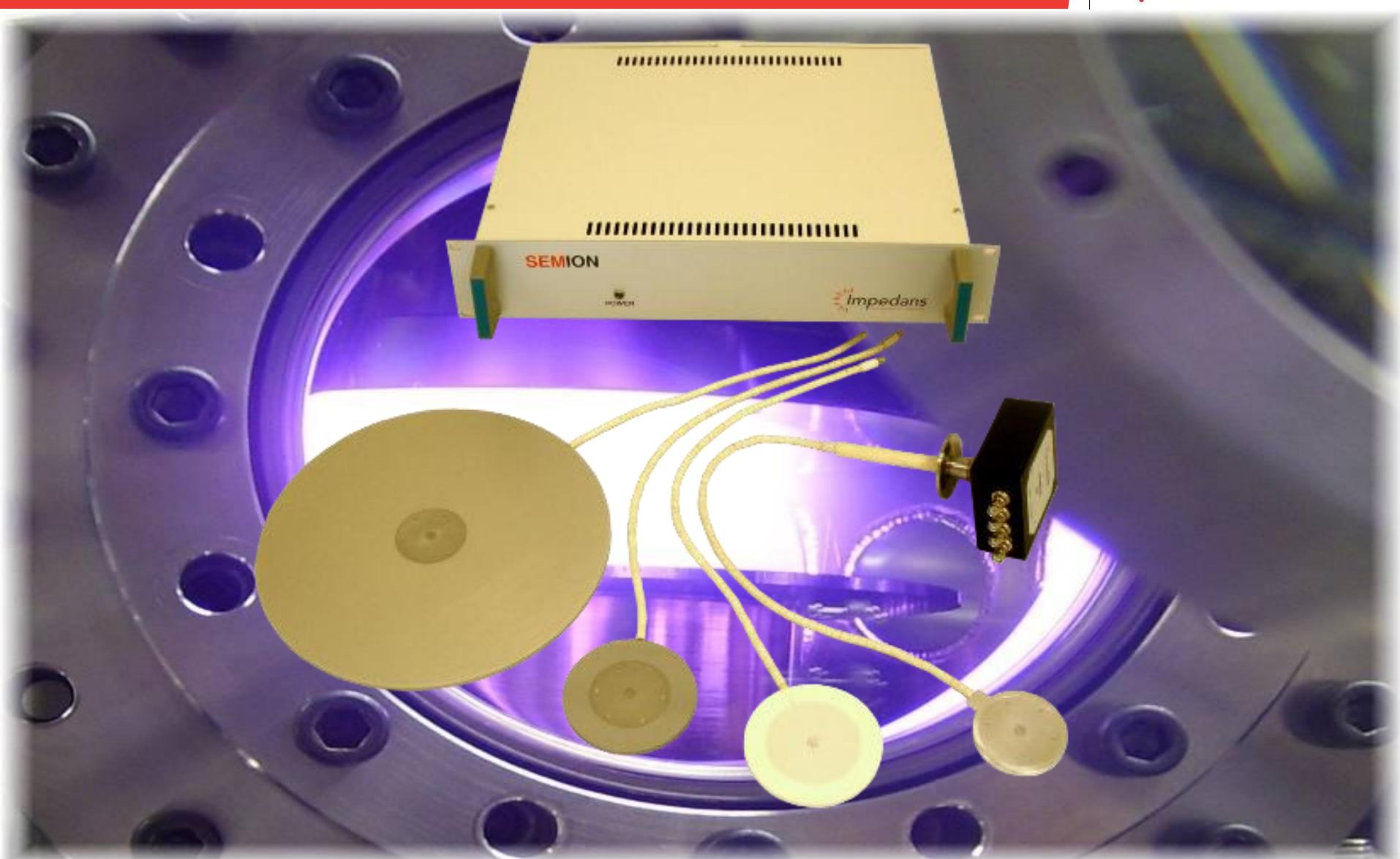
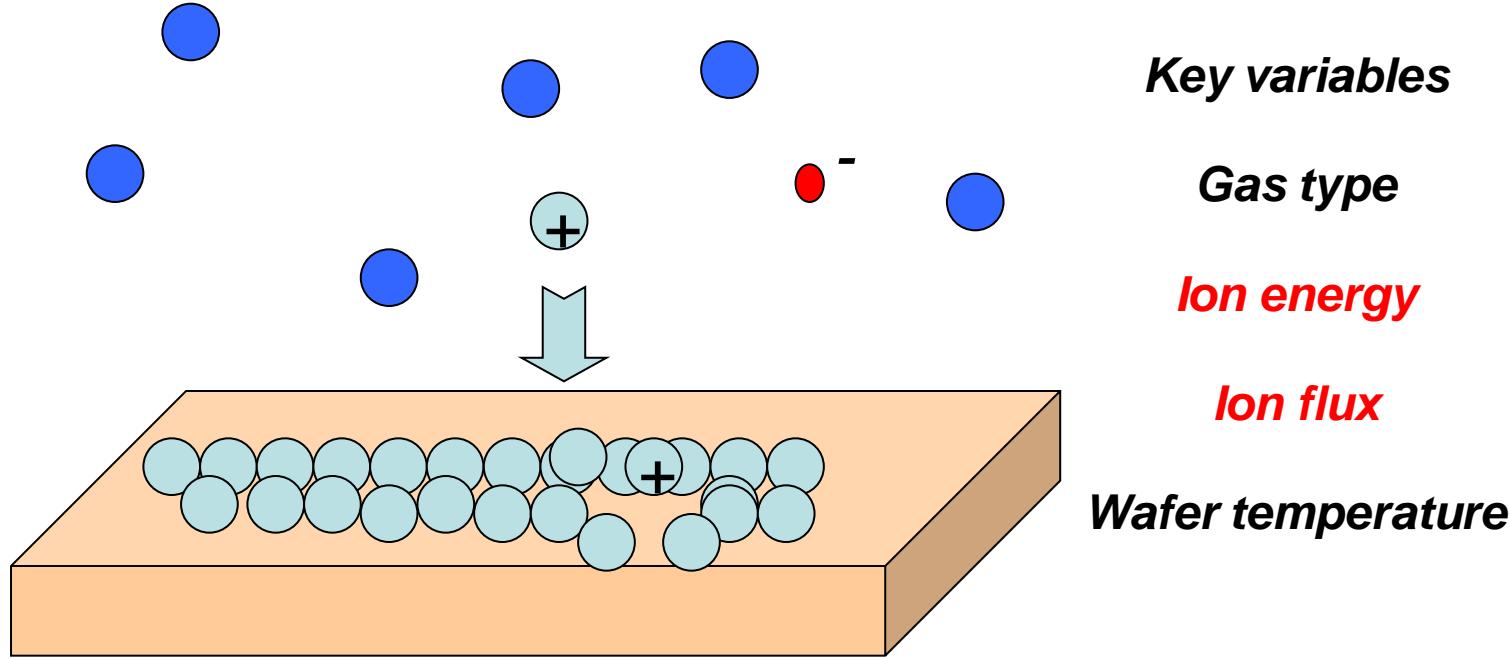


