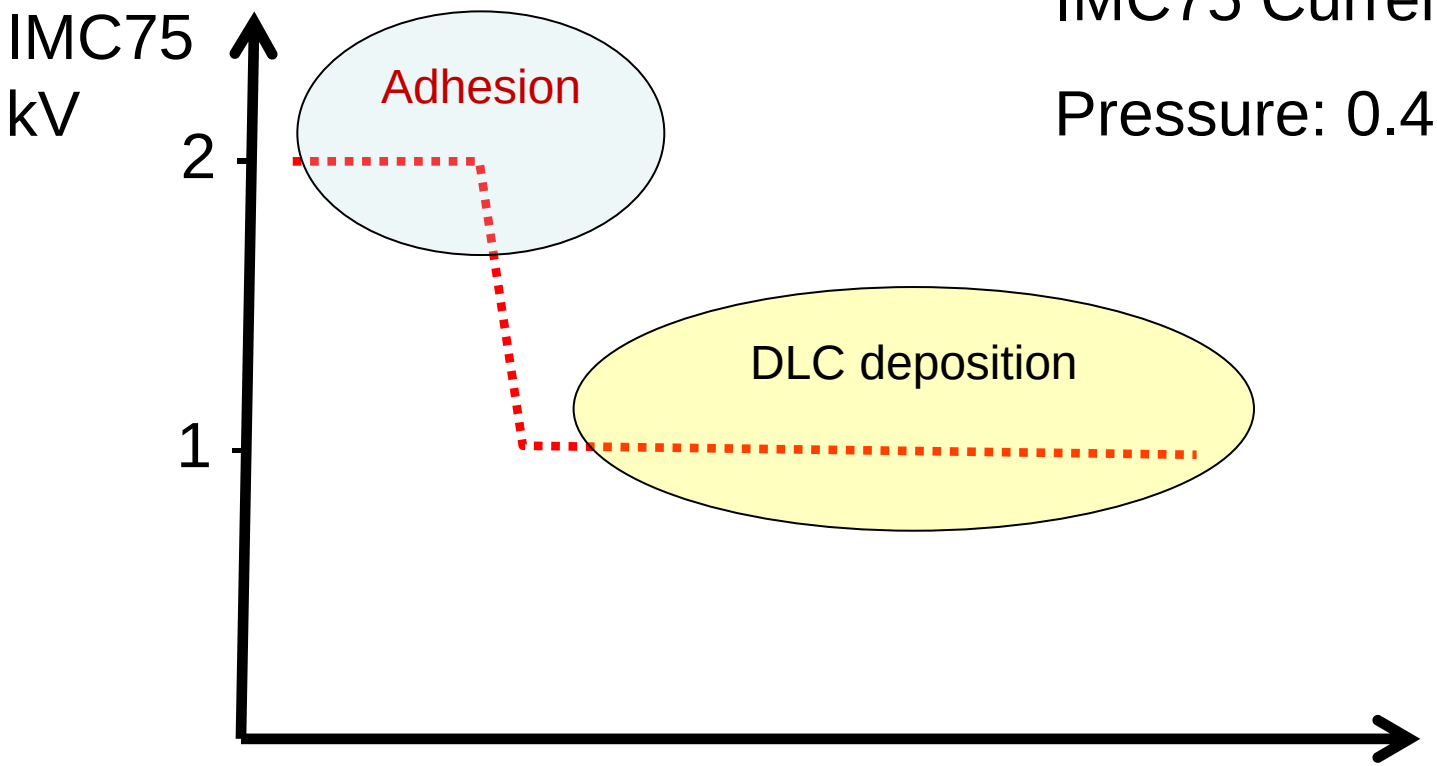


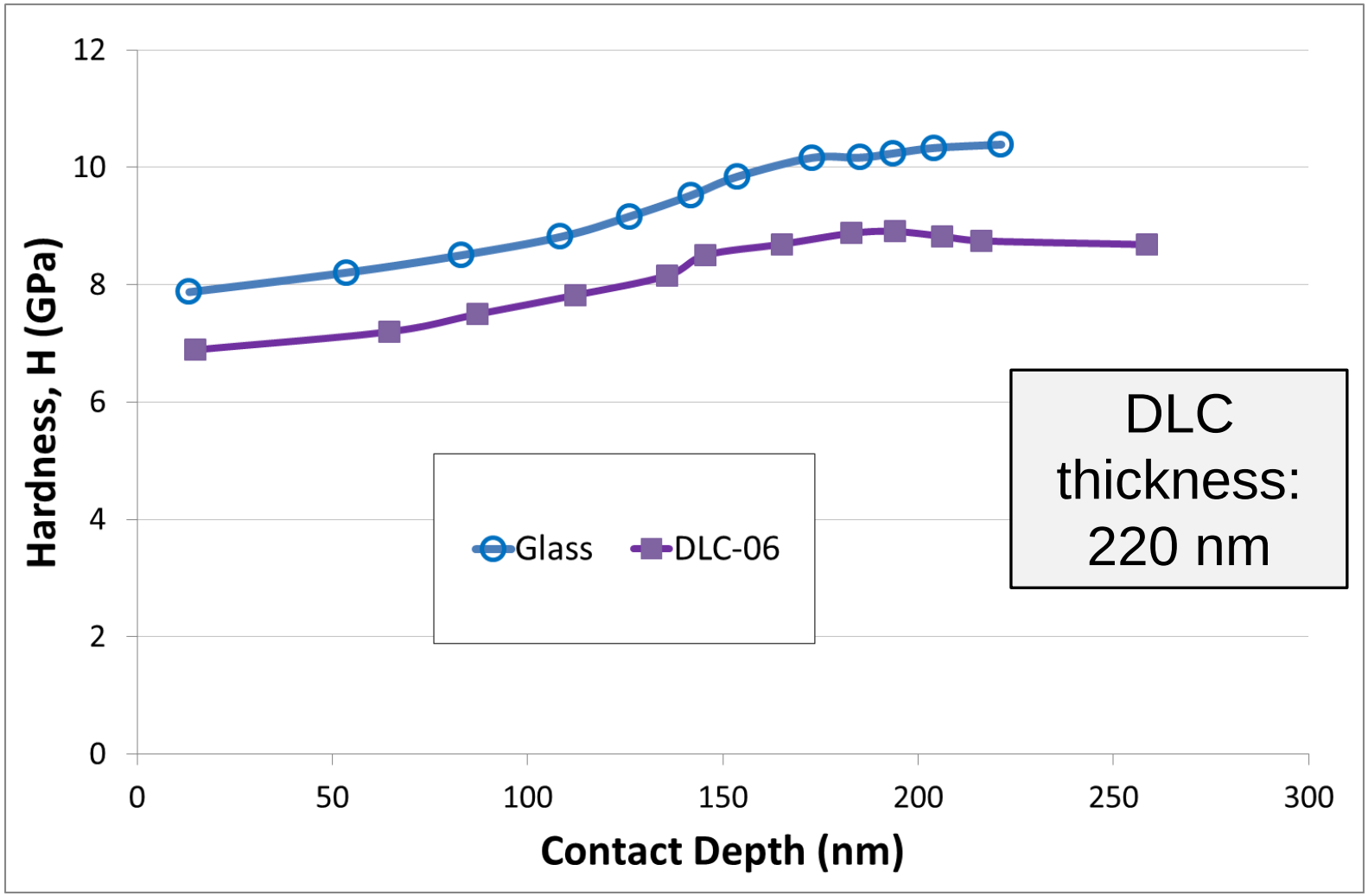


IMC75 Current: 45 mA

Pressure: 0.4 – 3 mTorr

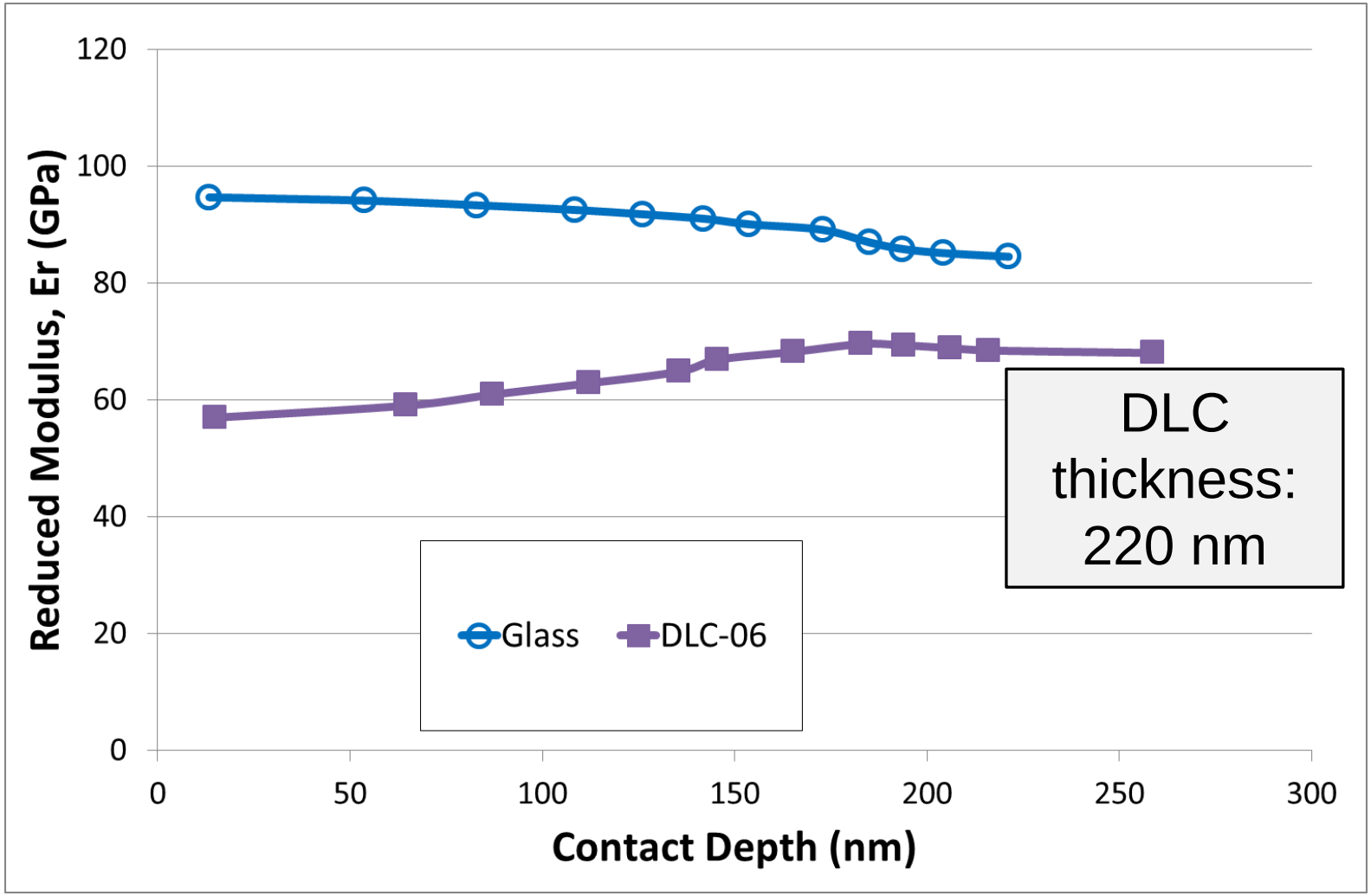
Process Control : feedback mode

Loads from 100 µN to 10000 µN



Acknowledgement: Dr José Fernández Palacio & Dr Satishkumar Kulkami
AIN (www.ain.es)

Loads from 100 µN to 10000 µN



Acknowledgement: Dr José Fernández Palacio & Dr Satishkumar Kulkami
