

# Quantum System RFEA Applications

Ion and Neutral Deposition Rate Monitor

Retarding field Energy Analyser with Integrated QCM

<https://www.impedans.com/products/quantum-rfea-system/>



# How to transfer HIPIMS processes using different cathodes and machines?

## Process transfer from R&D to small industrial cathode

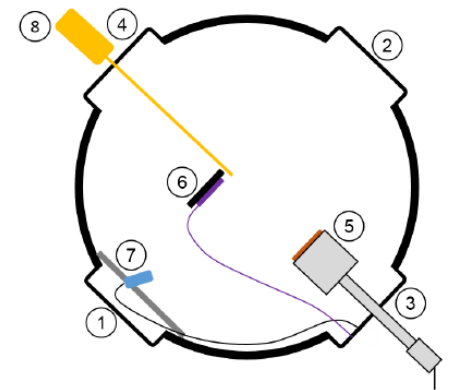
Ralf Bandorf et al, Fraunhofer IST, Braunschweig, Germany

DOI: [https://www.pse-conferences.net/tl\\_files/pse2018/Dokumente/PSE2018-abstracts\\_all.pdf](https://www.pse-conferences.net/tl_files/pse2018/Dokumente/PSE2018-abstracts_all.pdf)

This paper addresses issues concerning the transfer between different cathodes and coating systems. Instead of focusing on the electrical parameters applied at the cathode the situation at the substrate position is observed. Plasma properties like electron and ion density or electron temperature, as well as the ion to neutral ratio of the film forming species are used to characterise the process conditions for the film formation.

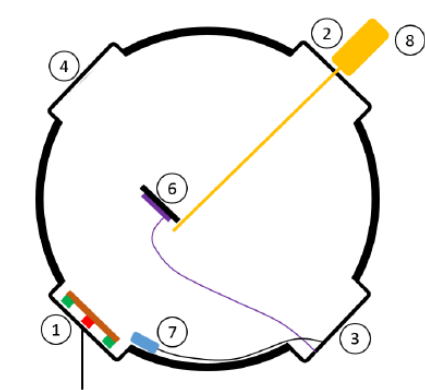
Some example data is shown to the right

R&D cathode setup  
45 cm<sup>2</sup>, Starfire HIPIMS



- (1) Industrial cathode (A= 315 cm<sup>2</sup>)
- (6) Impedans Quantum
- (8) Impedans Plato Probe

industrial cathode setup  
315 cm<sup>2</sup>, Melec HIPIMS



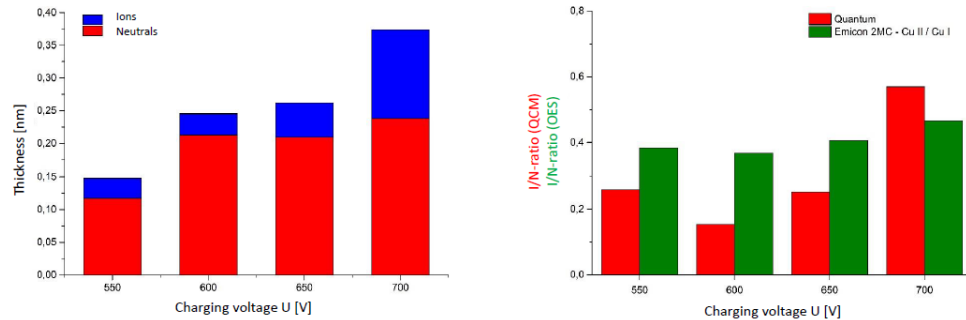
- (5) R&D cathode KJL (A= 45 cm<sup>2</sup>)
- (7) OES Optics

