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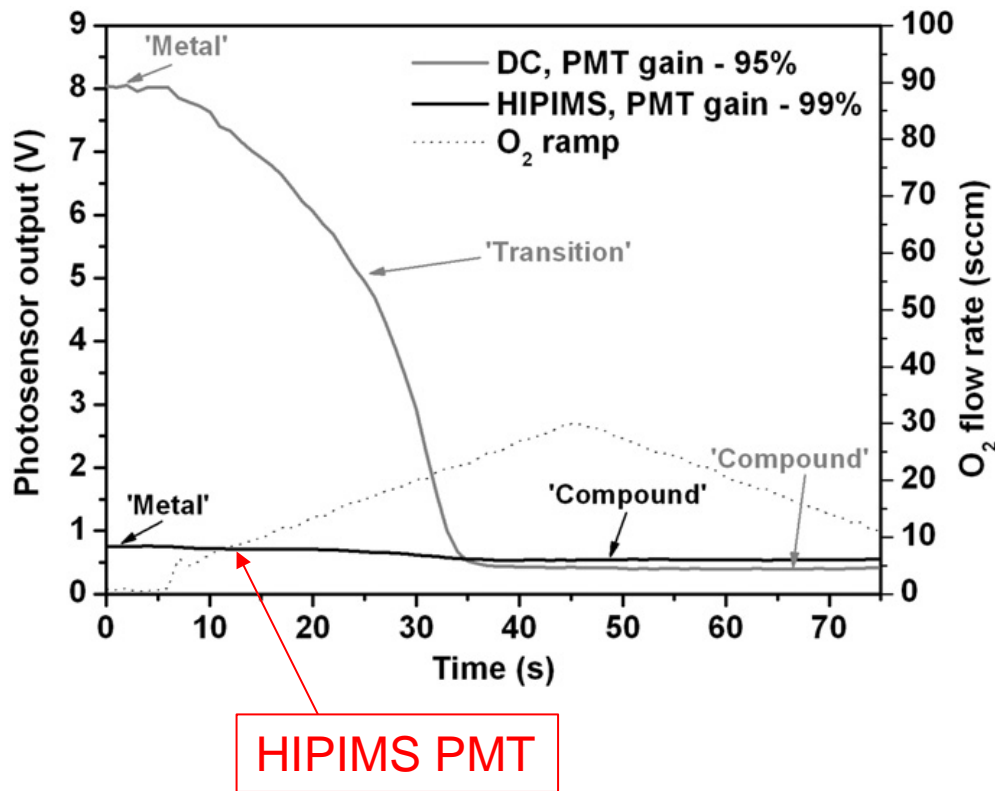
Reactive sputtering control in HIPIMS

Dr. Iván Fernández Martínez



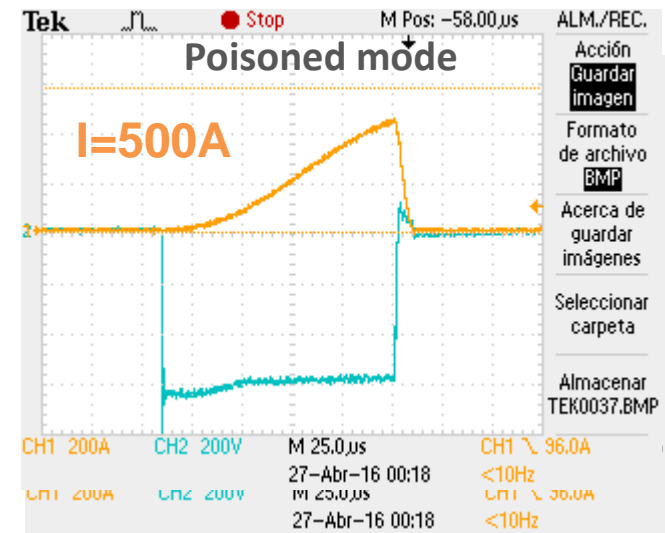
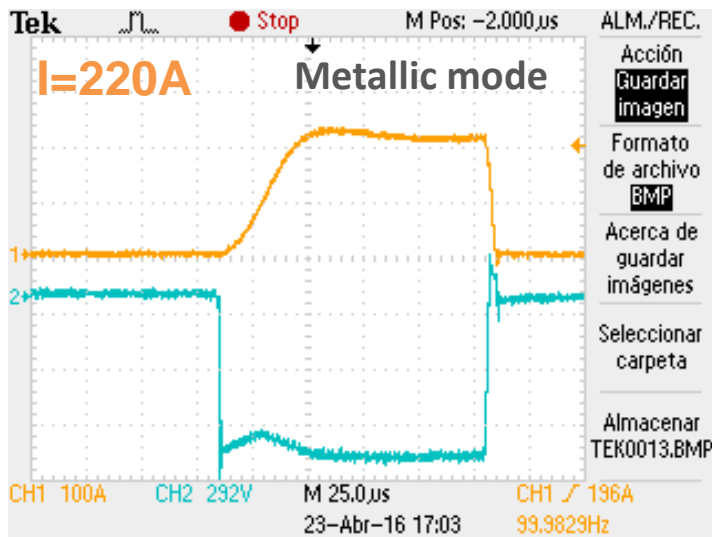
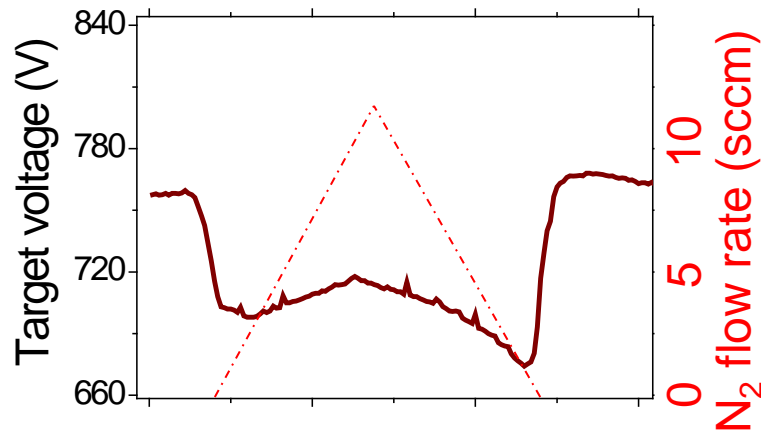
[www.nano4ENERGY.EU](http://www.nano4energy.eu)

Process stabilization in reactive HiPIMS



Standard processes may not work, such as PEM or I-V average control

Process stabilization in reactive HiPIMS



Ti (400mm²)

Ar + Nitrogen

Constant Average Power 3kW

120µs – 500Hz

I_{peak} : 220 – 500A peak

Process stabilization in reactive HiPIMS

Mass spectrometry / reactive gas [Sproul, Thin Solid Films 491 (2005)1]

