Semion RFEA System

Measure the Ion Flux and Ion Energy incident on your substrate

https://www.impedans.com/semion_sensors

The Semion RFEA System

Suitable for DC, CW RF biasing & pulsed RF biasing (sensor deployed on the grounded pedestal)

Parameters Measured:

- ✓ Ion energy distribution function (IEDF)
- ✓ Number of sensors: 1 – 13
- ✓ Average energy & ion flux
- ✓ Vdc

Specification

- ✓ 4 grid RFEA
- ✓ 2keV ion energy range
- ✓ Apply up to 1kV pk-pk RF bias
- ✓ RF frequencies 100 kHz to 80 MHz
- ✓ Available in anodized aluminum, bare aluminum, stainless steel, ceramic
- ✓ Easily replaceable button probes

Button Sensors Available

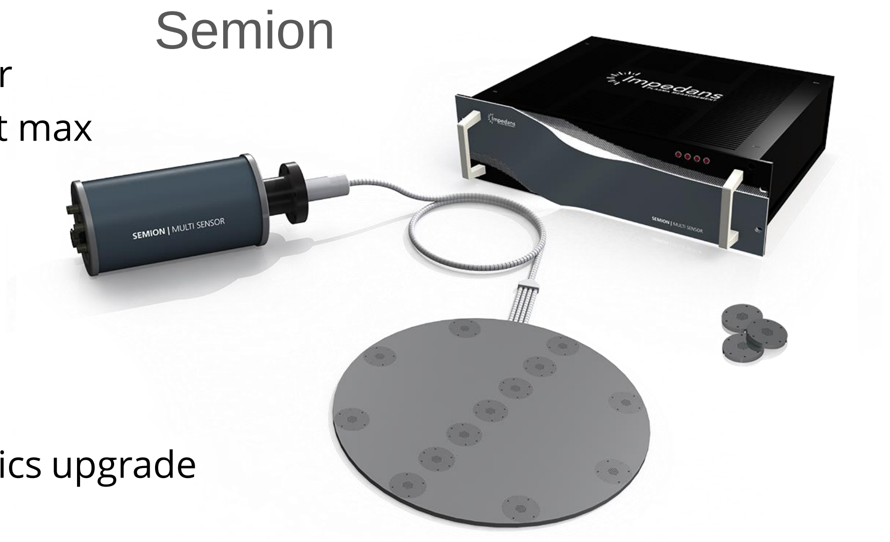
- ✓ Low density 0.001 to 3 A/m2
- ✓ Standard 0.01 to 50 A/m2
- ✓ High density 0.1 to 700 A/m2

NEW: High Pressure Buttons

- ✓ HP button extends range to 1.5 Torr
- ✓ Limited to 150 eV scanning range at max pressure in Argon

NEW: High Voltage Semion

- ✓ Extends ion range to 3 keV
- ✓ 1.5 kV RF Bias
- ✓ Requires feedthrough and electronics upgrade



Advantages of the Impedans Semion RFEA:

- ✓ Integrate up to 13 sensors into a single wafer for uniformity measurements
- ✓ Various shaped and sized wafers to suit the tool
- ✓ Over 100 publications using this hardware, trusted by universities and industry alike: impedans.com/semion-applications

Key Features

Various Holder Designs

Holders of different shapes and sizes available upon request

Compatible with majority of Biasing Conditions

Suitable for Grounded, Floating and RF Biased conditions

Material Finishes

Sensor elements and holders available in anodized aluminium, bare alumium, stainless-steel or ceramic

Replacable Sensor Elements

Can change the sensor elements to account for different plasma densities

Portable for use in many chambers

Standard vacuum flanges available, different holder form factors for any substrate shape

In-situ measurements of uniformity

Ion energy and ion flux contour maps produced in real time in the software

Data for industry and R&D

Provides data for plasma-substrate interaction for tool characterization and to quickly identify process issues

Advanced software

Fully automated software analysis of the IEDF and automatica DC bias potential measurement.

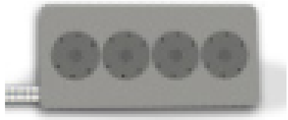
Technical Specifications

Parameters Measured	Range
Ion Energy Range	0 to 2000 eV (Standard/Low/High Density Buttons) 0 to 150 eV (High Pressure Button)
Ion Flux	0.001 to 700 $A\,m^{-2}$ (Dependent upon button)
Pressure Range	$\leq$ 300 mTorr (Standard/Low/High Density buttons) $\leq$ 1.5 Torr (High Pressure Button)
IEDF Resolution	± 1 eV nominal
Max RF Bias voltage (applied to probe)	1 kV (peak to peak)
Max DC Bias Voltage	-1940 V
Bias Frequency Range	100 kHz to 80 MHz
Sync Frequency Range	4 Hz to 100 kHz
Time Resolution	1 μs