*Schematic of experimental setup – R&D and Industrial cathode setup.*

# How to transfer HIPIMS processes using different cathodes and machines?

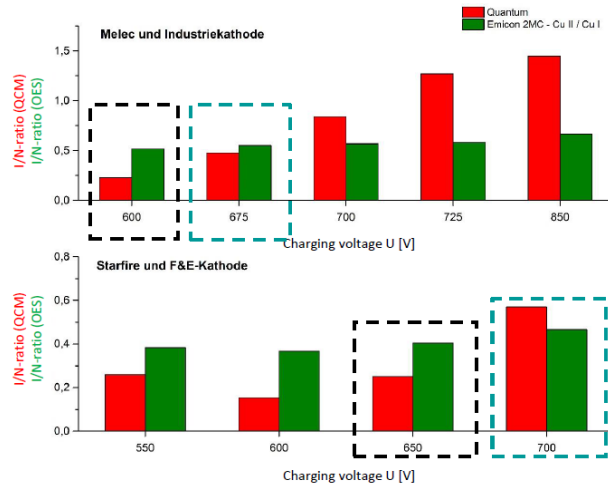
## General trends on 3" cathode

### Ion:neutral ratio as function of charging voltage



## Process transfer

### Ion:neutral ratio



#### Configuration C:

Melec: 600 V  
Starfire: 650 V  
I/N-ratio ~ 0.25

#### Configuration D:

Melec: 675 V  
Starfire: 700 V  
I/N-ratio ~ 0.55

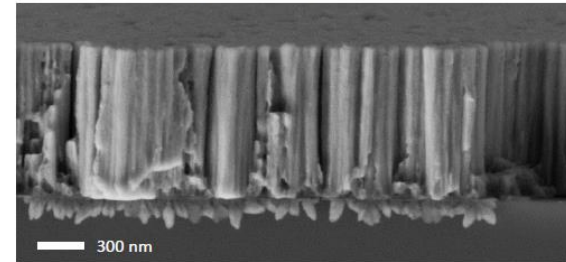
*Results of film growth and morphology shown below as first indication of proper choice for a successful approach for process scaling and transfer*

## Process transfer

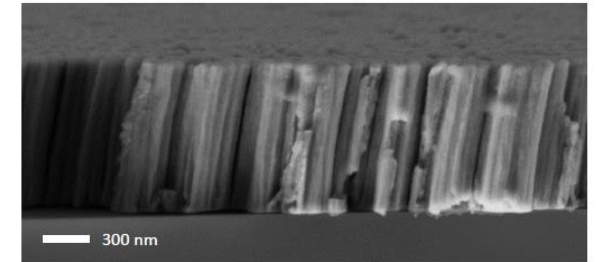
### Coatings with similar I/N-ratio

I/N film forming species ~ 0.25

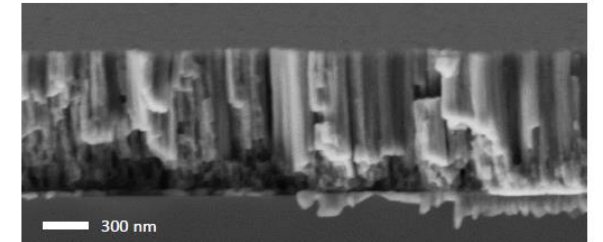
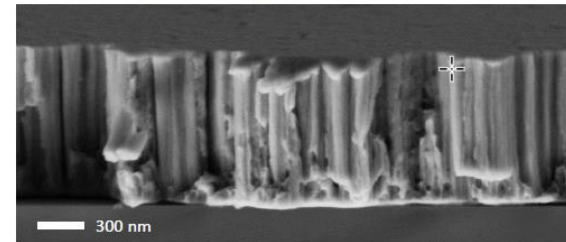
R&D Cathode (45 cm<sup>2</sup>)



Industrial cathode (315 cm<sup>2</sup>)



I/N film forming species ~ 0.55



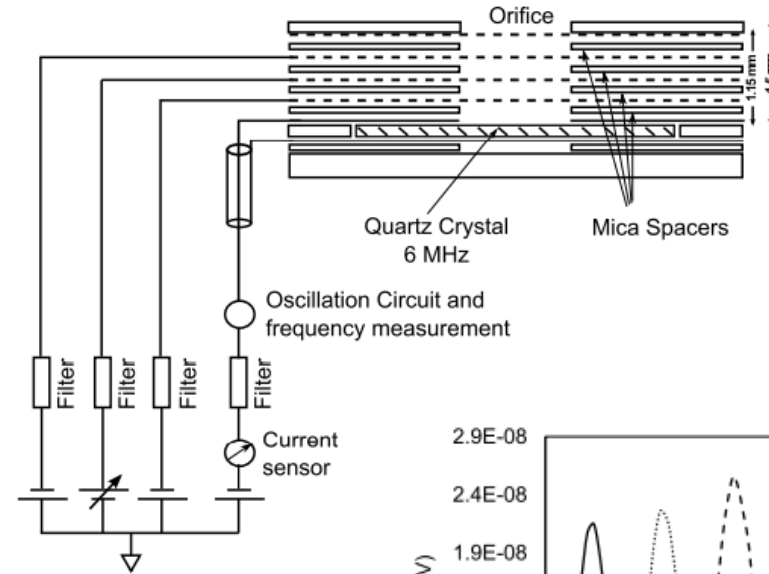
# New design of compact retarding field analyser with integrated quartz crystal microbalance: Impedans Ltd.