Pulsing reactive gas flow [Vlček, Surf. Coat. Technol. 236 (2013) 550]

Partial pressure / adjust average power [Sittinger, Thin Solid Films 516 (2008) 5847]

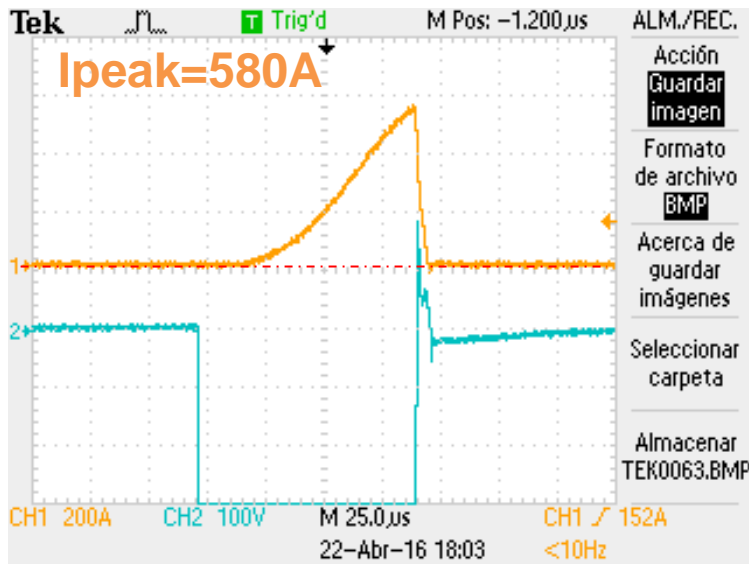
Adjusting average discharge current [Weichart U.S. Patent application No. 2009071667 (A1)]

Peak current / adjust frequency [D.Lundin J. Phys. D: Appl. Phys. 49 (2016) 065202]

Peak PEM / reactive gas [Bellido-Gonzalez, Surf. Coat. Technol 204 (2010) 2159]

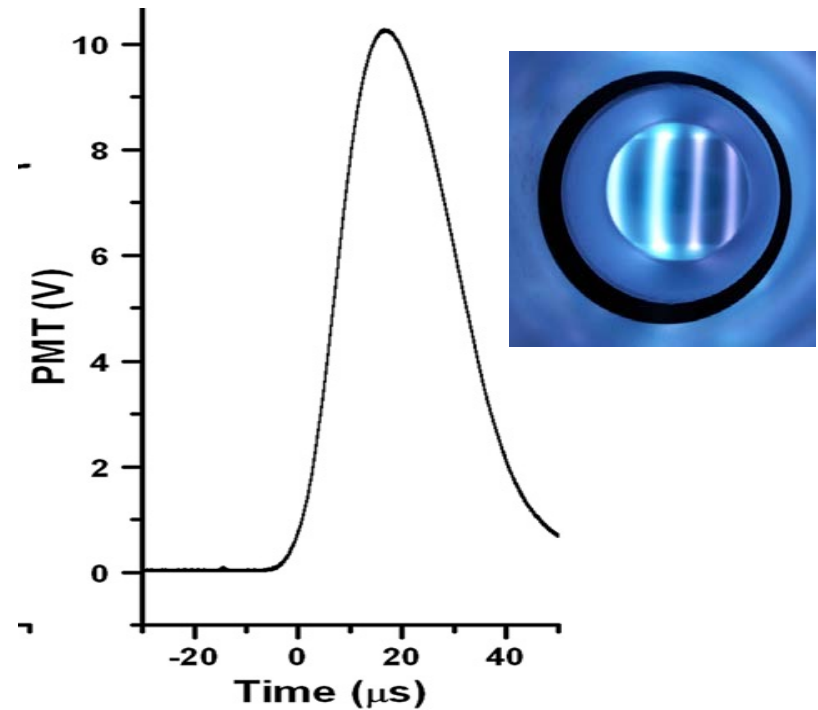
Process stabilization in reactive HIPIMS

Peak current



Stabilization during **Pulse-ON** phase

Peak plasma emission



For a specific wavelength (optical filter)

Hardware used for experiments



6kW DC + HIPIMS
Max. I pulse peak : 500A
Max. V pulse peak : 1.2kV



Planar rectangular
magnetron (400x100mm²)
Ti, Al targets
N,O reactive gas



With HIPIMS option
(optical and electrical)

New Joint venture
www.hiPV.eu

Vendor Innovators Showcase – Thursday May 12
V-15 hiP-V: A New HiPIMS Power Supply Technology - G. Eichenhofer



HiPIMS your system

The new industrial HiPIMS PS technology!