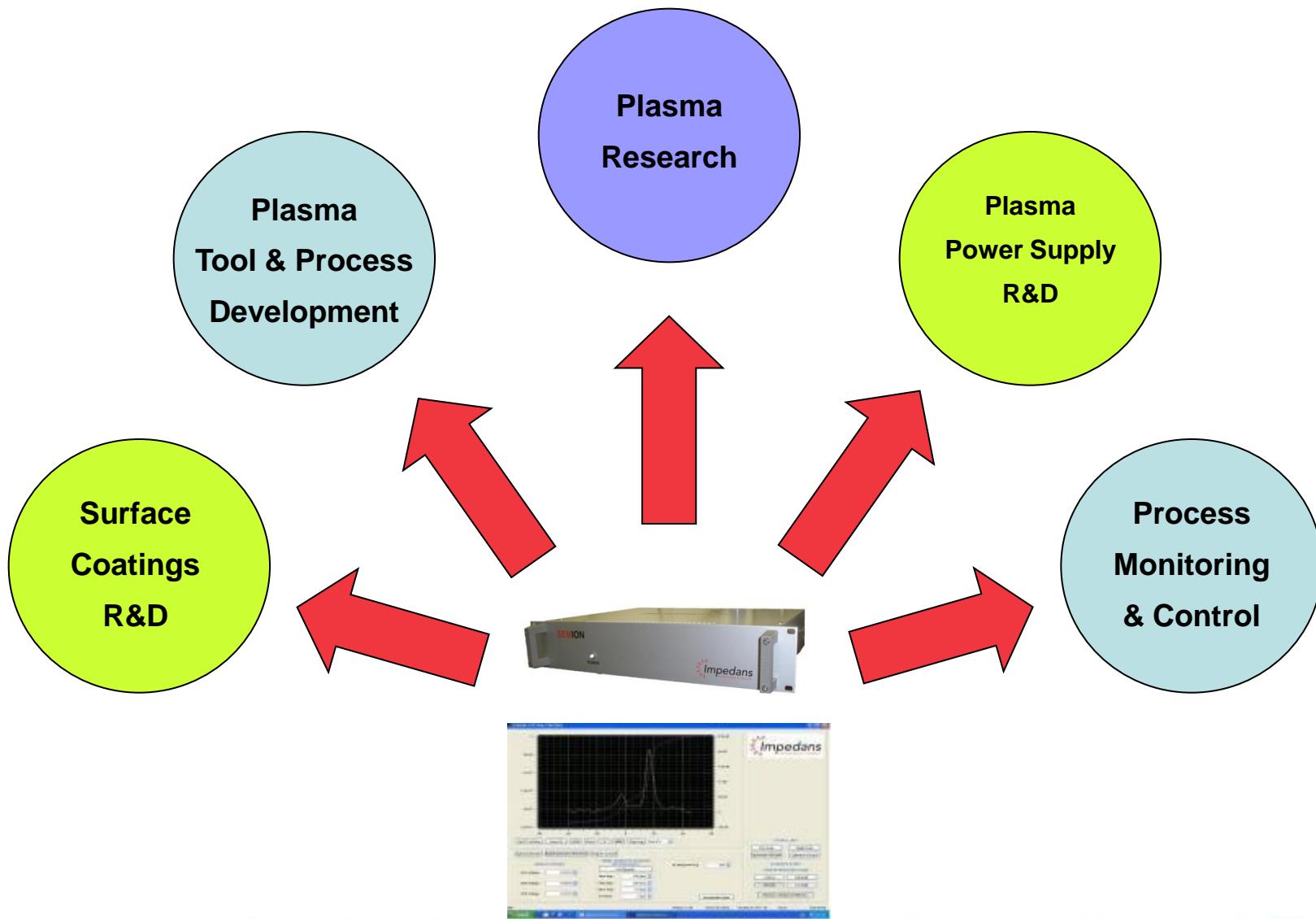


Semion – Ion Energy & Ion Flux measurement on the substrate surface

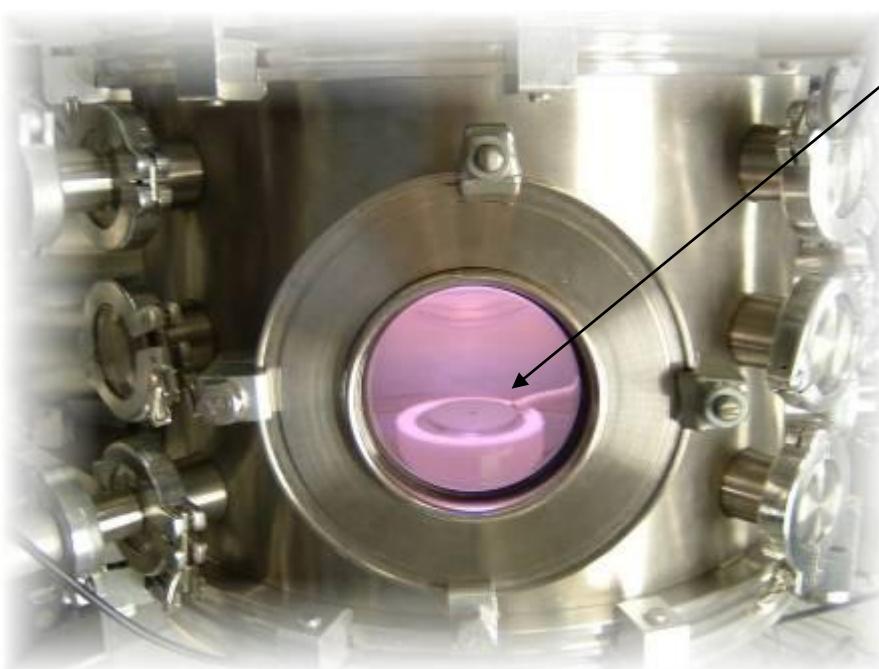


Ion etching /deposition





Plasma Diagnostics – Semion RFEA

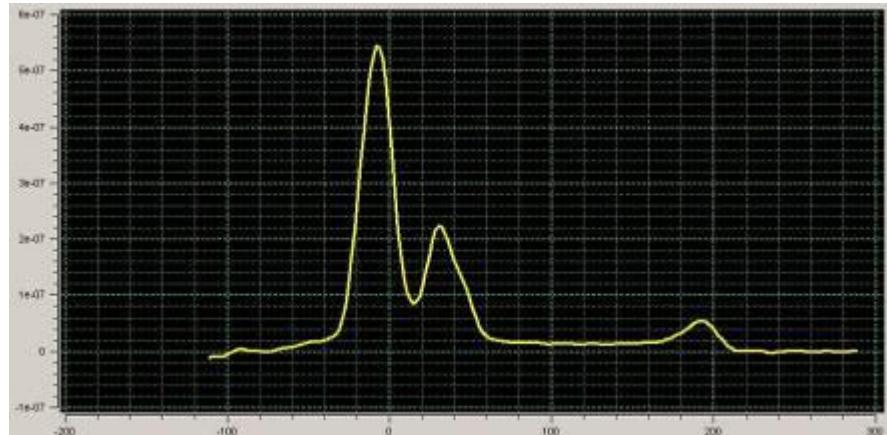


PLASMA PROCESS

The Semion System is a plasma diagnostic instrument which measures the ion energy and ion flux present at the substrate surface under grounded, self-bias, RF bias and Pulsed DC/RF bias conditions.