## Measurement of deposition rate and ion energy distribution in a pulsed dc magnetron sputtering system using a retarding field analyzer with embedded quartz crystal microbalance

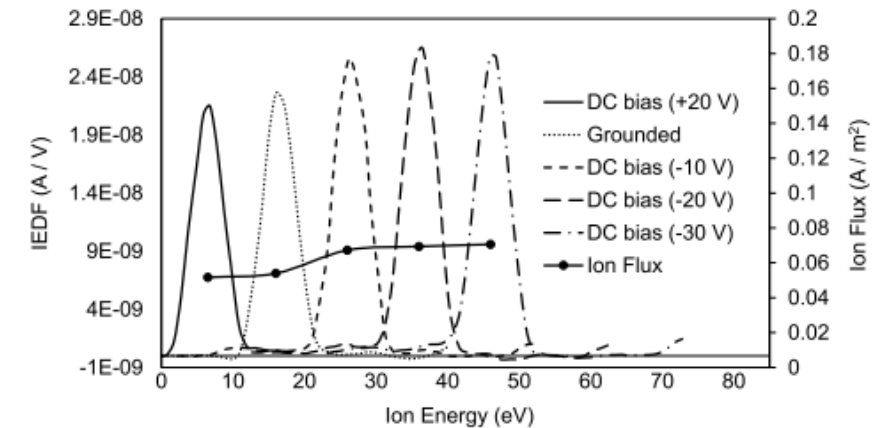
Sailesh Sharma et al, Dublin City University, Glasnevin, Dublin , Ireland  
Impedans Limited, Chase House, City Junction Business Park, Northern Cross, Ireland

DOI: <https://doi.org/10.1063/1.4946788>

In this research work, the IEDF and Cu deposition rates are studied in an asymmetric bipolar p-dc sputtering system using the Quantum RFEA-QCM design. The effect of ion energy, substrate rf biasing, discharge power, and pressure on the deposition rate are also examined.

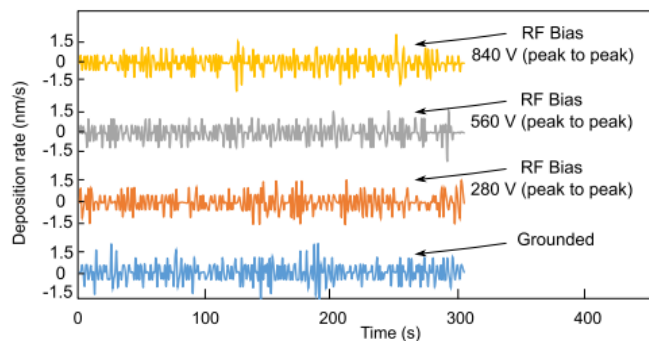


*Schematic of QCM embedded Quantum RFEA design*

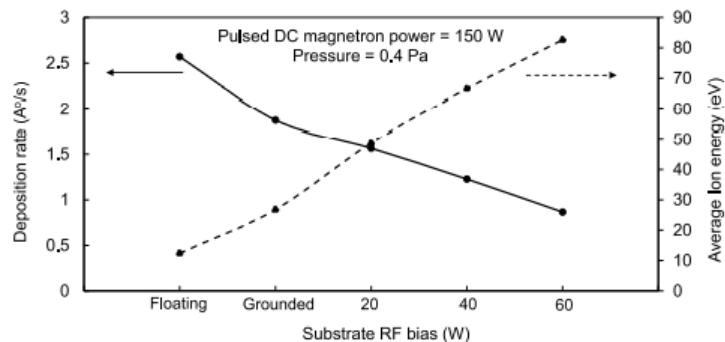


*IEDF and ion flux at different substrate dc biasing*

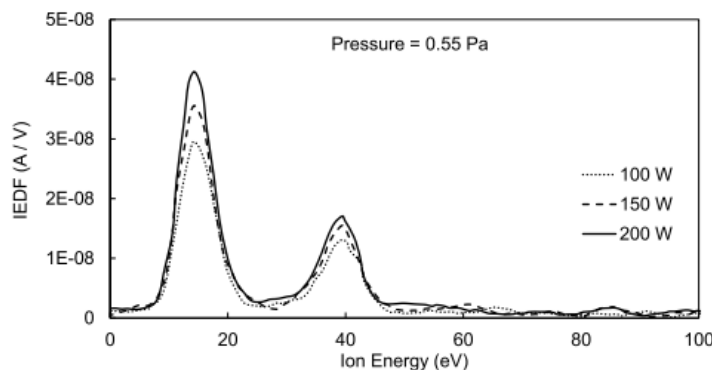
# New design of compact retarding field analyser with integrated quartz crystal microbalance