The All in ONE
H **PIMS-PS**

- Flexible
- Reliable
- Modular
- Multi-Functional



 A collaboration of

4A-PLASMA
Technology & Engineering

Booth 437

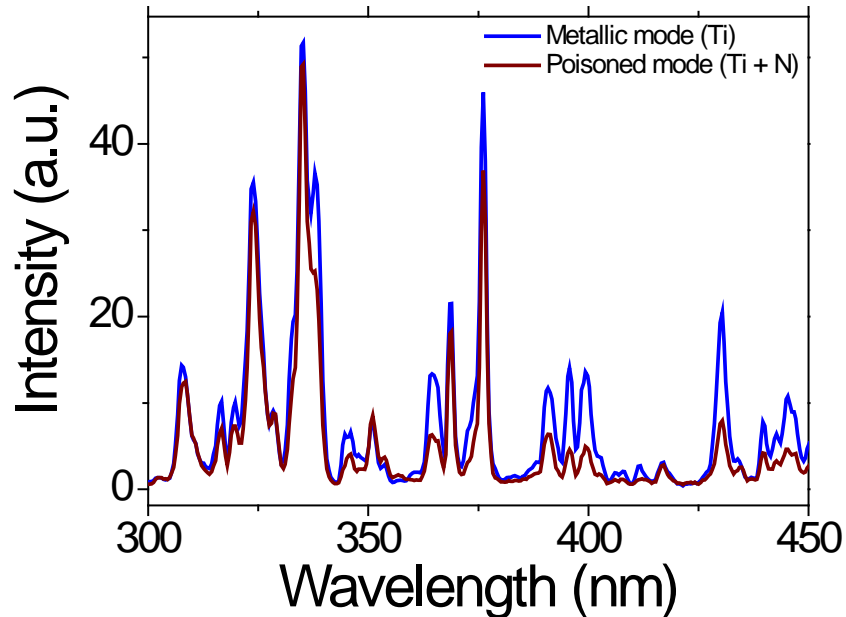
nano4ENERGY

Booth 506

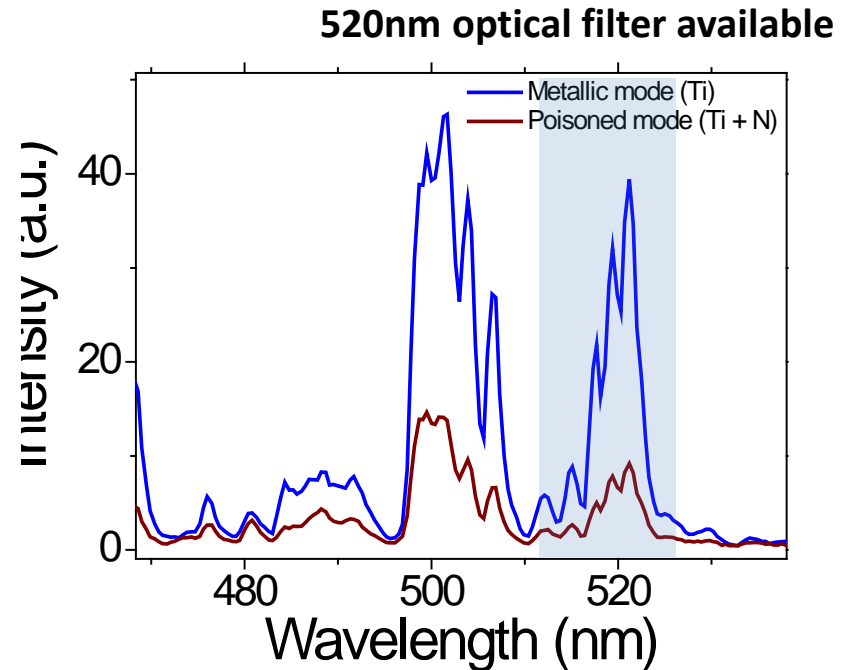
 ingeniería
VIESCA

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Plasma emission lines Ti + N

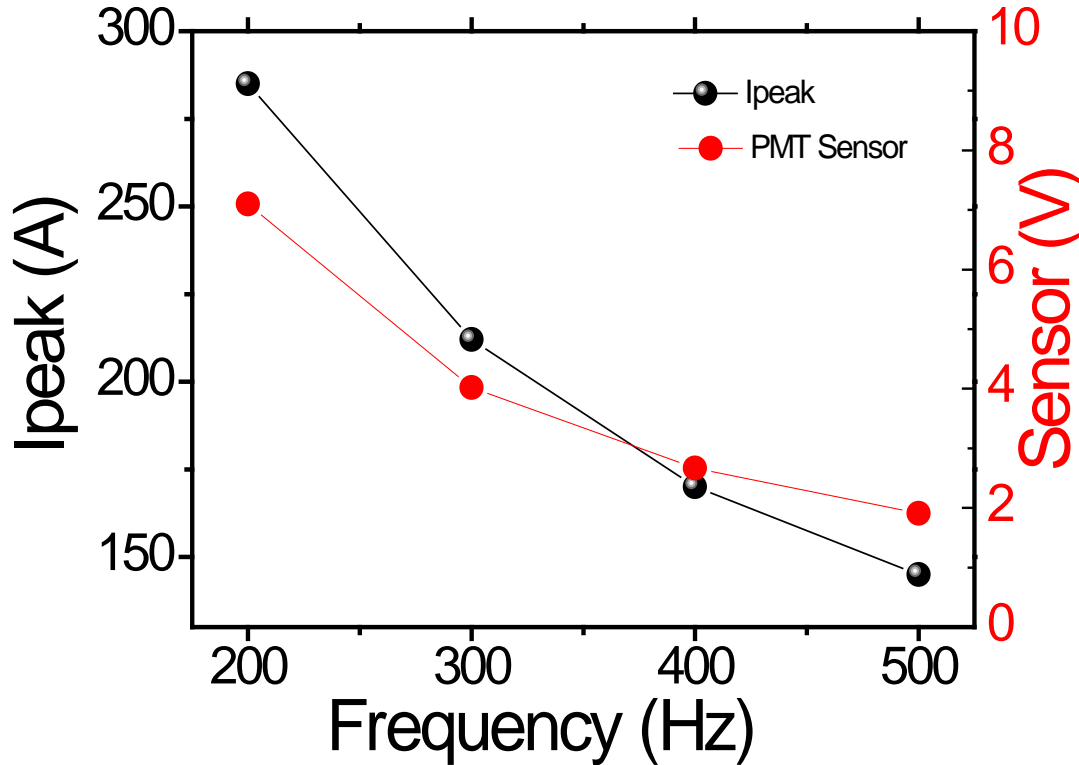


Highly ionized Ti remains constant
320nm filter not useful



Ti (400mm²)
Ar + Nitrogen
Constant Average Power 3kW
120us – 500Hz
 I_{peak} : 220 – 500A peak

HIPIMS TiN coatings: plasma dynamics



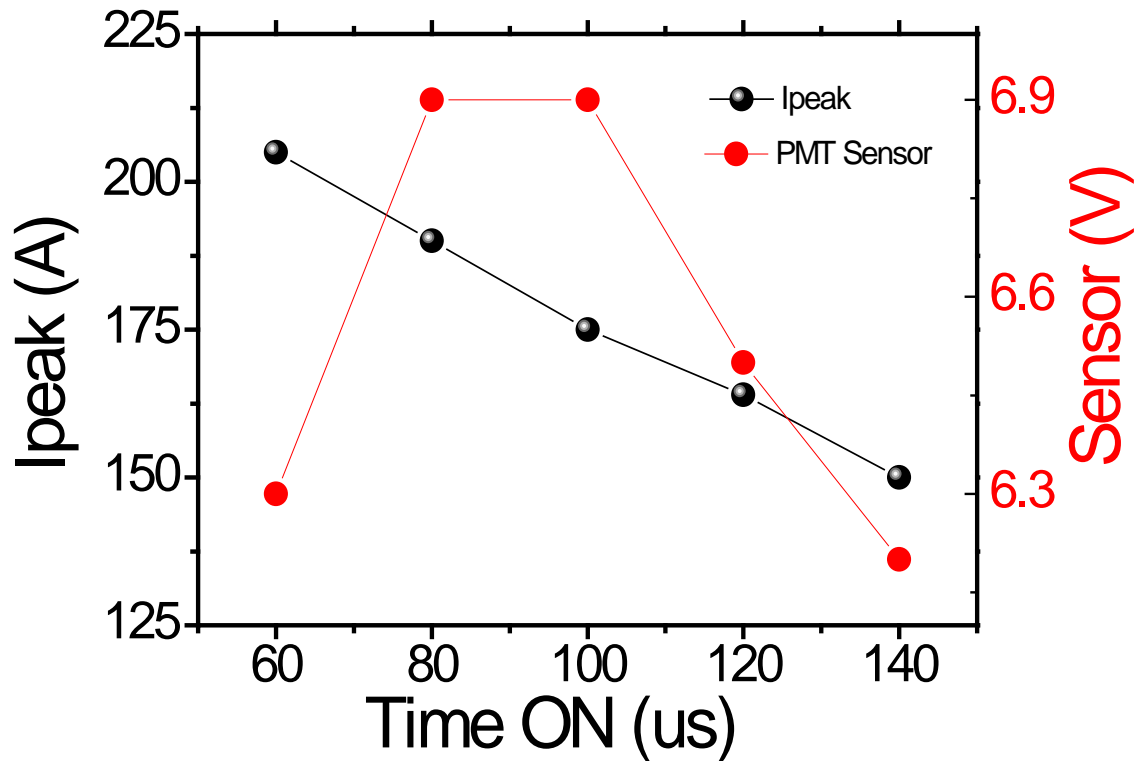
Ti (400mm²)