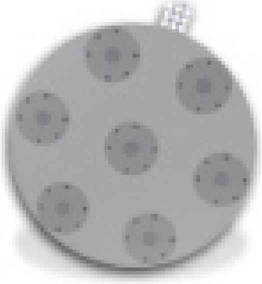
✓ For more detailed specifications and different models available, visit https://www.impedans.com/semion_sensors

✓ To see if the RFEA is suitable for your plasma application, see the applications list at impedans.com/semion-applications

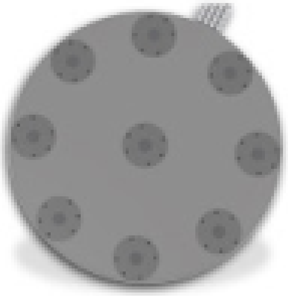
✓ To arrange a technical discussion, contact support@impedans.com



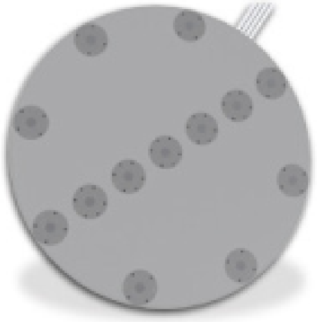
150x70mm



150mm



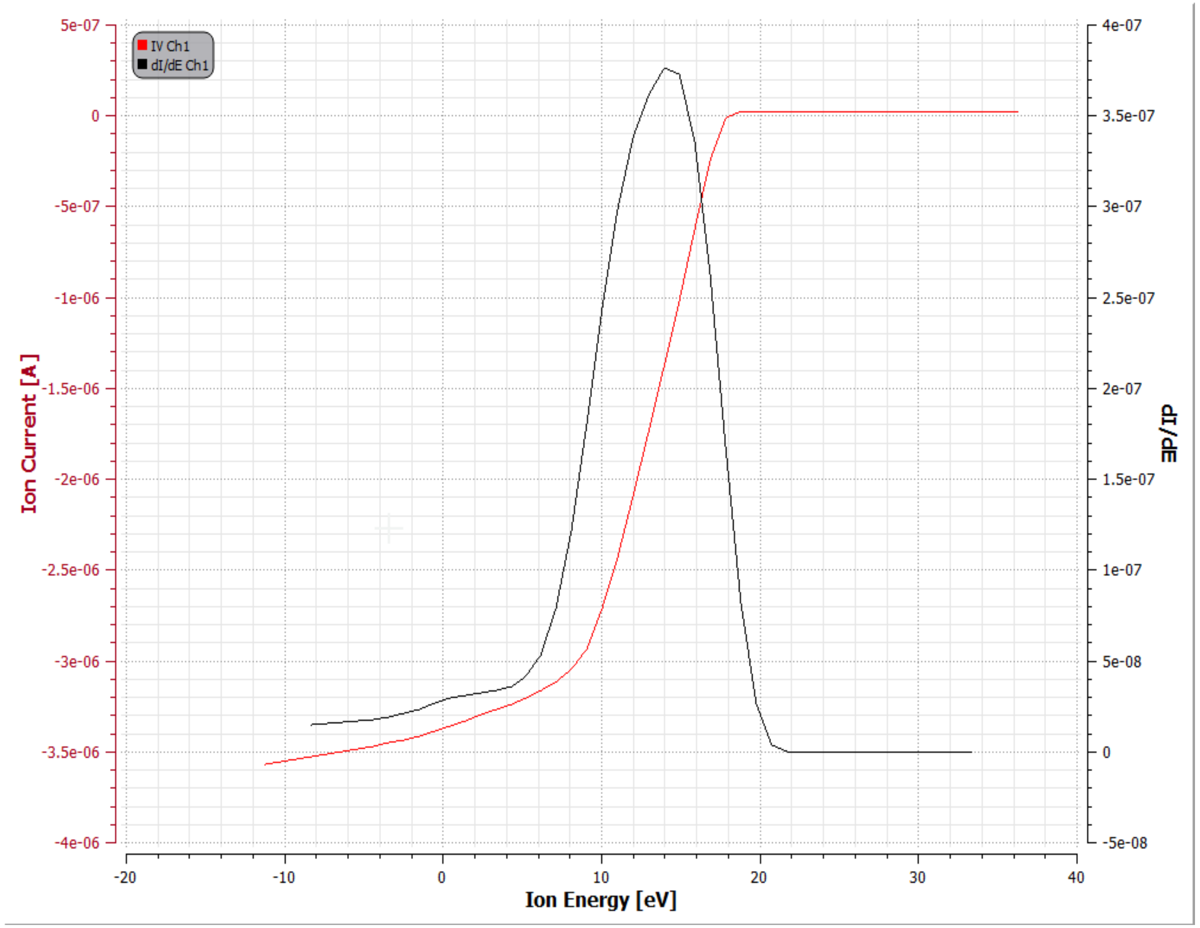
