Semion Dual Frequency Applications

Measure the Ion Flux and Ion Energy incident on your substrate

https://www.impedans.com/semion_sensors

Impedans
PLASMA MEASUREMENT

Impact of focus ring design on plasma conditions at the wafer edge

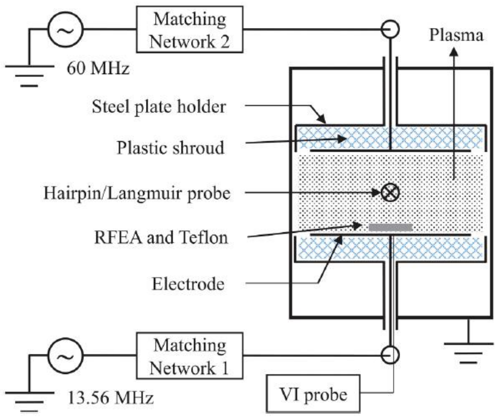
Focus ring geometry influence on wafer edge voltage distribution for plasma Processes

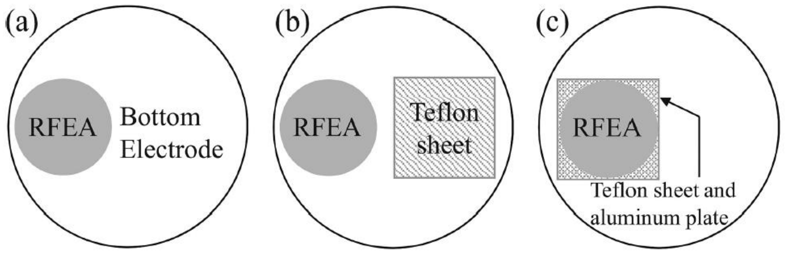
DOI: https://doi.org/10.1116/6.0000981

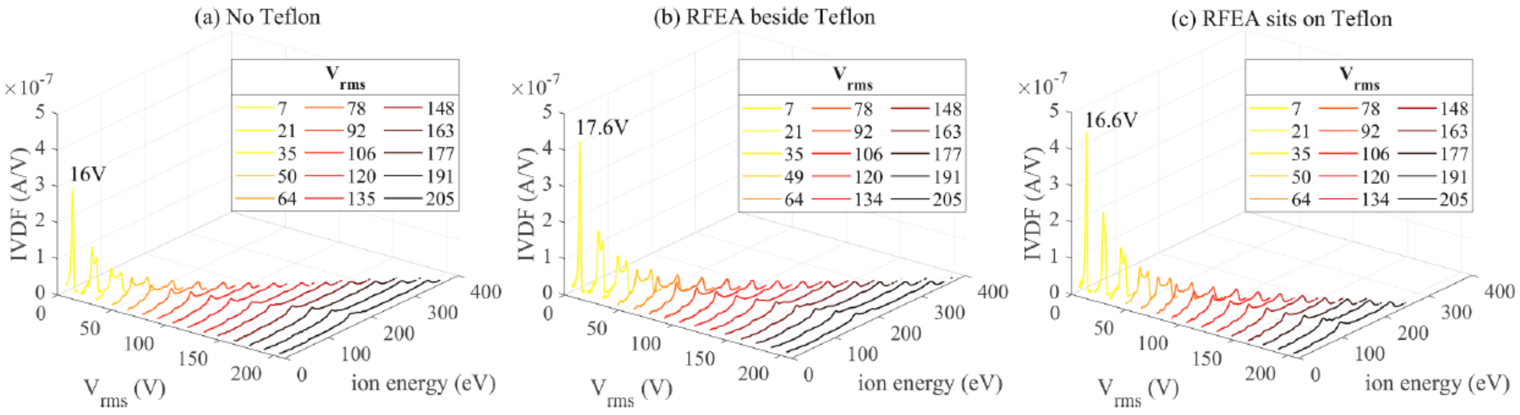
Terminating structures at the wafer edge such as focus rings are used to improve uniformity and minimize costly edge exclusion. In this work, a one-dimension circuit model with focus rings was developed.

The simulations were compared to experimental results measured using hairpin probe, VI probe, and a retarding field energy analyzer (Impedans RFEA).