Ar = 110sccm, Nitrogen = 26sccm

Constant Average Power 1.5kW

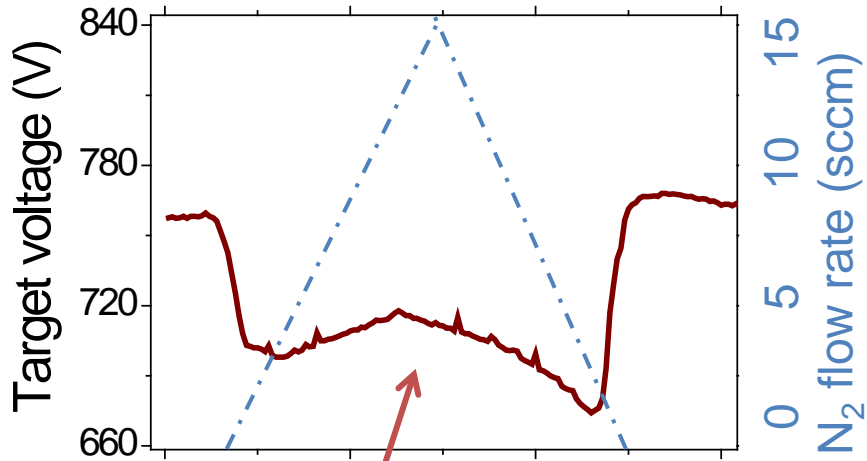
T_{ON} = 100us

HIPIMS TiN coatings: plasma dynamics

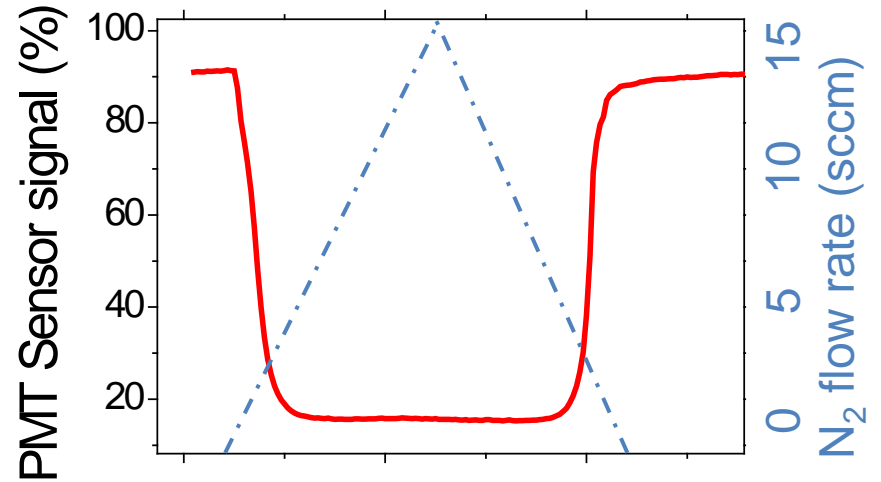


Ti (400mm²)
Ar = 110sccm, Nitrogen = 0sccm
Constant Average Power 1.5kW
Frequency = 300Hz