RFEA PROBE

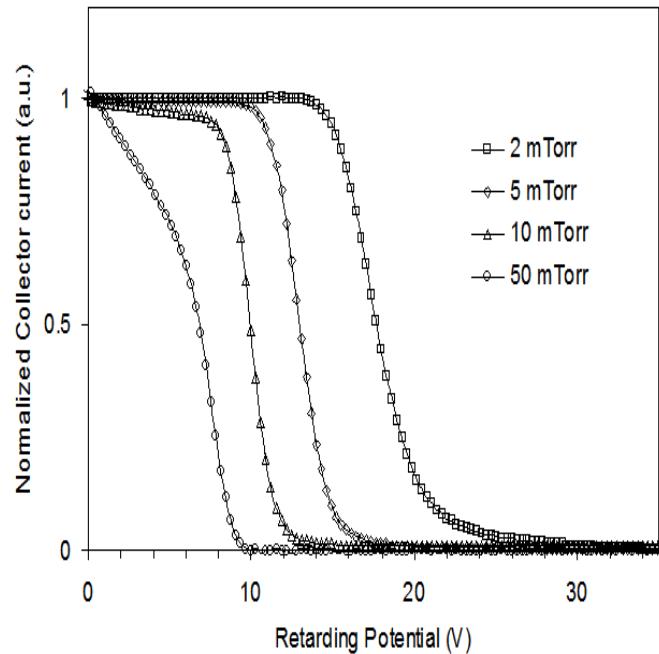
SEMIION™ SYSTEM



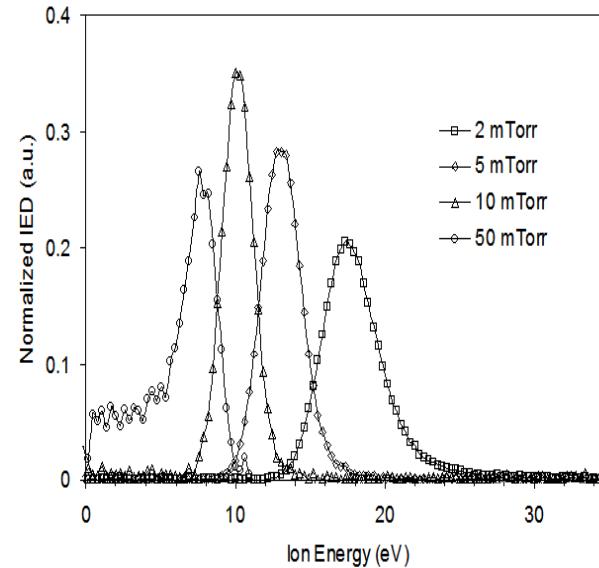
Ion Energy Distribution

Ion Energy Characteristic

RESULTS

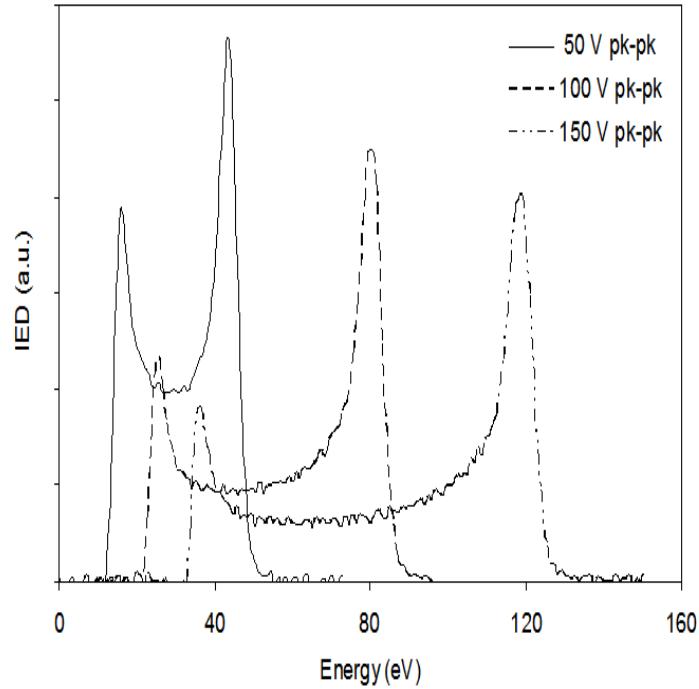


Current-voltage characteristics at various discharge pressures for the grounded electrode.

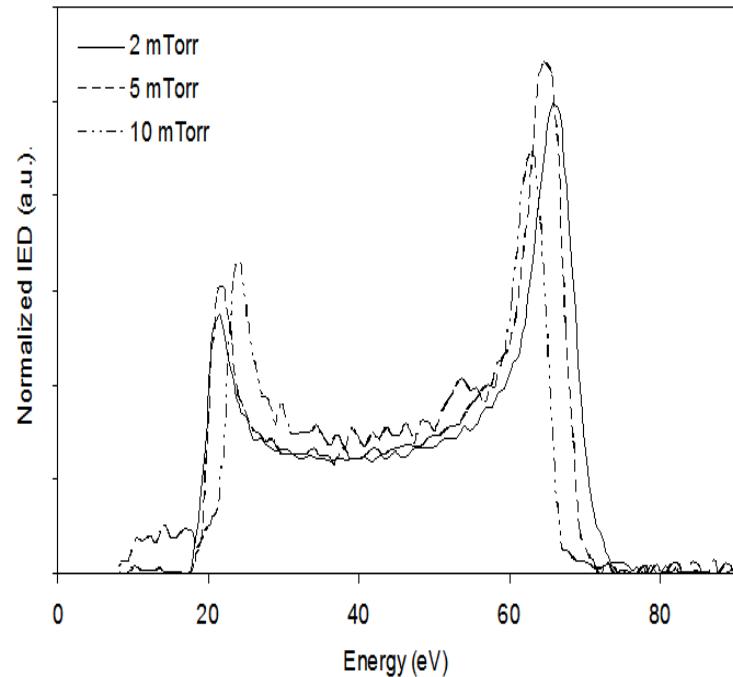


Ion energy distributions calculated from the current-voltage characteristics.