Some example data is shown to the right

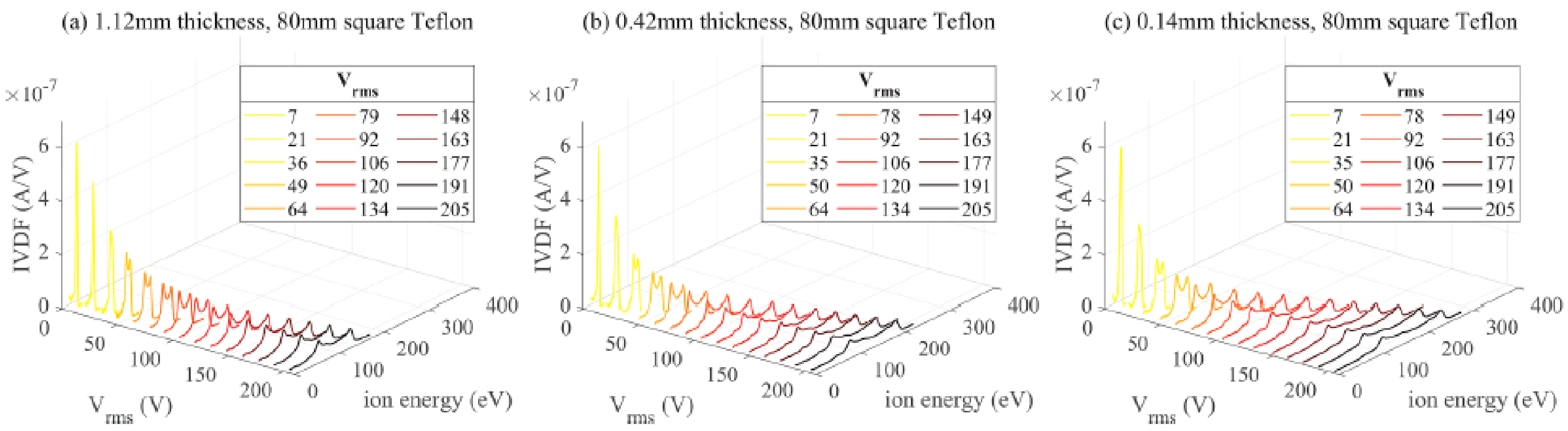




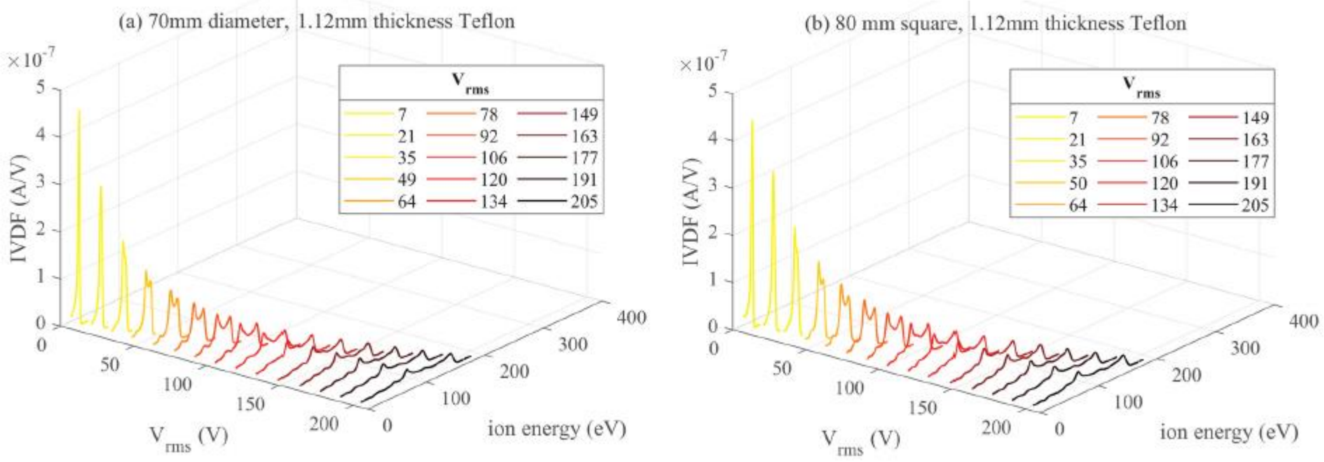


Example of measured IVDF for the three setups for RFEA: (a) without Teflon, (b) placed alongside Teflon, and (c) sitting on Teflon in 20 mTorr argon. The root mean square voltage of RF power (V_{rms}) varies from 7 to 205 V for all setups.