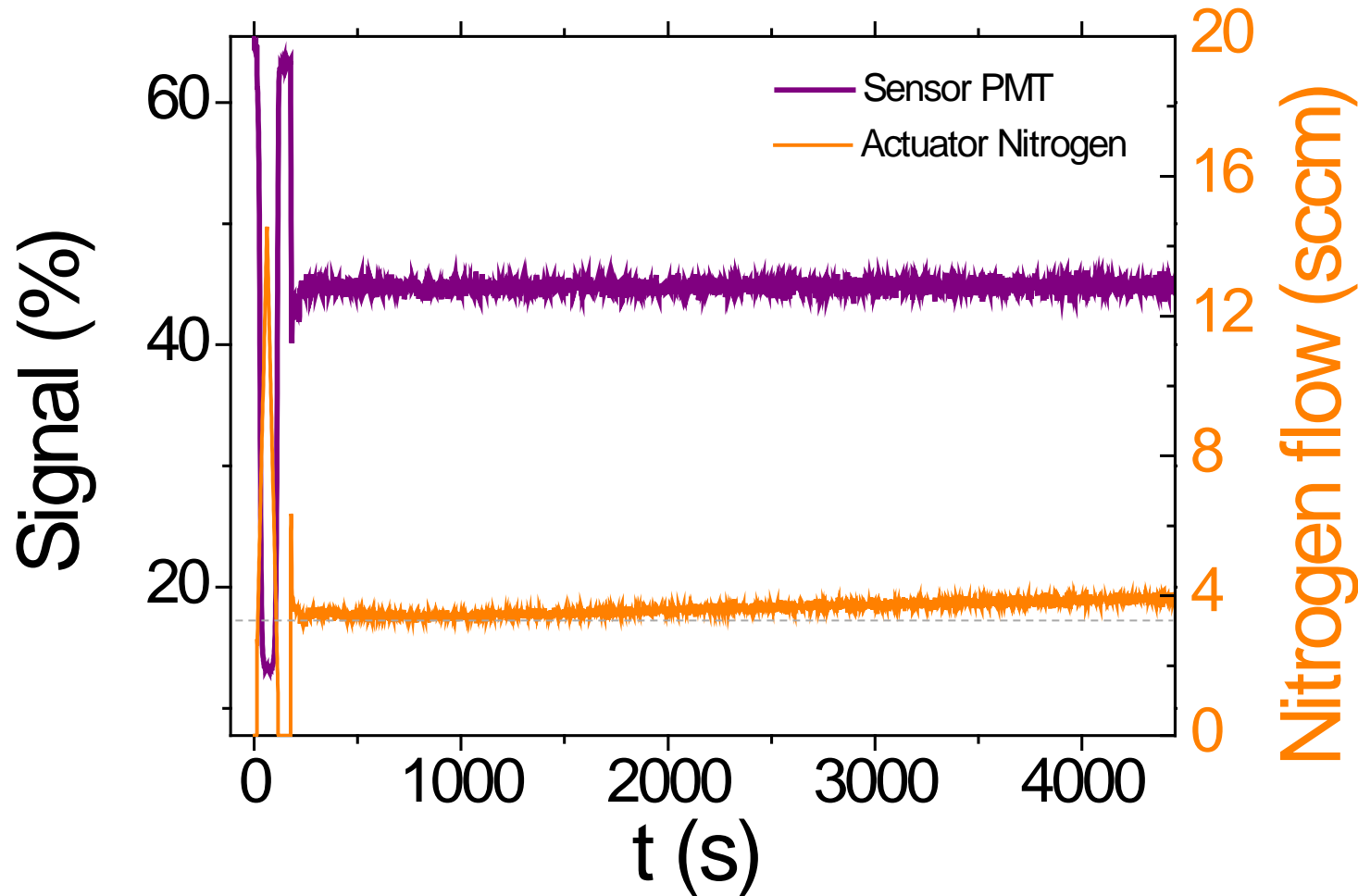
Plasma emission lines Ti + N



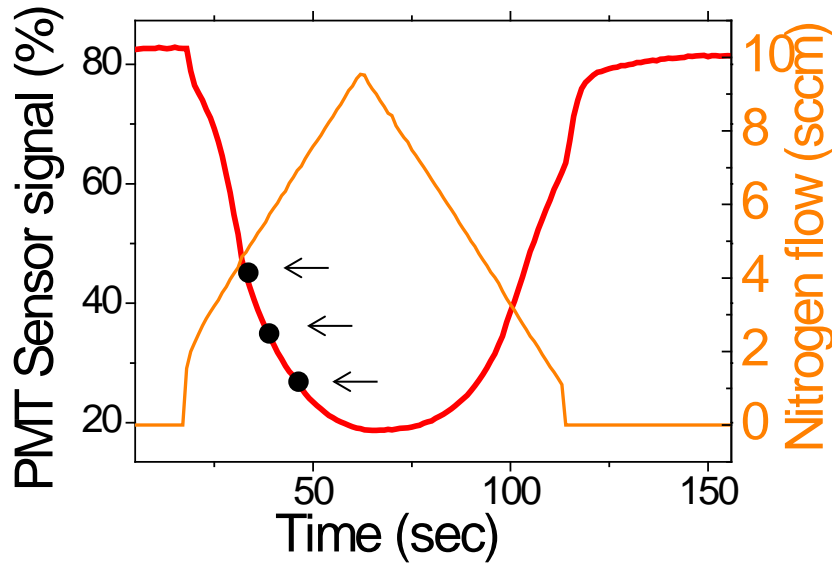
No feedback control possible



HIPIMS TiN coatings: feedback control



HIPIMS TiN coatings: feedback control



Nitrogen flow at setpoint

45% ~ 4.5 sccm

35% ~ 5.5 sccm

25% ~ 7.0 sccm

Ti (400mm²)