Ion Energy Distribution

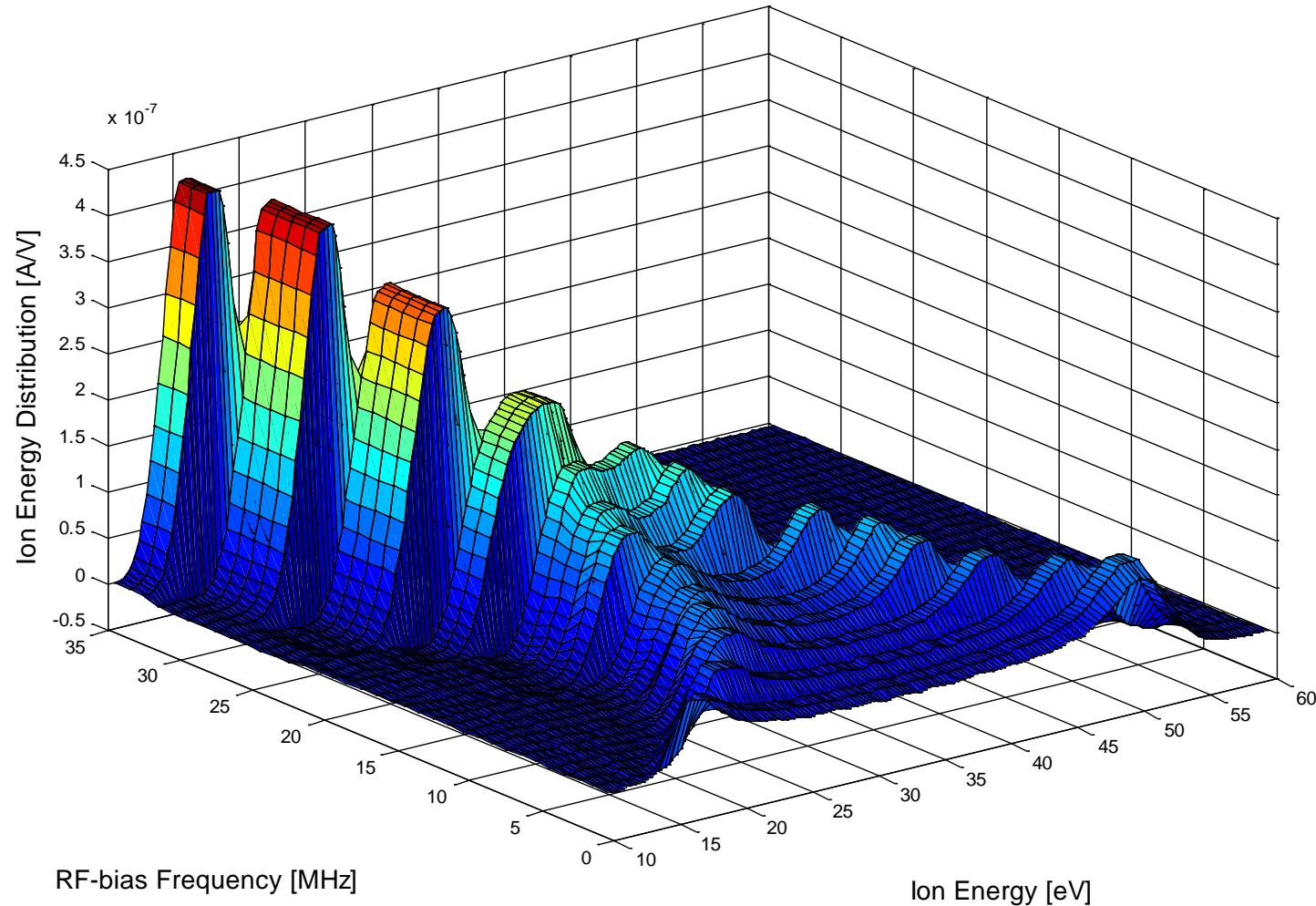


IED's with 2 MHz rf bias at various potentials. Discharge pressure was 2 mTorr.

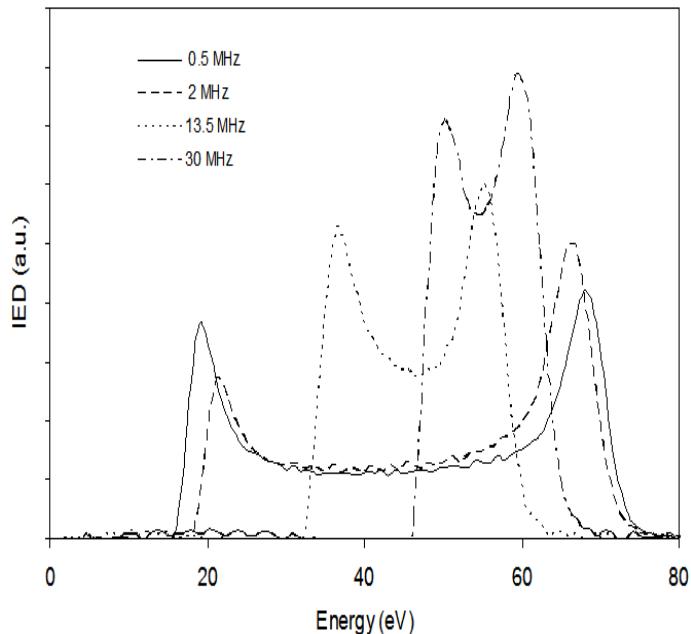


IED'S with 2 MHz bias at 80 V peak-to-peak for various discharge pressure.

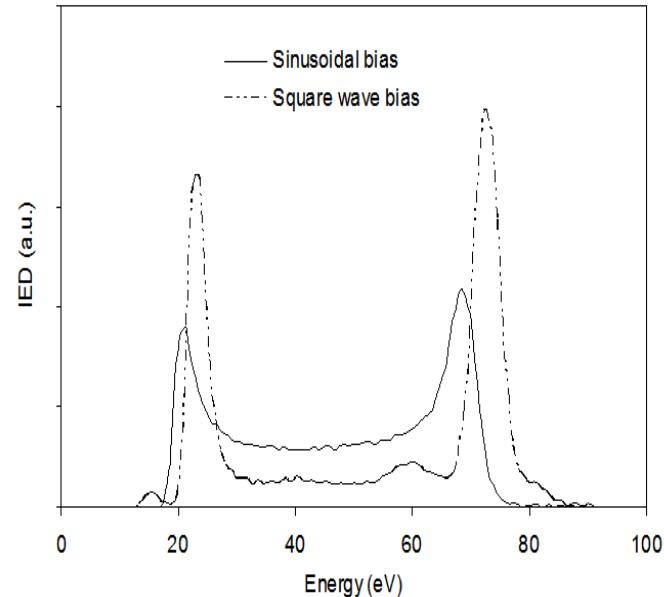
IEDs continued



Measurement Results contd.

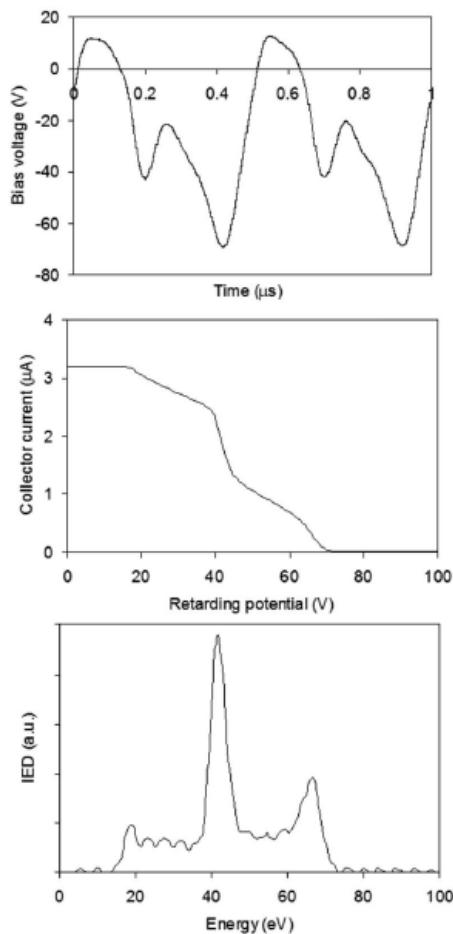


IED's for 80 V peak-to-peak bias for various frequencies. Discharge pressure was 2 mTorr.