Impact of focus ring design on plasma conditions at the wafer edge



Thickness effects. (a) 1.12 mm thickness Teflon sheet. (b) 0.42 mm thickness sheet. (c) 0.14 mm thickness sheet. All Teflon sheets have same area but different thickness [20 mTorr argon].



Area effects. (a) 70 mm diameter Teflon sheet. (b) 80 mm square Teflon sheet [20 mTorr argon].

Impedans PLASMA MEASUREMENT

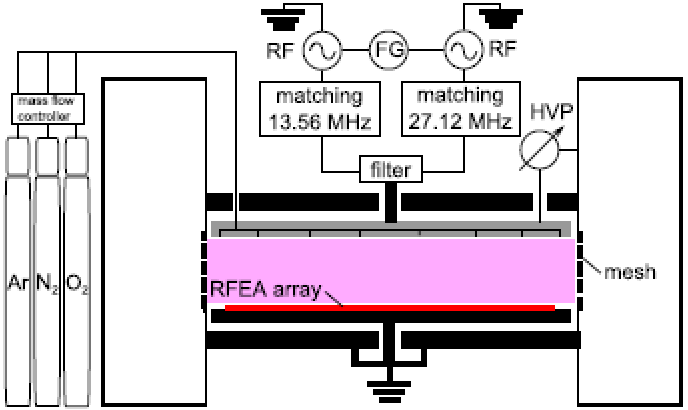
Calibration routine for an array of retarding field energy analyzer sensors

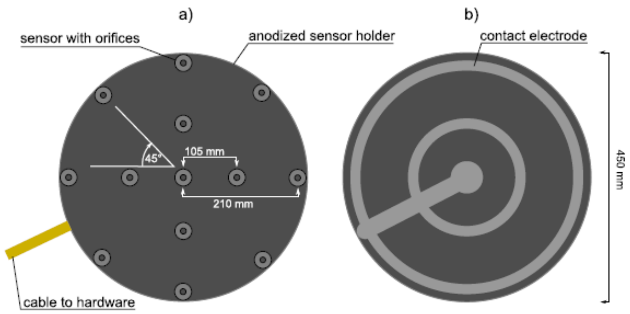
Relative calibration of a retarding field energy analyzer sensor array for spatially resolved measurements of the ion flux and ion energy in low temperature plasmas

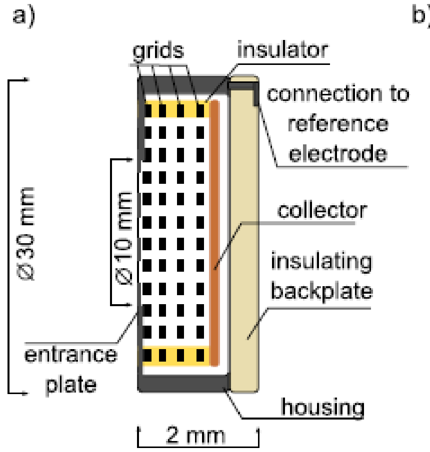
DOI: https://doi.org/10.1063/5.0059658

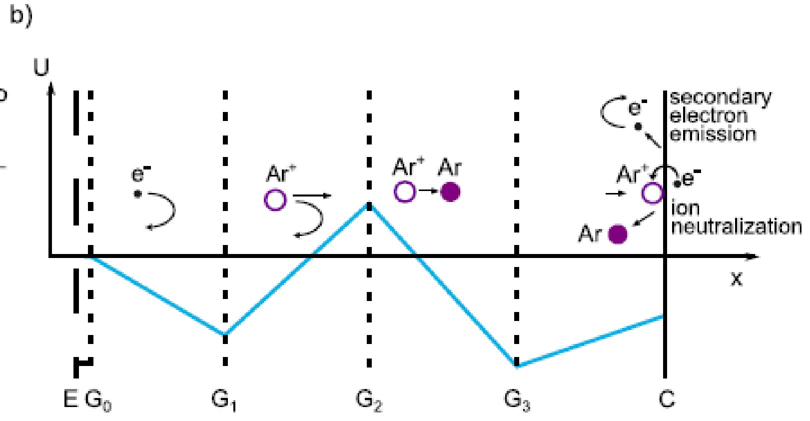
This work presents a calibration procedure, tested by exposing an RFEA array to a large-area capacitively coupled argon plasma driven by two frequencies (13.56 and 27.12 MHz) at a gas pressure of 0.5 Pa. Up to 12 sensors are calibrated with respect to the 13th sensor, called the global reference sensor, by systematically varying the sensor positions across the array.