Ar + Nitrogen

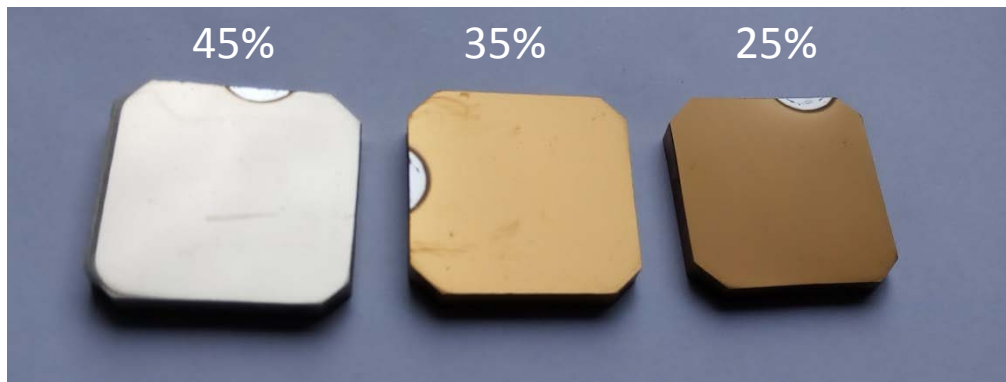
Constant Average Power 3kW

120us – 500Hz

I_{peak} : 220 – 500A peak

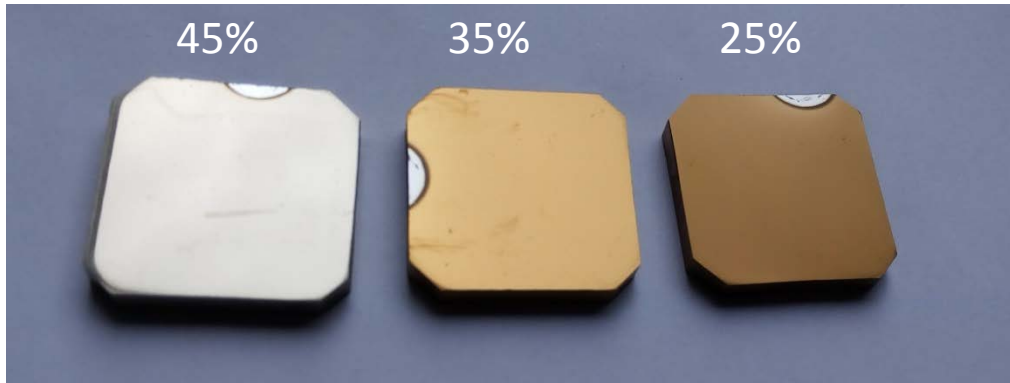
1hr deposition

SetPoint

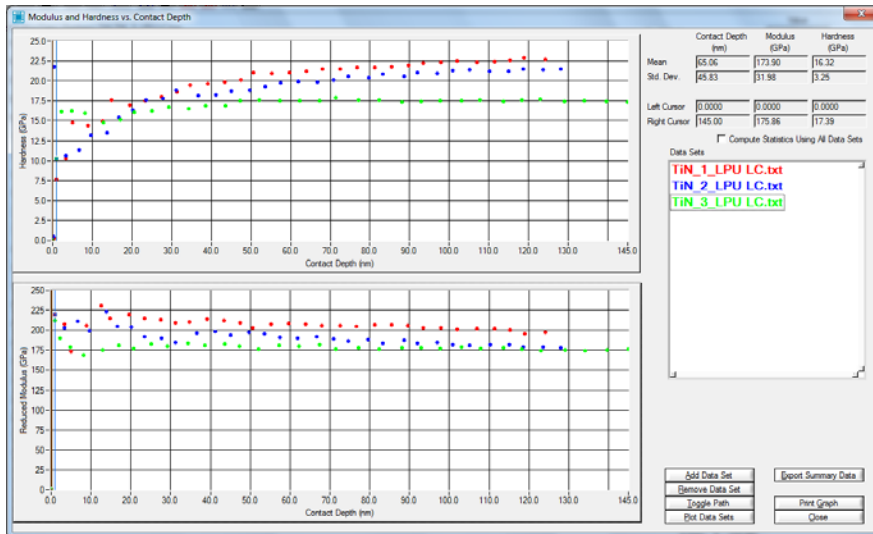


HIPIMS TiN coatings: feedback control

SetPoint



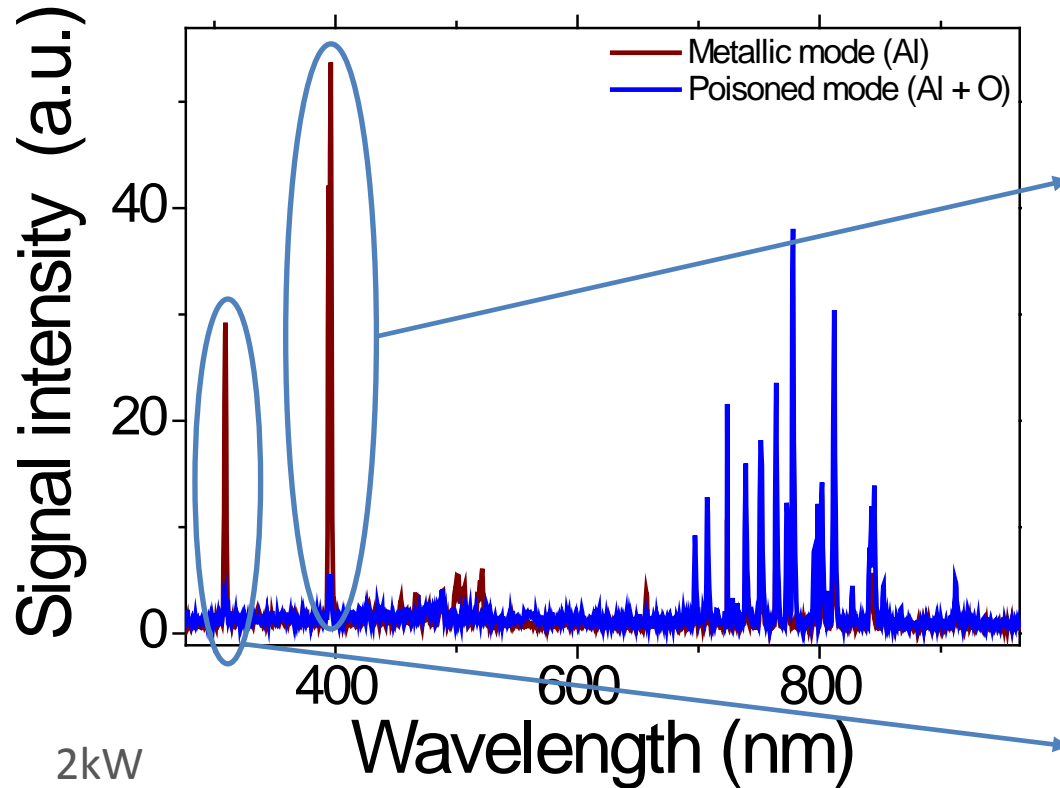
Ti (400mm²)
 Ar + Nitrogen
 Constant Average Power 3kW
 120us – 500Hz
 I_{peak} : 220 – 500A peak



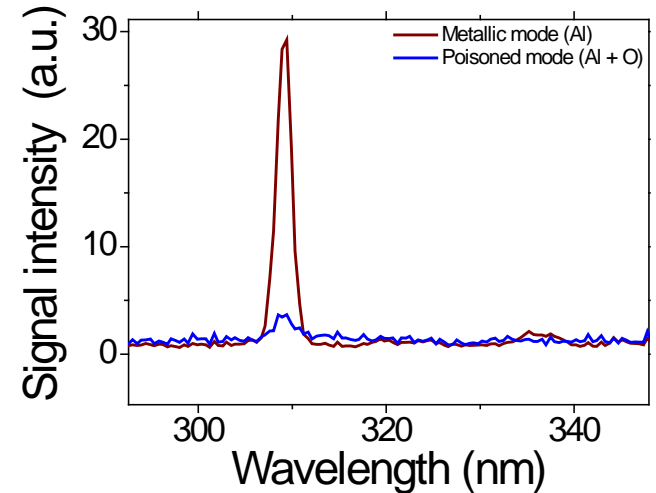
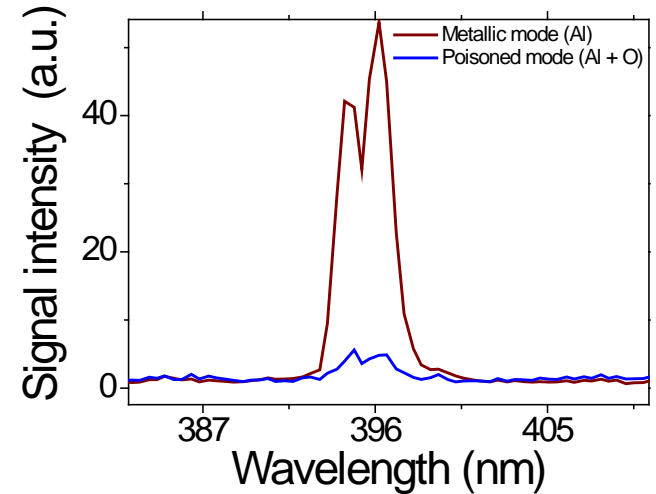
Setpoint [%]	45	35	25
Hardness [GPa]	22.0	22.5	17.5
Dep. Rate [μ m/hr]	3.7	3.7	3.5