200mm



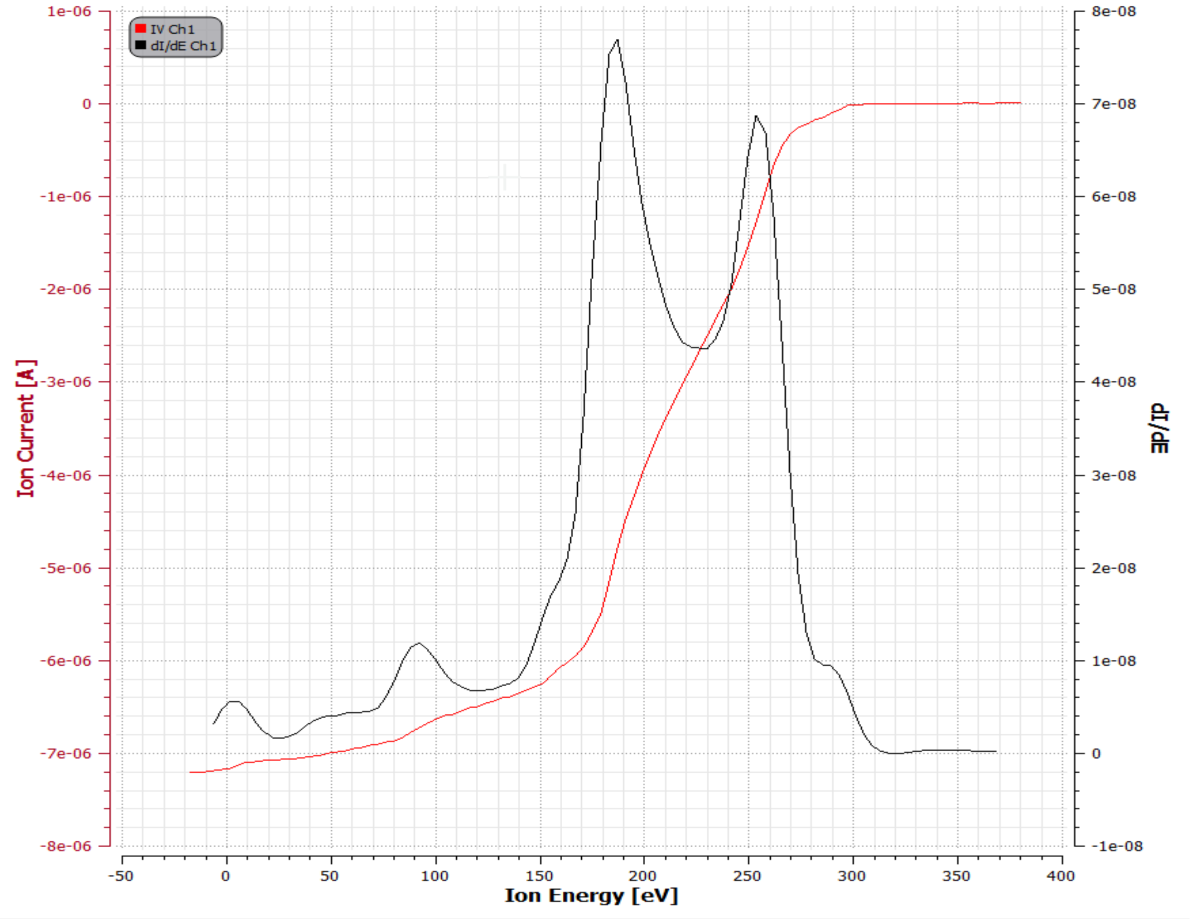
300mm

450mm

Example Data: IV curve and IEDF Curve

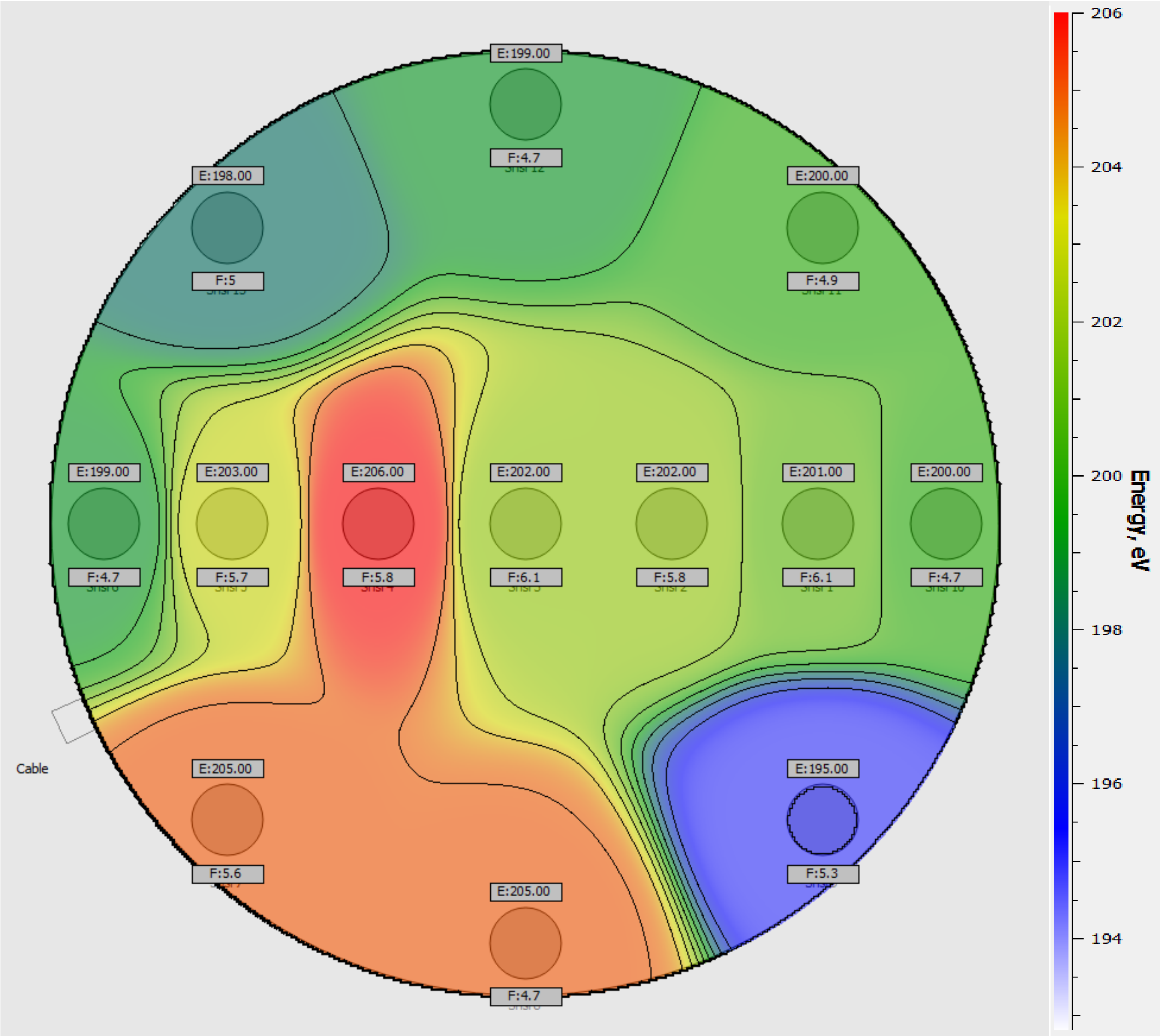


Grounded IEDF

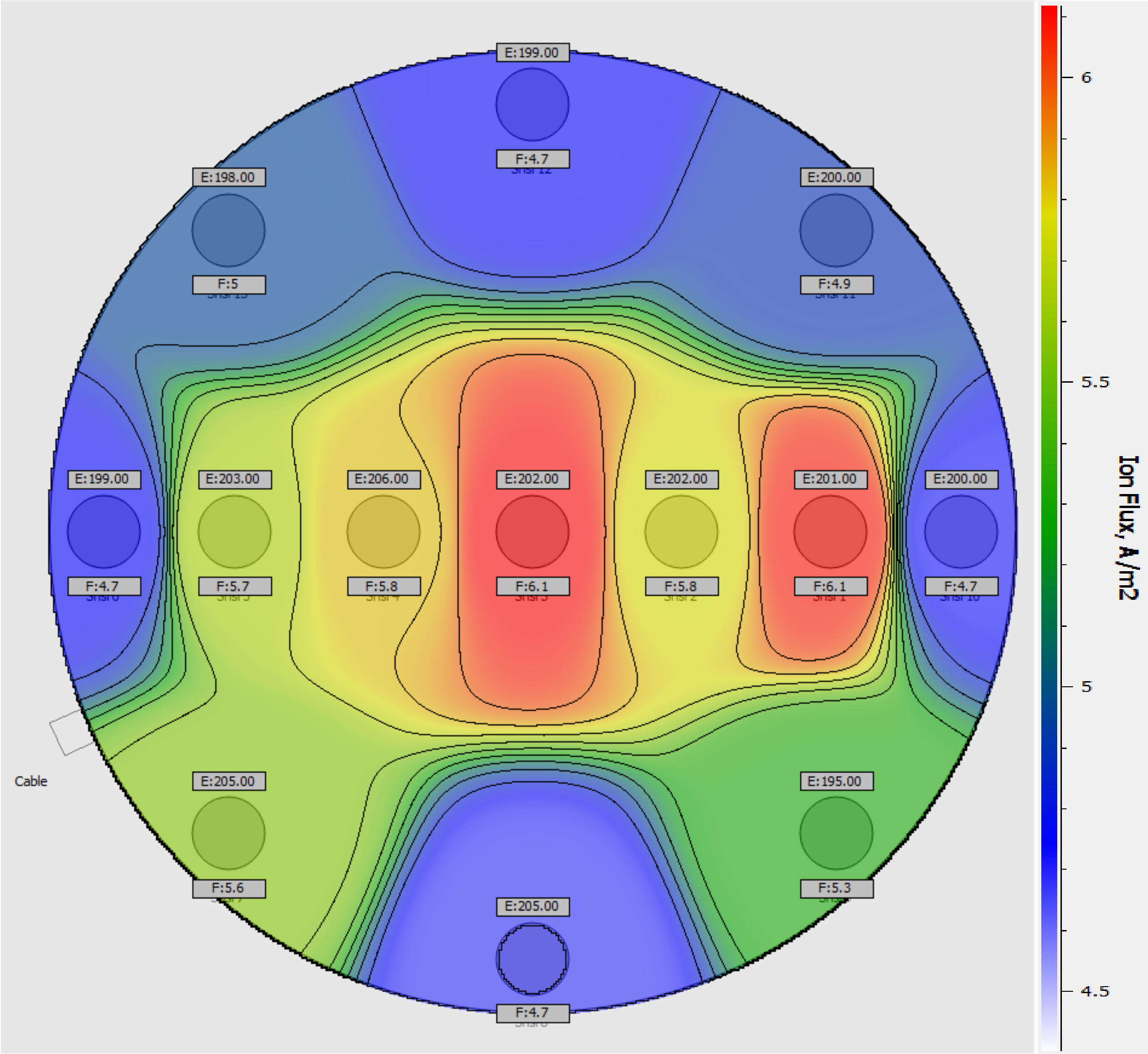


RF Biased IEDF

Example Data: Ion Energy Contour Map