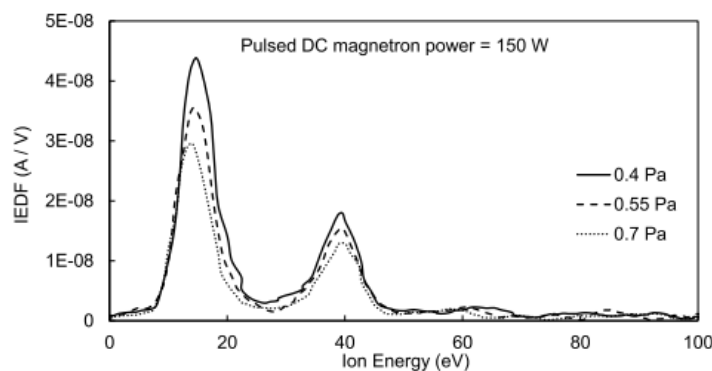
Deposition rate vs time at different substrate rf biasing



Deposition rate and average ion energy vs different substrate biasing.

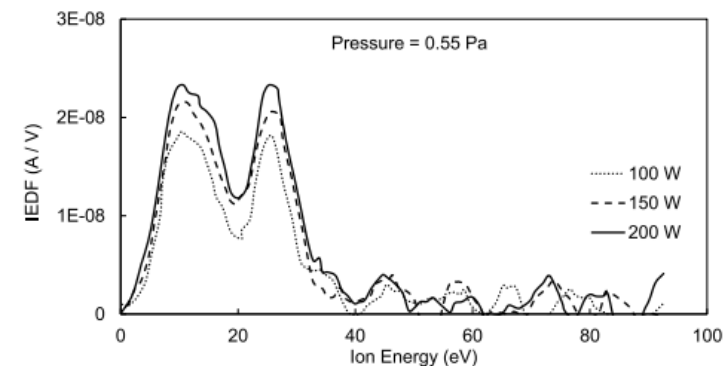


(a)

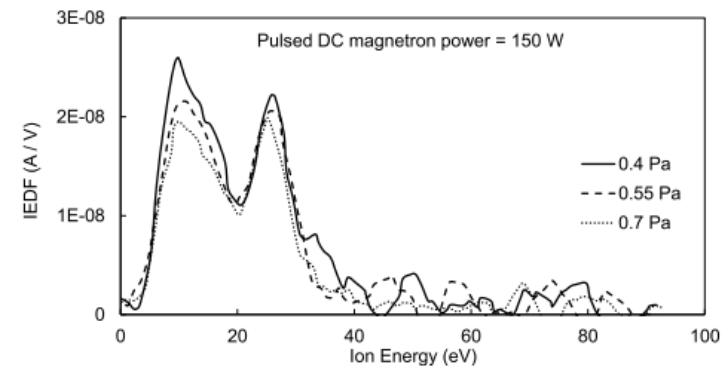


(b)

IEDF on a grounded substrate at a fixed (a) pressure and (b) power.



(a)

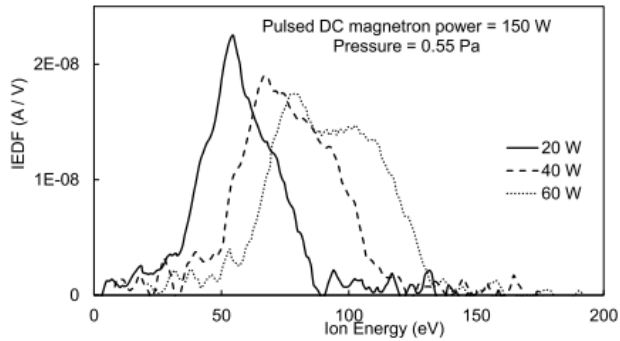


(b)

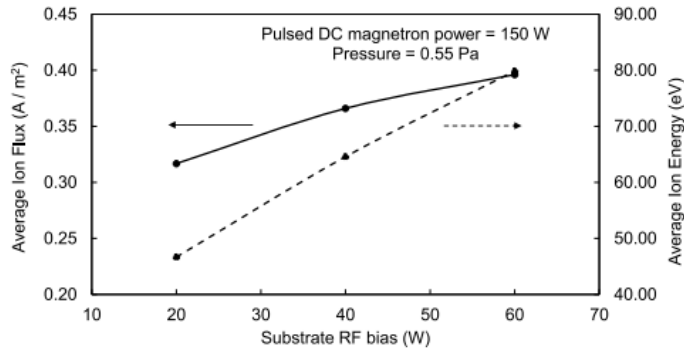
IEDF on a floating substrate at a fixed (a) pressure and (b) power