RT deposition
 Floating potential

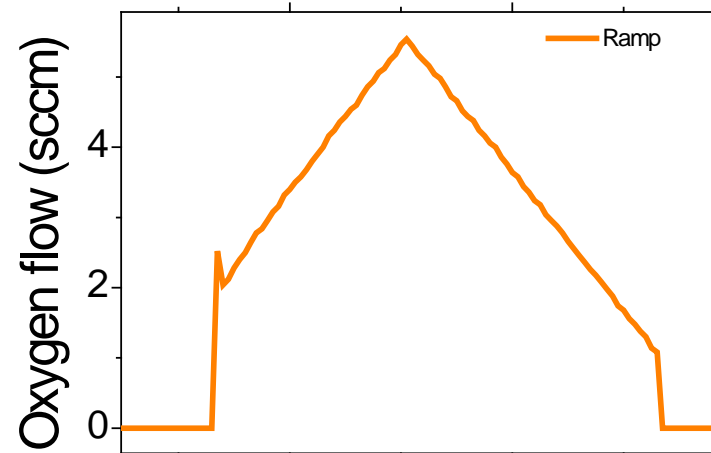
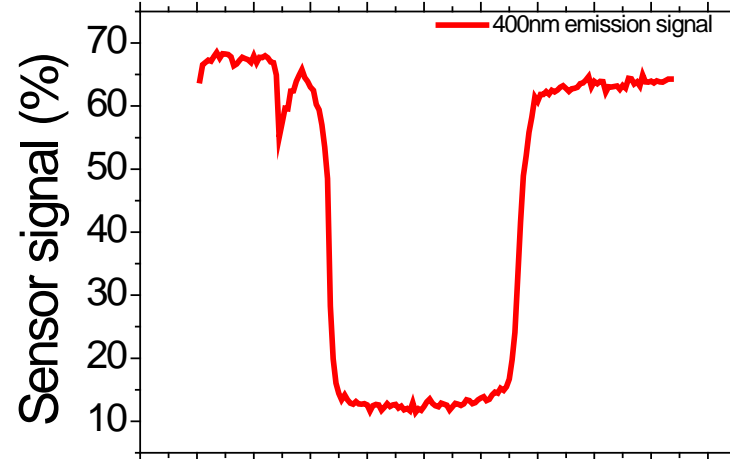
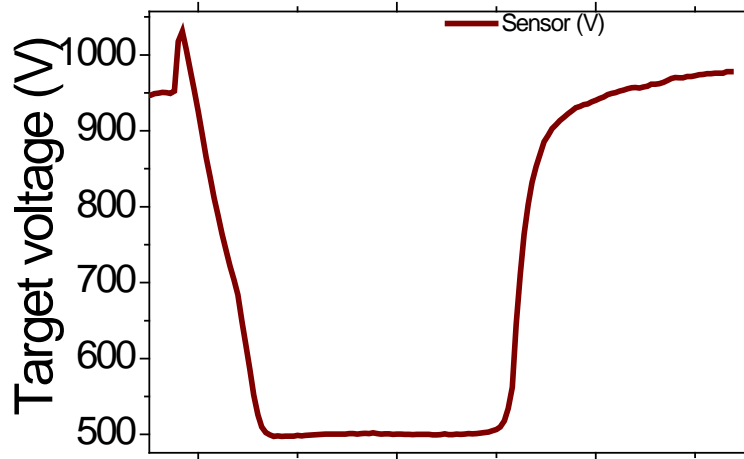
HIPIMS reactive control Al-O



2kW
35us – 1kHz
Ar flow 150sccm
O2 flow 15sccm



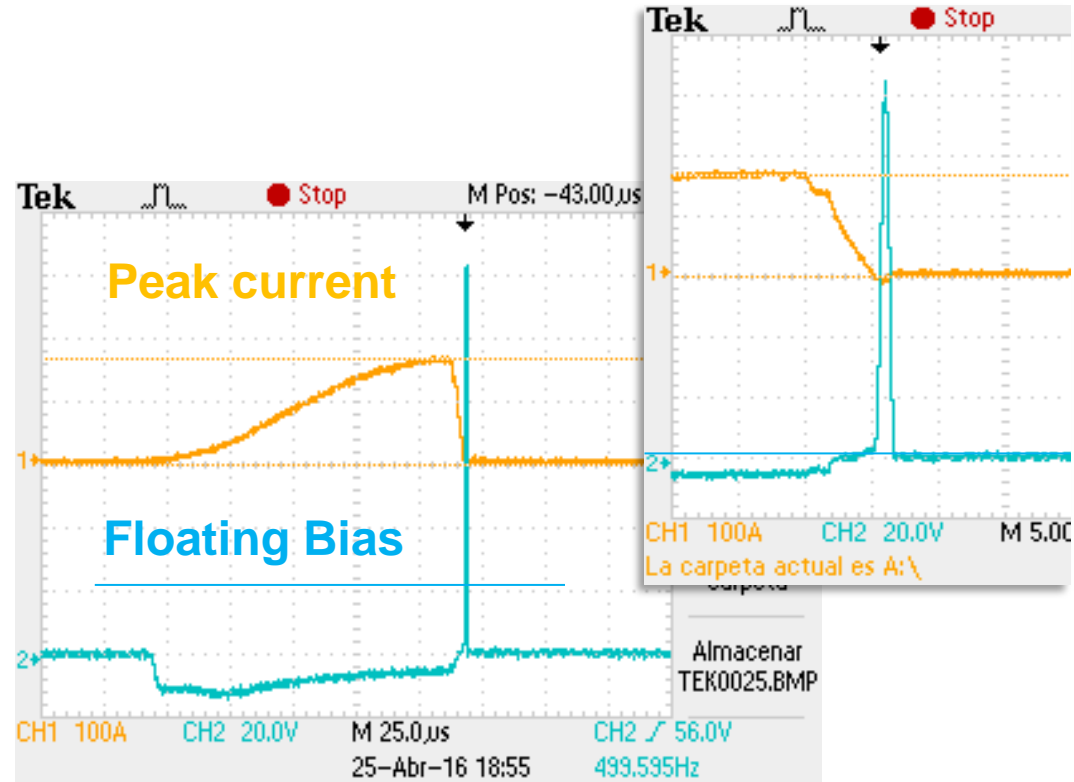
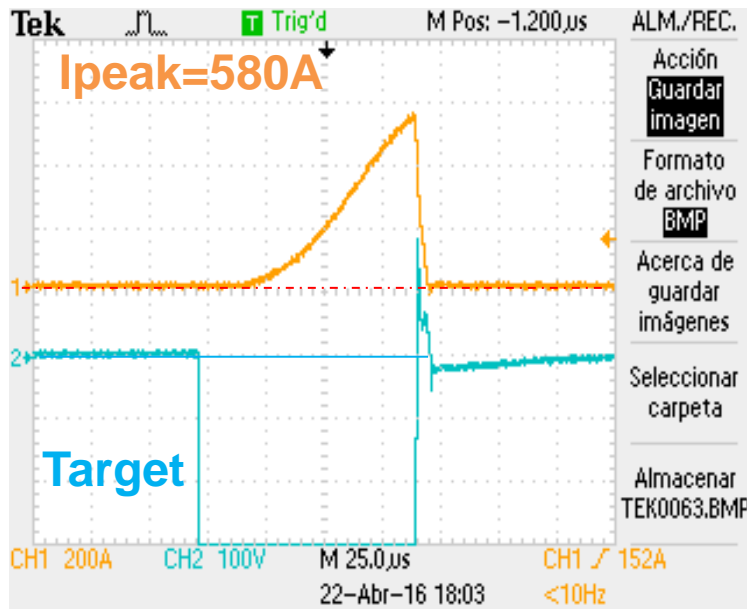
HIPIMS reactive control Al-O