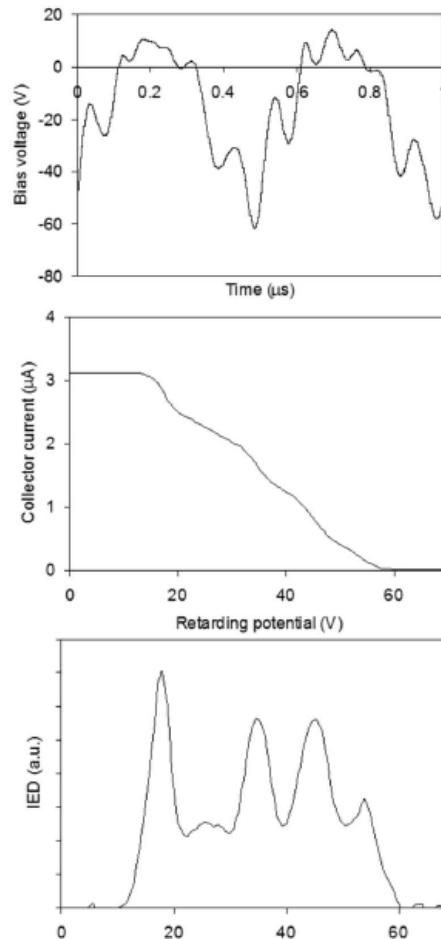


IED's for 500 kHz bias at 80 V peak-to-peak. Square and sinusoidal signals are compared.

Measurement Results contd.

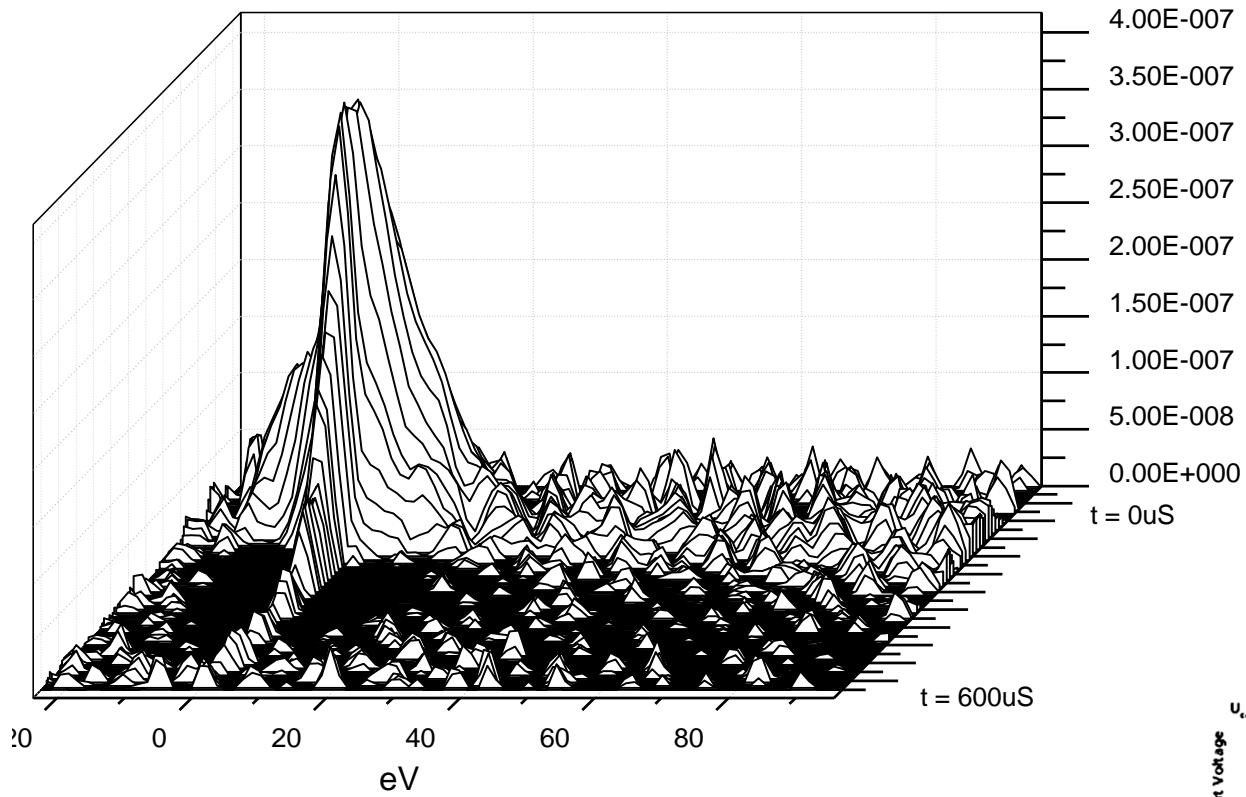


Bias waveform, current voltage characteristics, and IEDF for a dual-frequency biased electrode containing 2 & 4MHz components



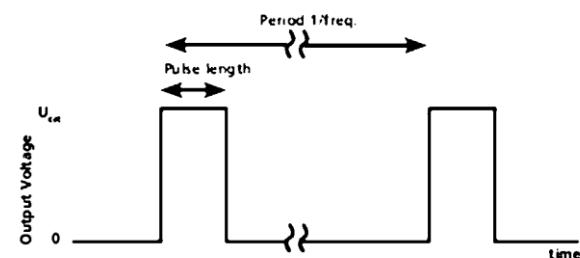
Bias waveform, current voltage characteristics, and IEDF for a dual-frequency biased electrode containing 2 & 10MHz components

Ion Flux as a function of time and energy through the pulse



Time Resolved
Measurements in a
HIPIMS PULSE Source

- Freq = 100Hz
- Power = 300W
- Pulse length 100us
- I = 28A
- Grounded electrode



Calibrating Flux with Langmuir Probe

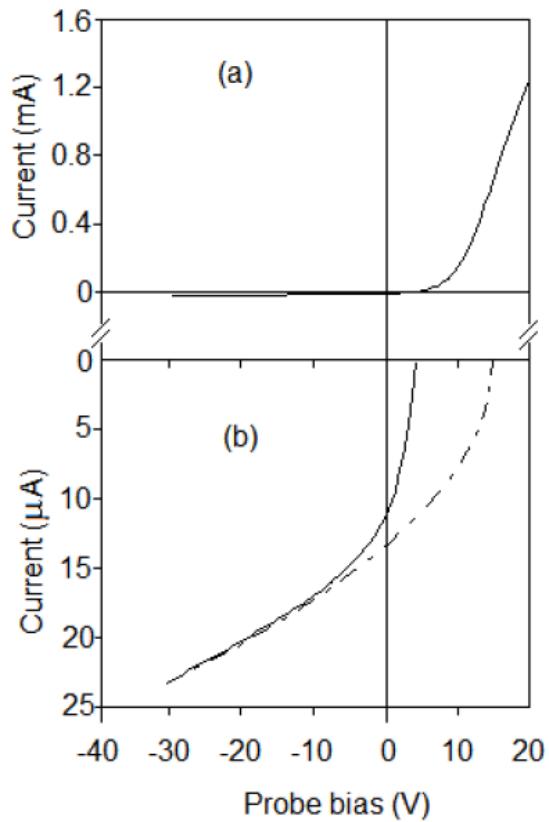


FIG. 4: Langmuir probe (solid line) characteristic (a) and the predicted ion current (dashed line) to the probe (b) taken at 2.25 mTorr.