# New design of compact retarding field analyser with integrated quartz crystal microbalance

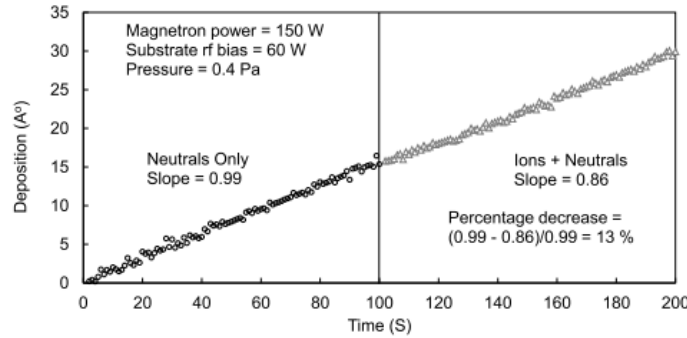


(a)

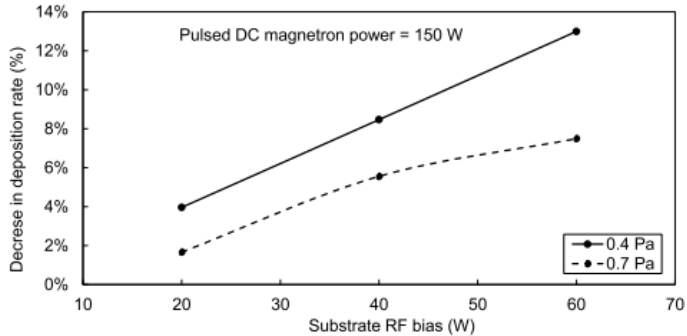


(b)

(a) IEDF on a substrate biased at three different rf powers (20 W, 40 W, and 60 W). (b) Average ion flux and average ion energy vs RF bias.

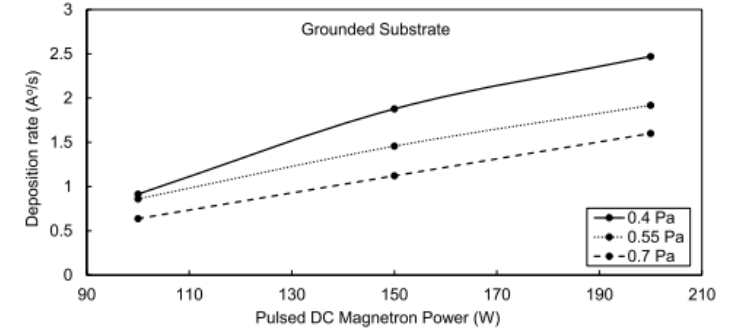


(a)

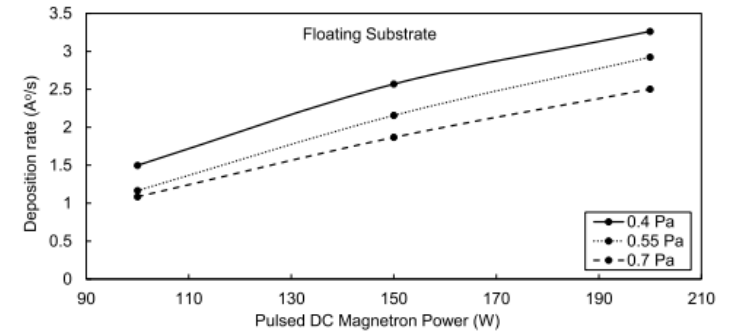


(b)

(a) Deposition vs time graph to determine percentage decrease. (b) Percentage decrease in the deposition rate after ions are turned on.



(a)



(b)

Deposition rate vs p-dc power at different pressures on a (a) grounded substrate and (b) floating substrate