Example Data: Ion Flux Contour Map



Semion Applications

Measurement of the IEDF for various driving frequencies

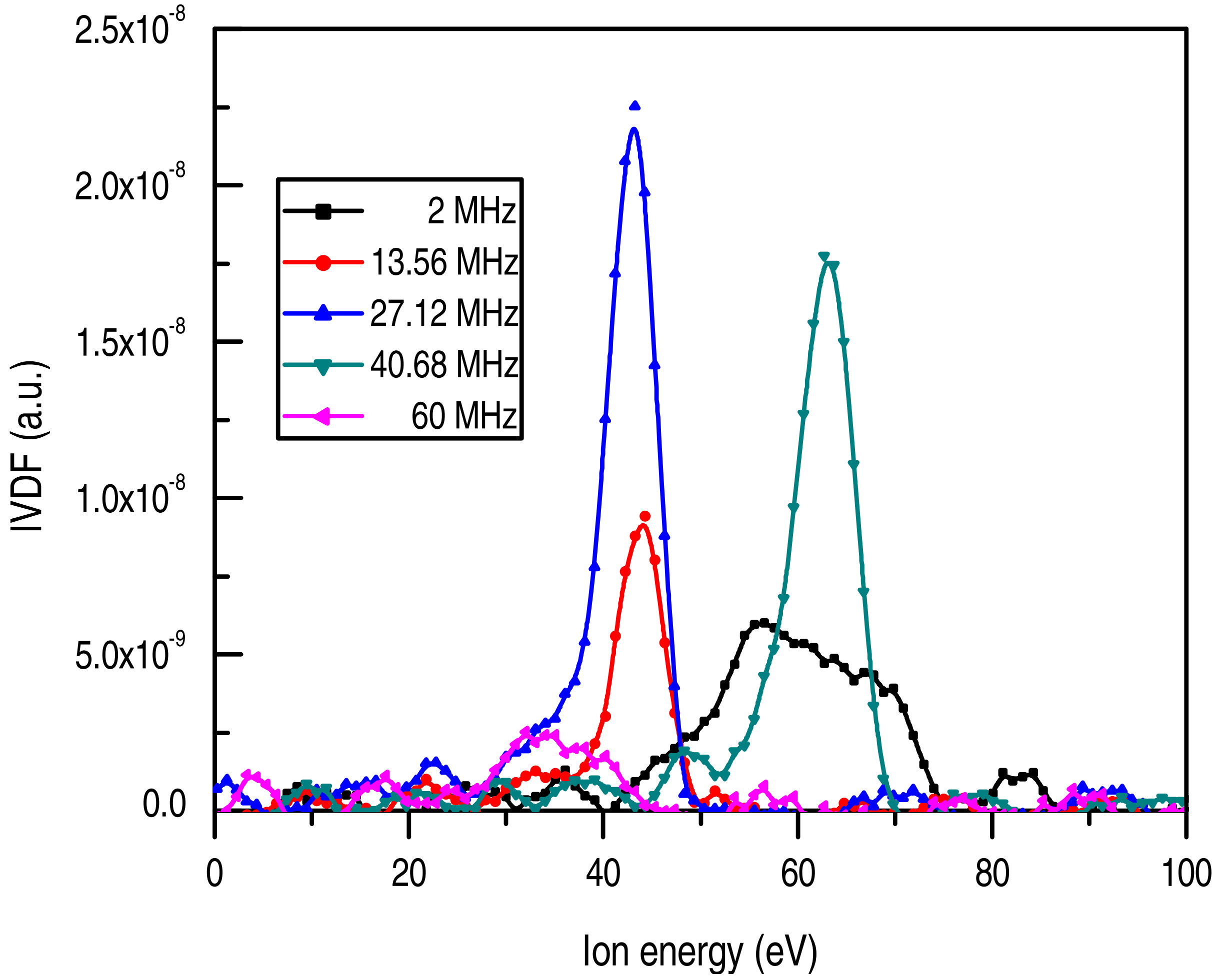
The effect of driving frequency on the IVDF in a magnetron sputtering system