2kW average power
35us – 1kHz
Ar flow 150sccm
O2 flow 15sccm

HIPIMS TiN coatings : positive reversal

With positive voltage reversal

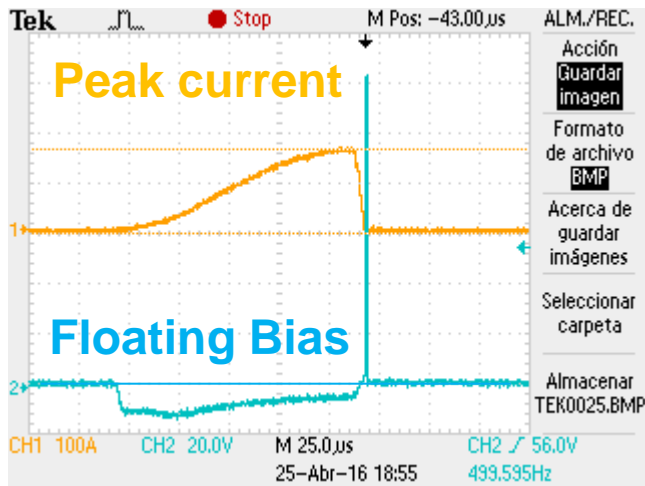


Heurka Session– Tuesday May 10 6:10 p.m.

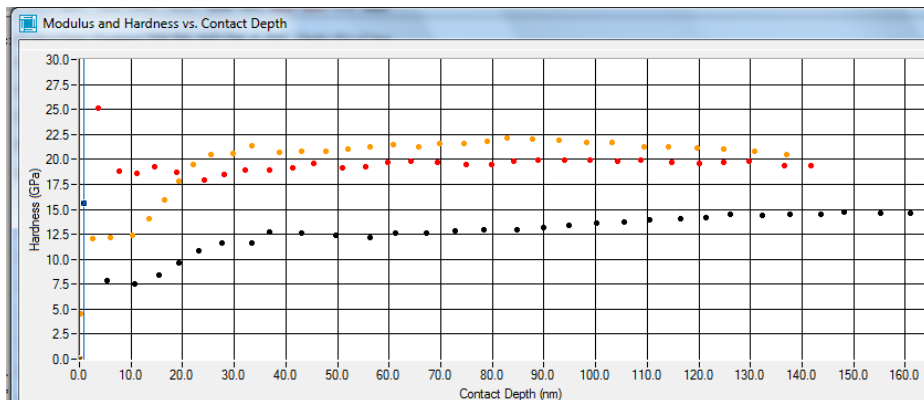
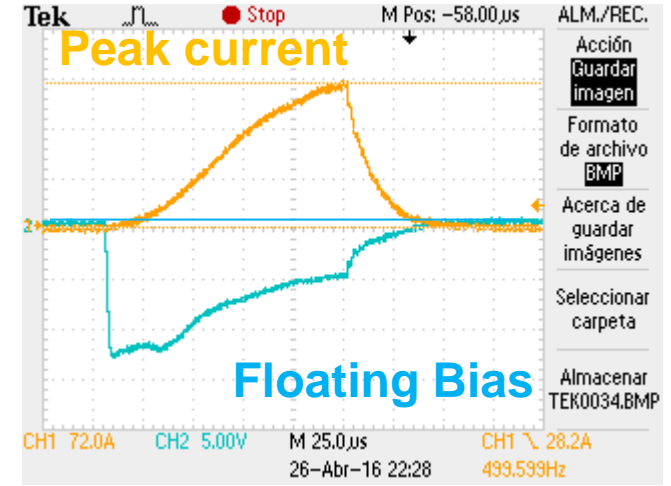
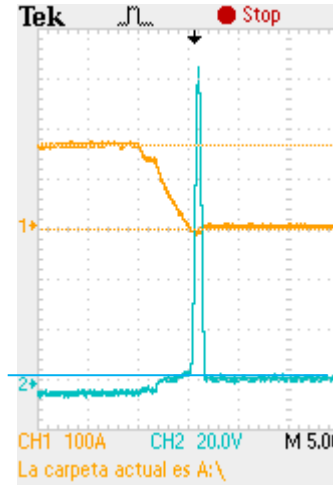
H-3 Tribomechanical properties of DLC deposited by magnetron sputtering on metallic and insulating substrates. **I.Fernandez-Martinez**

HIPIMS TiN coatings: feedback control

With positive voltage reversal



Without positive voltage reversal



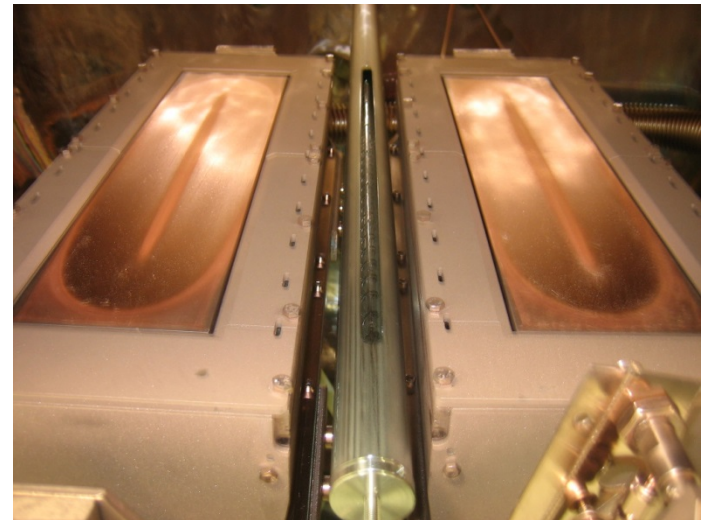
Setpoint [%]	45	45
Hardness [GPa]	22.0	13
POSITIVE	YES	NO

Summary

Peak intensity signals for process stabilization.

Peak current stabilization also possible, ongoing experiments.

I promised Dual Magnetron...



Submit your abstract in May!!!

www.ecnf2016.org



Main topics:

Tribological coatings

Energy conversion (solar, batteries) and catalysis

Nanostructured coatings

From molecules and nanoparticles to thin films

Novel 2D materials

Characterisation techniques and Properties

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Thank you for your attention!

Visit us in booth 506-508