Calibrating Ion Energy with Langmuir Probe

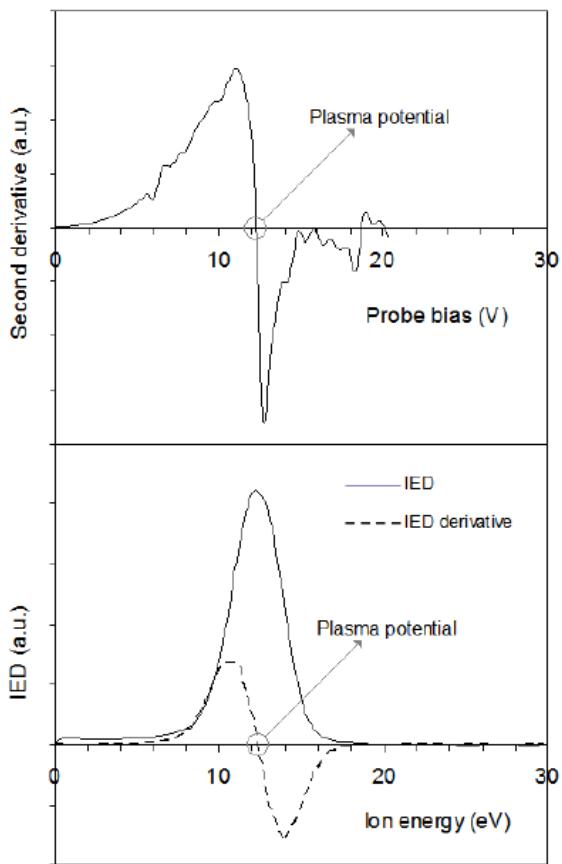


FIG. 3: Comparison of plasma potential measured using the Langmuir probe second derivative (12.44 V) and the IED from the RFEA (12.51 V).

Measuring EEDF with Langmuir Probe and RFEA(Semion)

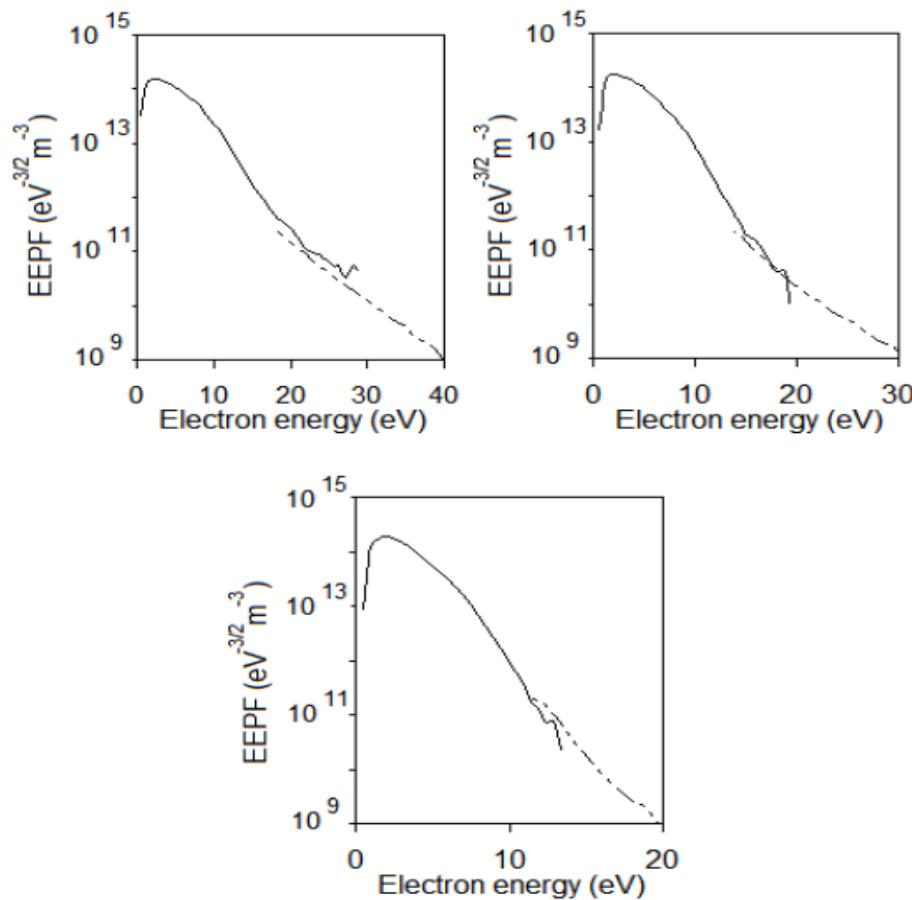


FIG. 6: EEPF's measured with Langmuir probe (solid line) and RFEA (dashed) at various pressures, top left 2.25 mTorr, top right 4.5 mTorr and bottom 7.5 mTorr.

Standard 70mm and 100mm (4") Aluminium RFEA Probe and holder

- Standard plasmas Ar, O₂ etc.
- Deposition Plasmas CH₄, Ti etc.



100mm (4") & 300mm (12") Anodized Aluminium RFEA Probe and holder

- Etch plasmas
- Compatible with various etch chemistries



Ceramic Coated RFEA Probe and holder

- Nickel only construction of RFEA Probe
- Etch plasmas
- Compatible with aggressive etch processes (SF₆, F₂, C₄F₈, HBr)



100mm, 4", Al₂O₃



300mm, 12", Al₂O₃

- Semion™ Control Unit provides scanning voltages to RFEA Probe and interfaces with Semion™ software