DOI: 10.1088/2058-6272/aa6619

The objective of this paper was investigate the effects that the driving frequency of the source (from 2 MHz to 60 MHz) had on the IEDF.

Some example data is shown to the right

https://impedans.com/semion-rfea-application-note-se16



Examples of the IEDF for driving frequencies ranging from 2 to 60 MHz

IEDF Measurement in an AMAT AdvantEdge DPS etch tool

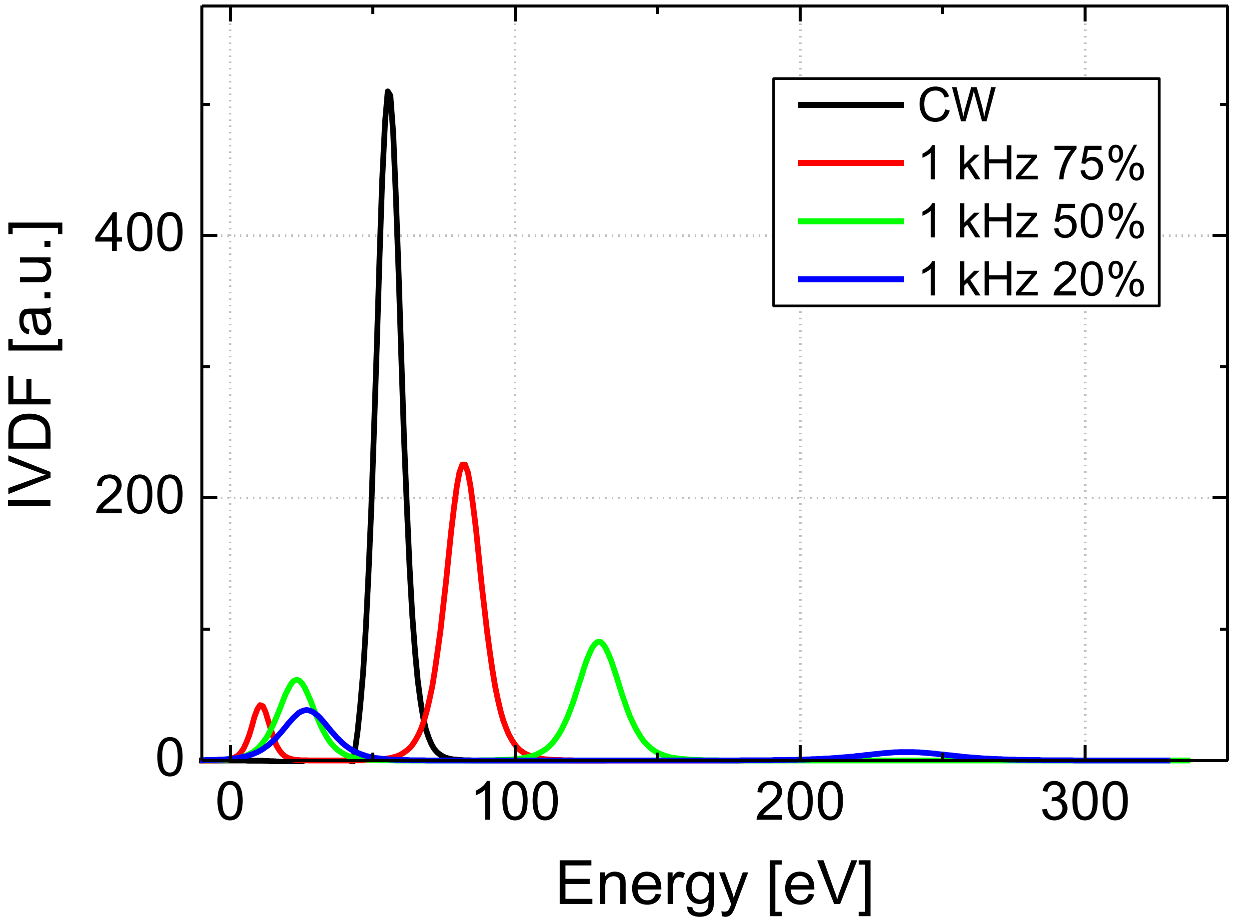
Silicon etching in a pulsed HBr/O2 plasma. 1. Ion flux and energy analysis.