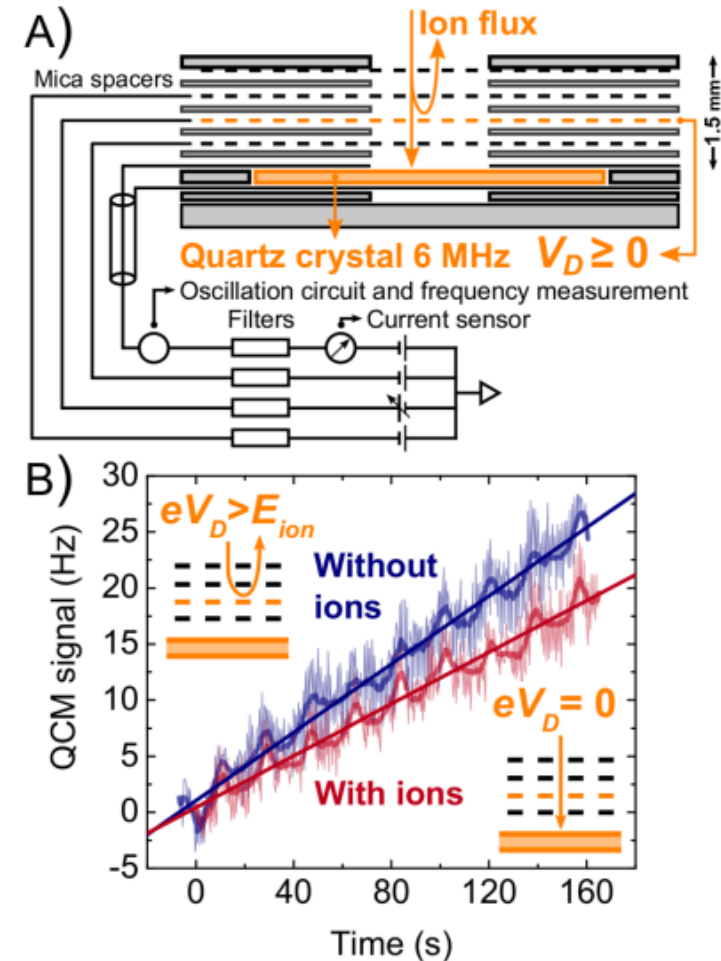
# Measurement of the deposition rates in an ALD Plasma

## Evidence for low-energy ions influencing plasma-assisted atomic layer deposition of $\text{SiO}_2$ : Impact on the growth per cycle and wet etch rate

K. Arts et al, Eindhoven University of Technology, The Netherlands  
Aalto University School of Chemical Engineering, AALTO, Finland  
Oxford Instruments Plasma Technology, North End, Bristol, United Kingdom

DOI: <https://doi.org/10.1063/5.0015379>

The Quantum sensor was used in this paper to measure the Deposition rate with and without Ions in an Atomic Layer Deposition (ALD)  $\text{SiO}_2$  plasma. Results demonstrated that ions have a stronger impact on the plasma ALD of  $\text{SiO}_2$  than usually considered.



Cross-sectional side view of the ion-selective quartz crystal microbalance sensor – Quantum RFEA. Example of the change in the QCM with and without the effect of ions in an ALD Plasma

# Measurement of the deposition rates and Ion:Neutral fraction in a HiPIMS discharge

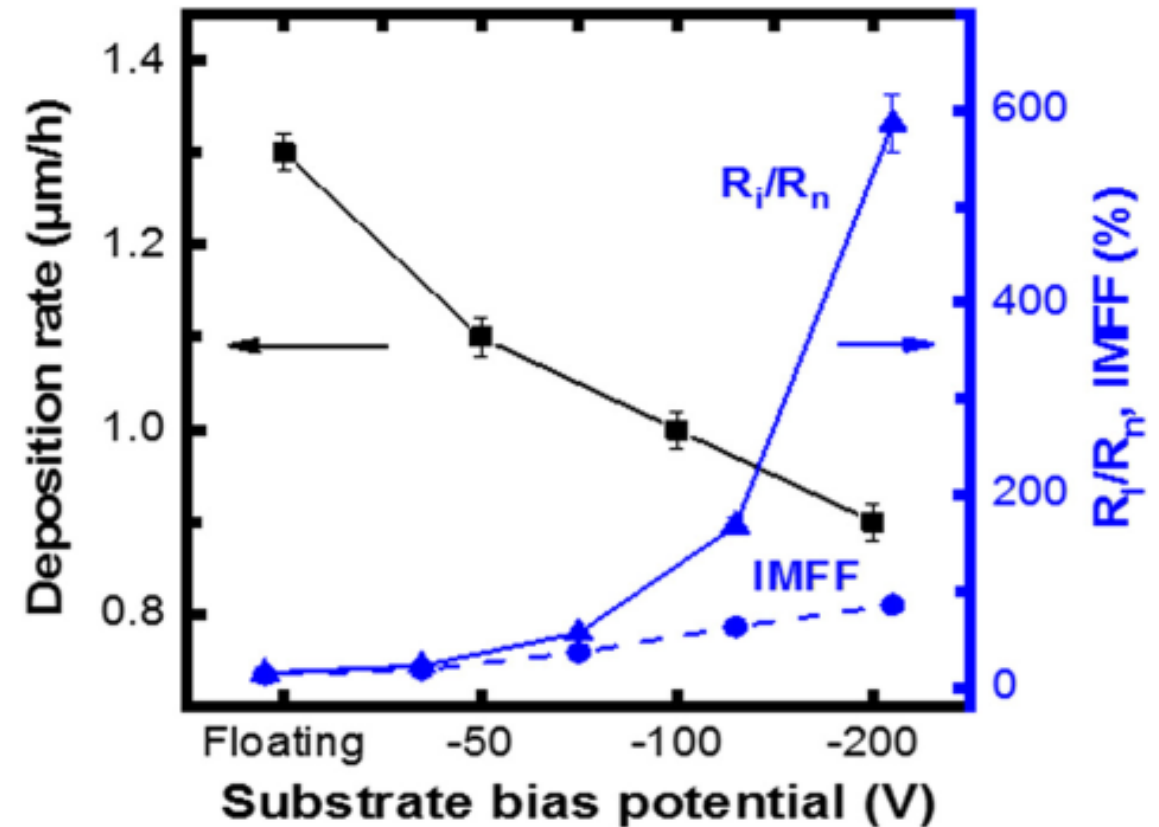
## Effects of HiPIMS discharges and annealing on Cr-Al-C thin films