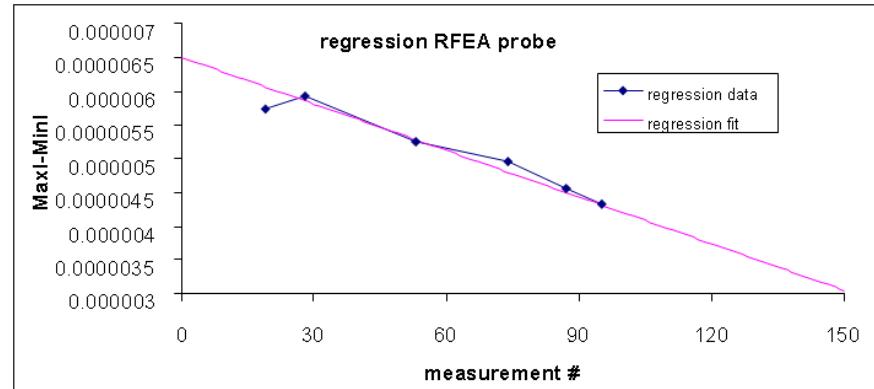
Semion™ Control Unit



Semion™ Feed-Through

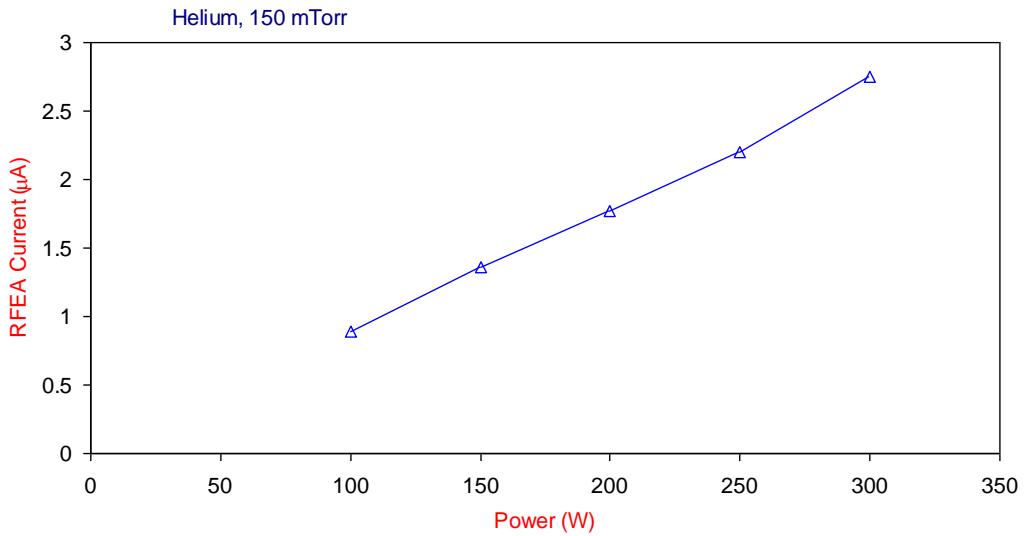
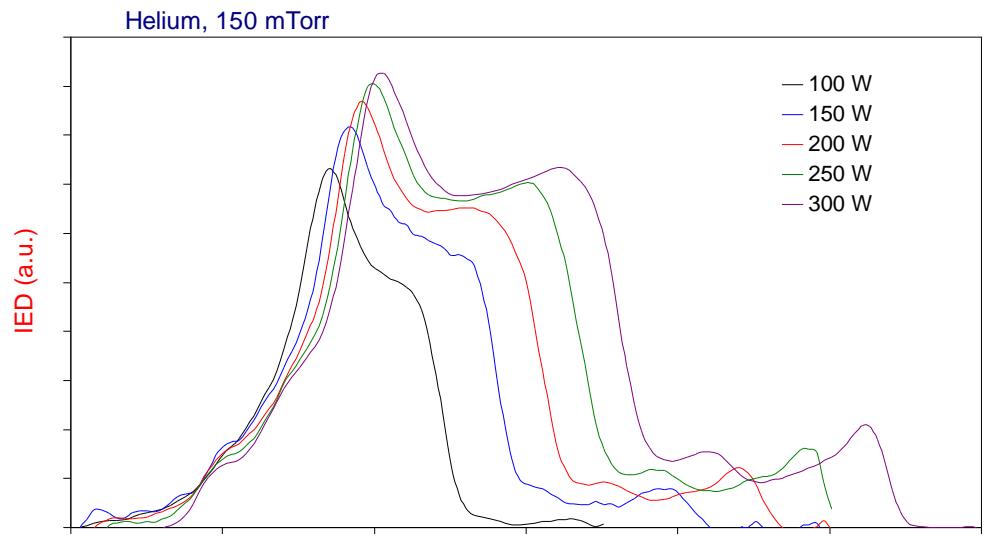
- Feed-through interfaces RFEA Probe to Semion Control Unit
- Mounted on KF40 chamber flange
- UHV vacuum compliant
- Compatible with a wide range of process chemistries and configurations
- Multiple installs worldwide (> 50 units)

- Following extended period of exposure to etching or deposition process, RFEA Probe replacement is required
- Customer Serviceable Button Probe™ facilitates probe replacement
- Insert new RFEA Probe and continue with measurements

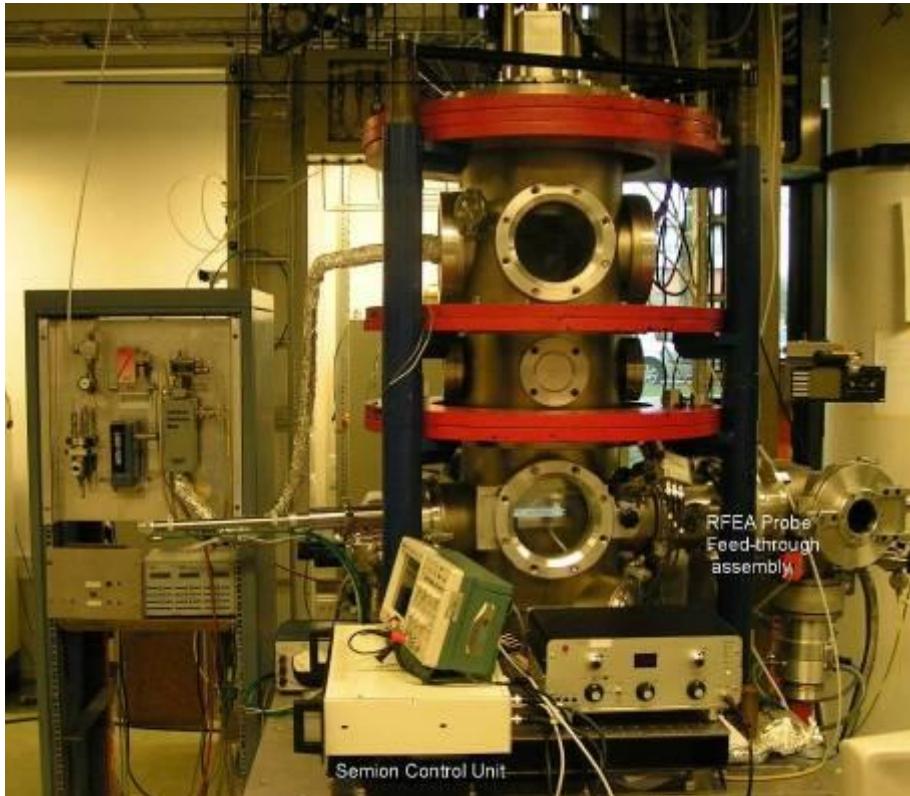


Case Study 1: LAM 4520 IEDF measurements

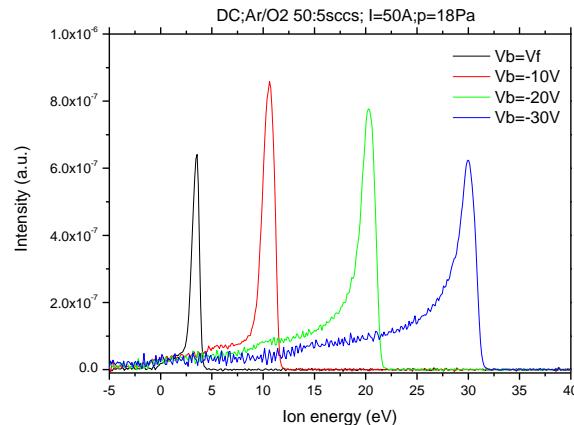
- Measurements performed on an LRC4520 Oxide Etcher
- Ion Energy Distribution Function measured at various source powers
- Ion current measured versus delivered power