DOI: 10.1116/1.4917230

The objective is to investigate the effects of the gas composition (not shown here) and the effect of different duty cycles when pulsing the source on the IEDF and therefore the Ion flux and Energy

Some example data is shown to the right

https://impedans.com/semion-application-note-se14



Example of the effect of pulsing the source on the Ion Energy Distribution function (IEDF) in a HBr plasma.

Semion Theory

Semion RFEA Structure

All grids are made of nickel with a 20 x 20 μm square apertures

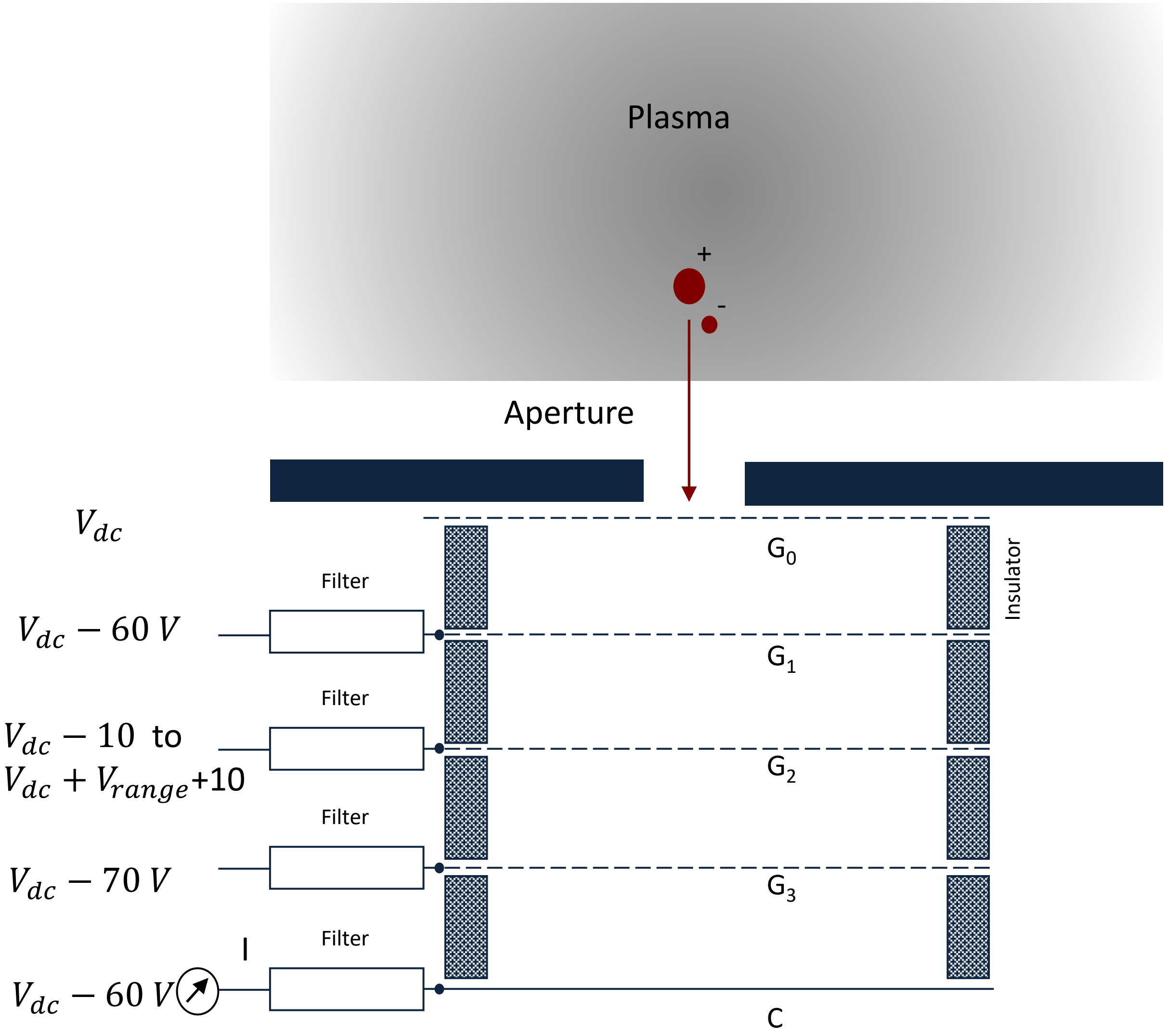
G_0 is designed to reduce the diameter of the sampling orifice to less than the Debye length in order to prevent plasma formation within the RFEA. The grid, which is connected to the body of the sensor (and therefore the electrode), will be biased (V_{dc}) according to the condition of the electrode (Grounded, Floating, RF Biased).

