



Hip³

High Rate Ion Etching Technology 'The Power of Positive'

Rapid coating removal and surface preparation based upon positive voltage Hipims – patent pending



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Rapid substrate etching

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- Uses +600V & 150 Amps Hipims style positive pulse on a magnetron cathode
- DC bias applied to the substrate (pulsed for insulating coatings)
- 2nd Magnetron active with low DC power
- Rates are x 20 standard pulsed plasma etching

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Easily adapts to existing machines

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- Requires hipV HiPIMS HiPlus Positive Pulsing Unit
- 2 magnetron sputter sources
- 1 magnetron uses the Hip³ mode of purely positive pulse mode of operation
- 2nd magnetron DC power
- DC or DC pulsed bias supply

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Hip³ ion creation without deposition hipV with HiPlus



- No negative phase applied to ion source magnetron target no sputtering
- High current positive pulse to ionise gases present
- Negative bias on substrates attracts ions

 typically 200V
- Rapid removal of coating or surface contamination
- Magnetrons can revert to coating sources after etching phase







Hip³ areas of application



- Faster pre-cleaning of parts prior to sputter coating
- Rapid plasma surface treatment
- Rapid selective etching of coatings and surfaces
- Dual mode operation switch from pretreat to coating with the same hipV power supply
- Can be combined with other gases for reactive ion etching





Hip³ Pulsing Parameters

Pulse width as high as 120us with stable peak current around 150A. No negative phase to the pulse.



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22us pulse width Max. frequency – 2kHz Max. Average Power – 20kW



50us pulse width



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Etching tests – system setup

Total distance in 3-fold rotation (approx.):

3 times 2*p*(7.5) = 140cm = 1.4m

Time : 1min @1rpm

Speed (@1rpm) = 1.4m/min = 1pass/min (@5rpm) =7.0m/min = 5 pass/min

If etching rate (Carbon) equal to 50nm in 60min then: 50nm * 1.4m /60 min = 1.16nm*m/min





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Etching of Carbon & Si₃N₄ 3 axis rotation for 60 min

ION SOURCE: 3kW average (145A peak, 660V peak) 2us - 2kHzAr gas 50sccm - P(Ar) = 5e-3mbar**DC Bias -200 V**

Etching Rate Stainless Steel = 90nm/hr (1.05nm*m/min)

Masked area stainless steel plate

Masked zone in Si3N4/Si wafer

Etching Rate Si3N4 on Silicon wafer = **38nm/hr (0.44nm*m/min)**



80nm taC on Stainless Steel (before etching)



taC sample after 60 mins etching



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Accurate etching assessment by AFM

ION SOURCE: 3kW average (145A peak, 660V peak) 22us – 2kHz **SUBSTRATE** Bias DC-200V Ar gas 50sccm - P(Ar) = 5e-3mbarEtching time = 60min





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0.165

0.185

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Etching of Carbon & Si₃N₄ Pulsed DC 50 min

ION SOURCE: 3kW average (145A peak, 660V peak) 2us – 2kHz Ar gas 50 sccm – P(Ar) = 5e-3mbar Pulsed DC Bias -250 V 150 kHz

Etching Rate Si₃N₄ on Silicon wafer measured by AFM = 160nm/hr (1.86nm*m/min)

Etching Rate Stainless Steel = **192nm/hr** (2.24nm*m/min)

Etching Rate Stainless Steel = **192nm/hr** (2.24nm*m/min)

ETCHING RATE ESTIMATION FOR STAINLESS STEEL FOR HIGHER APPLIED POWERS

If power is raised to 10kW = 7.46nm*m/min If power is raised to 20kW = **14.91nm*m/min**



Hence at 20 kW approx 15nm of SS removed from a plate pasing the ion source **once** at 1m/min speed which is equivalent to **150** times faster than a linear ion source. **Nano4energ**

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Hip3 etching rates – comparison with DC-Pulsed Argon Glow discharge

DC-P Glow discharge

ETCHING RATE FOR STAINLESS STEEL

Ion source + DCP (200V, 100kHz – 250W) = 160nm in 60min TOTAL = **192nm/hr (2.24nm*m/min)**

DCP (350V*, 100kHz – 350W) = 6-12nm in 60 min TOTAL = **0.1 to 0.2 nm*m/min**

* Minimum Voltage and frequency to ignite Plasma in chamber

Ar gas 60 sccm – P(Ar) = 6e-3mbar **Bias Pulsed DC-250V – 150kHz**







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Test on plastics – Ryton PPS-GF

- Hip³ can be used with argon and oxygen to rapidly pre-treat plastics

- Etching time 5minutes
- P (Ar+O2) 1.3 e-2mbar (Ar:O2 50:50)
- HiP³ parameters : 550V 40us 2000Hz, 130W



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Hip³ also compatible with other gases for reactive ion etching



Hip³ etching process

- High Power Positive Pulses can be used to perform etching in combination with Negative DC or Pulsed Bias and a second magnetron operating at very low power.
- A steady peak current state is achieved, allowing operation at high average power (up to 20kW) at low frequencies (as low as 2kHz) typical HiPIMS conditions.
- Etching rates as high as **2.24nm*m/min** were demonstrated for Stainless Steel with 3kW average operation on a 100 x 400mm ion source target.
- Etching rates as high as **1.12nm*m/min** were demonstrated for Si3N4 with 3kW average operation and pulsed DC Bias (100kHz).
- Etching rate can be estimated to be above **15nm*m/min** on Stainless Steel using Ar and a rectangular magnetron with 400cm2 with 20 kW applied power.
- The combination with reactive gases boosts the etching rate (observed for DLC etching using Ar+O2 plasma).



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Commercial options based upon Hip³ etching process

- The Hip3 technology is novel and subject to joint patent applications by Gencoa and N4E
- The technology can be implemented on existing equipment with a suitable power supply
- A license fee to apply the technology can be agreed
- The hipV HiPIMS HiPlus Positive Pulsing Units are available to apply the etching mode to any system
- Compact Gencoa dual electrodes Hip³ can be added to any system where suitable sources are not present
- Please contact your local Gencoa or N4E agent