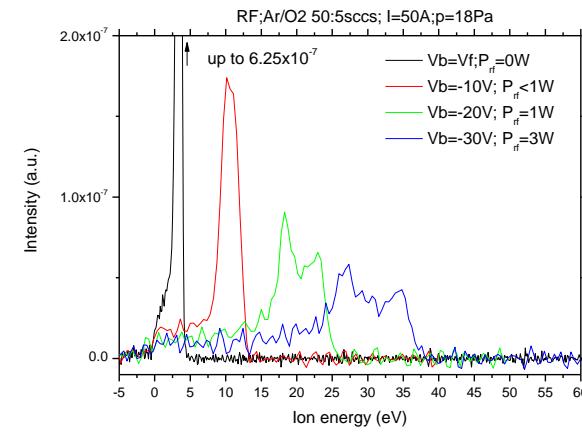
Case Study 2: ETP Chamber Plasma Diagnostics



Observation of the effect of DC and RF Bias on ion energies and ion flux impinging on substrate surface in an expanding thermal plasma



DC Bias



RF Bias

Summary

- The Semion™ system provides key process parameters to assist in the characterization and understanding of a wide range of plasma-based processes in both research and industrial environments
- Flexible and robust system provides insight into new and existing processes without chamber modifications
- Reduce the time and cost of product and process development
- Multiple system installations worldwide result in a broad range of applications knowledge and experience
- Semion™ technology roadmap aligned with needs of research and industry

- Introduce OCTIV IV sensor for RF biased electrodes
- Use of Octiv in pulsed plasma
- Use of Octiv to measure plasma parameters such as Ion Flux
- Standard Plasma Diagnostics not suitable to monitor plasma parameters in production tools – particularly deposition tools

Fixed Frequency VI Probe

Sensor based Fourier Analysis

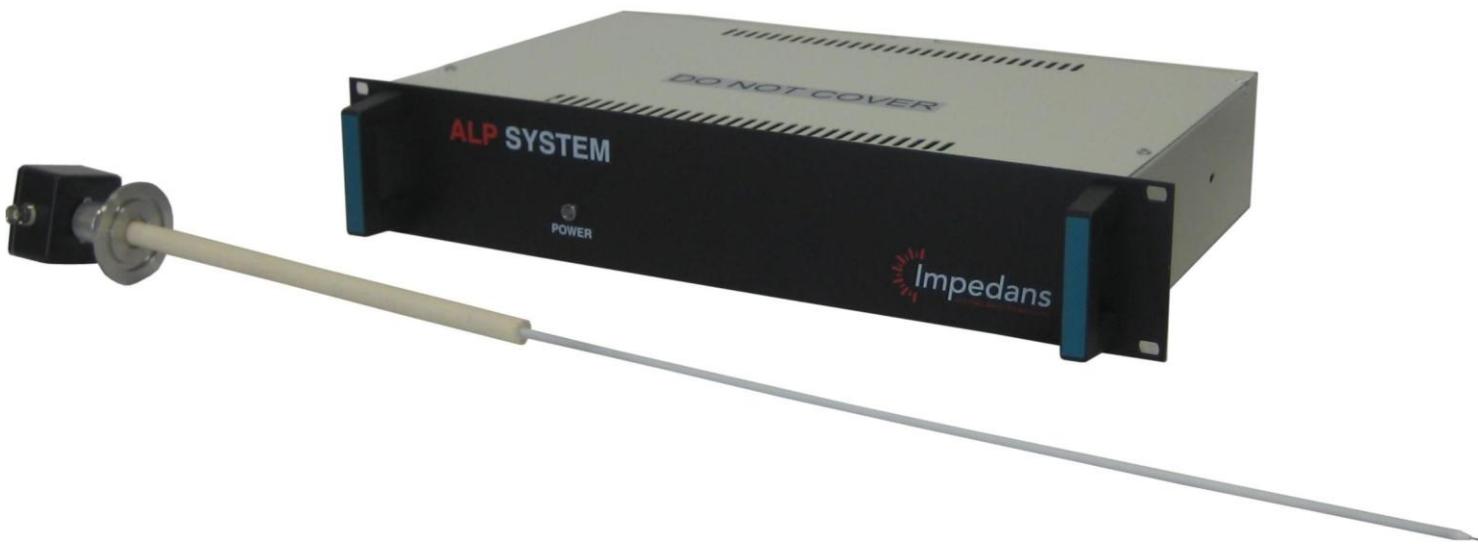
- Measure V, I, \emptyset , harmonics
- Complex Impedance
- Power (Fwd, Rev, Real)
- Time resolved mode for Pulsed RF Systems
- Monitor RF processes in realtime
- Post-match or Pre-match installation possible
- Measure Ion flux



ALP System™ Langmuir Probe



- Perform IV Scans in the range -125V to + 125V(@100mA average, 250mA pulsed)
- Measure Plasma Potential in range -100V to +145V
- Measure Plasma Density in range 10^{13} to 10^{18} m^{-3}
- Measure Electron Temperature in range 0.02 eV to 10eV
- Measure Ion current Density in range 1uA/cm² to 30mA/cm²
- Measure EEDF
- Time resolution 12.5ns with 500kHz rep rate



ALP System™ Specifications



Plasma Parameters		ALP System™ Control Unit	
Floating potential (Vf)	-145V to 145V	Probe Voltage Scan Range	-150V to +150V
Plasma potential (Vp)	-100V to 145V	Probe Current range	100pA to 150mA
Plasma density (Ne)	10^8 to 10^{12} cm $^{-3}$	Communication	USB 2.0
Ion Current Density (Ni)	1uA/cm 2 - 30mA/cm 2	Sampling rate	80 MSPS (V,I)
Electron temperature (kTe)	0.1 to 15eV	Data Acquisition Resolution	4.5mV 100pA
Electron energy distribution function (EEDF)	0-100eV	Time Resolved step resolution (boxcar mode)	12.5nS
Langmuir Probe		External Trigger	TTL compatible, 1MHz
DC, pulsed DC, Microwave plasma	Standard Probe	Application Software	
RF plasma	Broadband Probe 2MHz – 100MHz	Operating System	Windows 2000, XP, Vista, Windows 7
Length	300mm to 1.4m, other lengths on request	Automated Linear Drive System	
Diameter	2mm to 5mm	Stroke	300mm, 600mm, 900mm, 1.4m, on request
Customisation	45° bend, 90° bend, multiple bend	Maximum speed	25mm/sec.
Max. operating temperature:	230°C without cooling	Step resolution	0.025mm
		Bakeout Temperature	230° C.
		Vacuum	Leak Rate better than 1×10^{-10} mbar.l.sec $^{-1}$

- Comparison of plasma parameters determined with a Langmuir probe and with a retarding field energy analyzer D Gahan et al 2008 *Plasma Sources Sci. Technol.*
- Ion energy distributions at a capacitively and directly coupled electrode immersed in a plasma generated by a remote source C Hayden, D Gahan and M B Hopkins 2009 *Plasma Sources Sci. Technol.* 18 025018 (11pp)
- Abstract: [http://www.iop.org/EJ/abstract/-
alert=33330/0963-0252/18/2/025018](http://www.iop.org/EJ/abstract/-alert=33330/0963-0252/18/2/025018)

Further Information



- Company:

<http://www.impedans.com/about-us.html>

- Products:

<http://www.impedans.com/products.html>

- Publications:

<http://www.impedans.com/publications.html>

- References: On Request