G_1 acts a an electron repulsion grid. This is designed to repel electrons from the plasma that enter into the sensor as they can distort the IED being measured.

G_2 acts as the discriminator of the ions based on their energy. As the voltage is swept from V_{dc} to $V_{dc} + V_{range}$ fewer ions are able to pass through the electric potential causing the current to change.

G_3 acts as a secondary electron suppression grid. It is negatively biased with respect to the collector ($C - 10\ V$ typically) to create a retarding potential for secondary electrons that can be emitted from the surface of the collector due to energetic ion impact.

C is the collector electrode to which a negative bias is applied to attract the ions for detection.



Semion RFEA Equations

Ion Energy Distribution Function (IEDF) Calculation:

$$f(x_i) = \frac{y_i - y_{i-1}}{x_i - x_{i-1}} \qquad \mathrm{n} = 1 \qquad (1)$$

$$f(x_i) = \frac{\sum_{j=1}^{n} y_{i+j} - \sum_{j=1}^{n} y_{i-j}}{\sum_{j=1}^{n} x_{i+j} - \sum_{j=1}^{n} x_{i-j}} \qquad n \geq 2$$

x and y representing the voltage and current values respectively

Ion Flux:

$$J_i = \frac{0.5\, f(x_i)}{Area\, *\, Transmission} \qquad (2)$$

Average Energy:

$$E_i = \frac{\int_{E_{min}}^{E_{max}} E\, f(E) dE}{\int_{E_{min}}^{E_{max}} f(E) dE} \qquad (3)$$

Impedans
PLASMA MEASUREMENT

Sheath Width:

$$\bar{s} = \frac{2}{3}\left(\frac{2e}{M_i}\right)^{\frac{1}{4}} \left(\frac{\varepsilon_0}{\bar{J_i}}\right)^{\frac{1}{2}} \bar{V_s}^{\frac{3}{4}} \qquad (4)$$

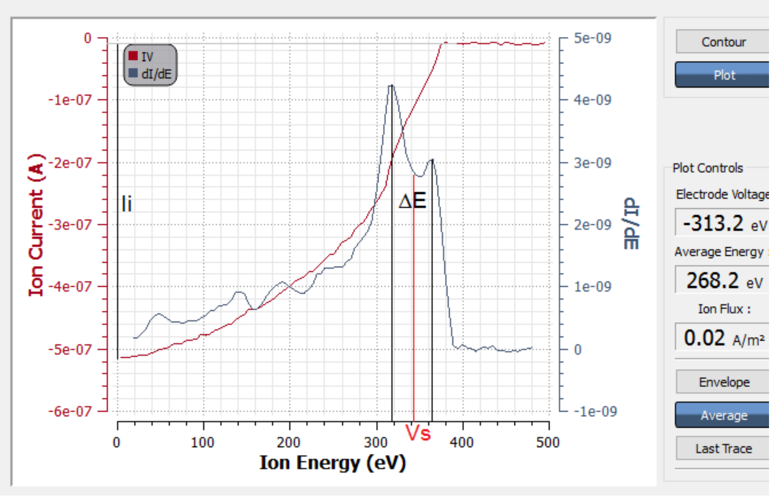
$\bar{V_s}$ is the DC sheath voltage

Ion Transit Time:

$$\tau_i = 3\, \bar{s} \sqrt{\frac{M}{2\, e\, \hat{V_s}}} \qquad (5)$$

Peak Separation:

$$\Delta E = \frac{2eV_{pp}}{\pi} \left(\frac{\tau_{RF}}{\tau_i}\right) \qquad (6)$$



Electrode Voltage
-313.2 eV
Average Energy
268.2 eV
Ion Flux :
0.02 A/m²

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