AIN (www.ain.es)

IMC75 Characterization

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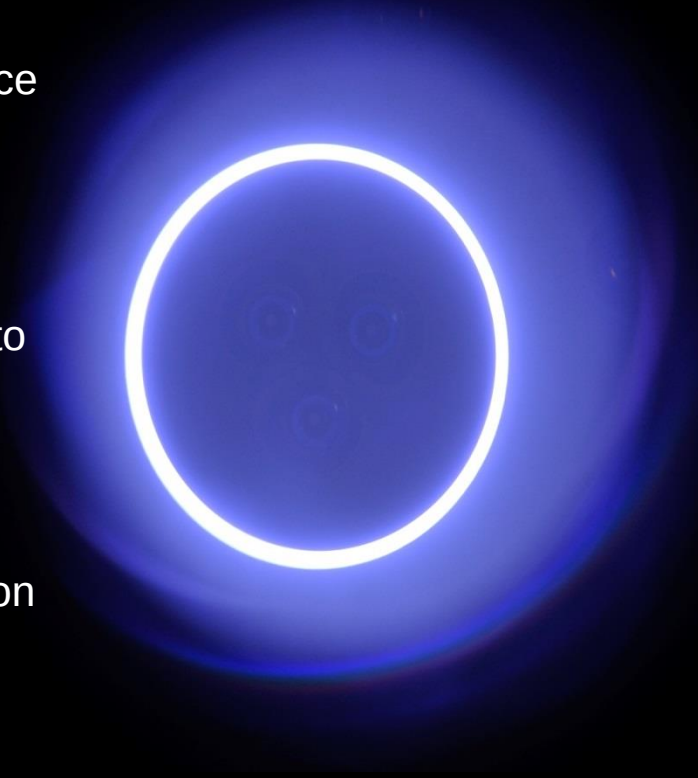
Operation Range for IMC75 Ion Source

- Inverted Magnetron Ion Beam
- Grid/Filament-less Ion source – Long maintenance & no contamination.
- Self-neutralised ion beam
- Operating pressure in large pressure range (E-4 to E-3 mbar)
- Tilting head – ion angle control.
- Stable ion beam current and ion energy distribution due to integrated closed loop feedback control
- Variety of gas feeds possible
- Suitable for pre-treatment of both metals, polymers and ceramics
- Scalable to linear ion sources for large scale production equipment due to similar operating characteristics



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