Michael Ougier et al, Université Paris-Saclay, CEA, Service d'Études Analytiques et de Réactivité des Surfaces, France.

Université Paris-Saclay, CEA, Cross-Cutting Program on Materials and Processes Skills, Gif-sur-Yvette, France

DOI: <https://doi.org/10.1016/j.surfcoat.2020.126141>

The Quantum sensor was used in this paper to measure the Deposition rates and the Ion:Neutral ratio. The effect of HiPIMS duty cycle and substrate bias potential ( $U_B$ ) on the thin film composition were investigated in detail.



*Effect of the Substrate bias potential on the Deposition Rate and the Ion/Neutral ratio*



# High power impulse magnetron sputtering (HiPIMS) of copper, silver and zirconium: influence of different pulse widths (25, 50 and 100 $\mu$ s)

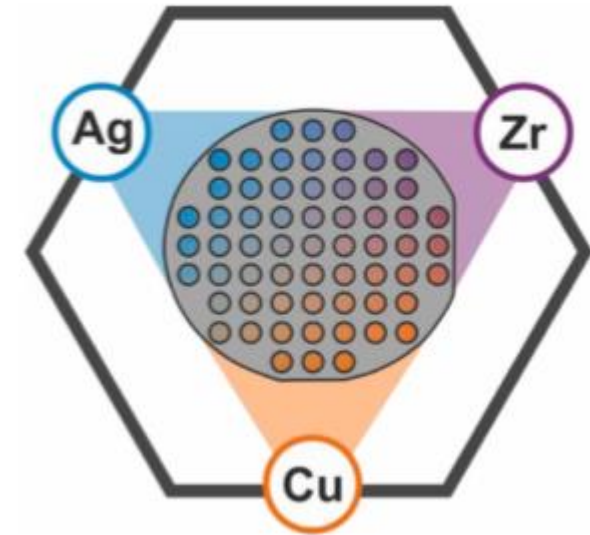
## Influence of HiPIMS pulse widths on the deposition behaviour and properties of CuAgZr compositionally graded films

L. Lapeyre et al, Bern University of Applied Sciences, Institute for Applied Laser, Photonics and Surface Technologies ALPS, Quellgasse, Switzerland

Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Mechanics of Materials and Nanostructures, Switzerland  
Tofwerk AG, Schorenstrasse, Switzerland

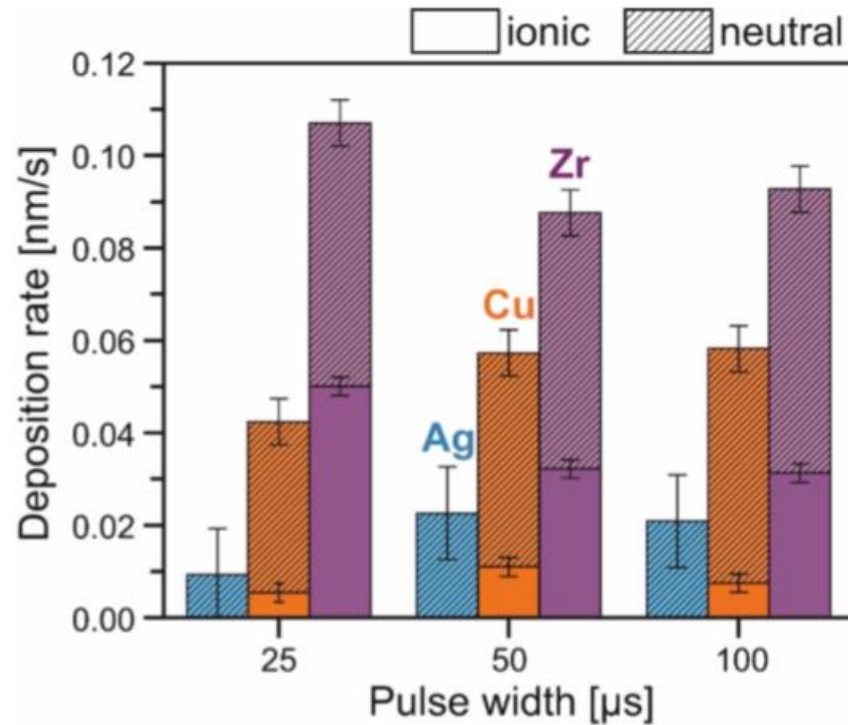
DOI: <https://doi.org/10.1016/j.surfcoat.2022.129002>

In this work, Three HiPIMS pulse widths were utilised to produce CuAgZr libraries. In situ plasma diagnostics identified the influence of pulse width, on each target. The microstructures of CuAgZr coatings were linked to the deposition conditions. Ionised flux fraction measurements were performed using a  $\varnothing$  100 mm Quantum™ System m-QCM probe (Impedans Ltd., Ireland), to determine the mass deposition rate of neutral species and the total (neutral +ions) mass deposition rate.

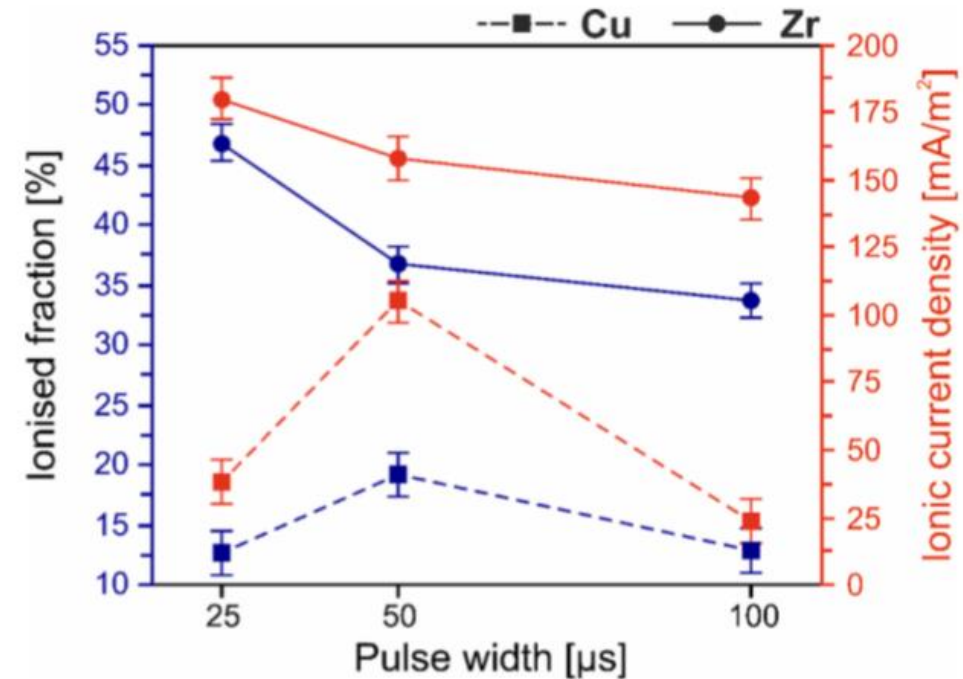


*Schematic of plasma source placement vs substrate and mask position*

# High power impulse magnetron sputtering (HiPIMS) of copper, silver and zirconium: influence of different pulse widths (25, 50 and 100 $\mu\text{s}$ )



Ag, Cu and Zr deposition rates, with distribution of neutral and ionic species, for 25, 50 and 100  $\mu\text{s}$  pulse widths (detailed values given in supplementary information)



Ionized fraction and ionic current density for Cu and Zr, with no ionic signal measured during Ag discharges.

# Impedans Ltd

Chase House, City Junction Business Park, Northern Cross,  
Dublin 17, D17 AK63, Ireland

Ph: +353 1 842 8826

Web: [www.impedans.com](http://www.impedans.com)  
Email: [support@impedans.com](mailto:support@impedans.com)