Some example data is shown to the right



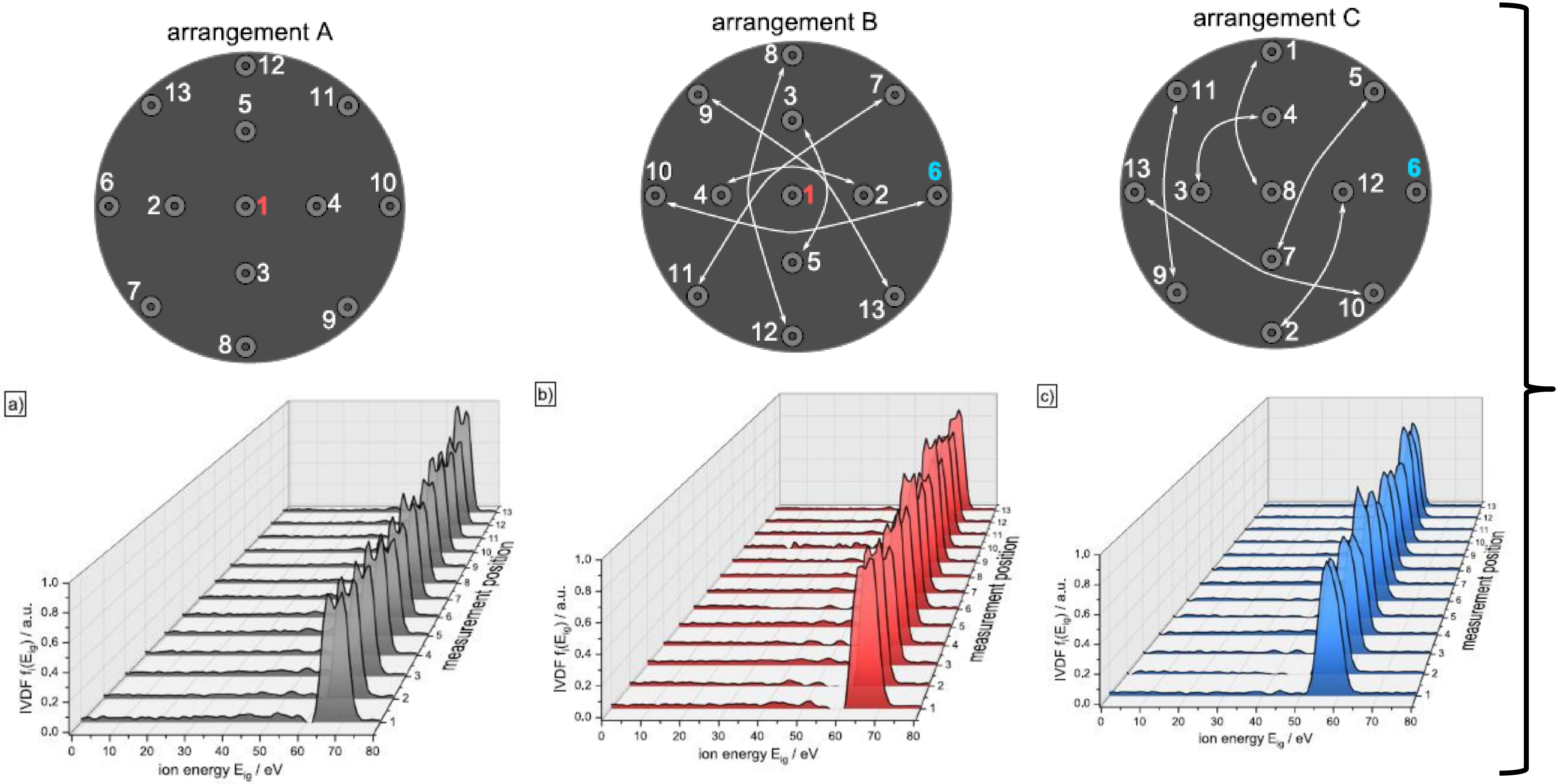


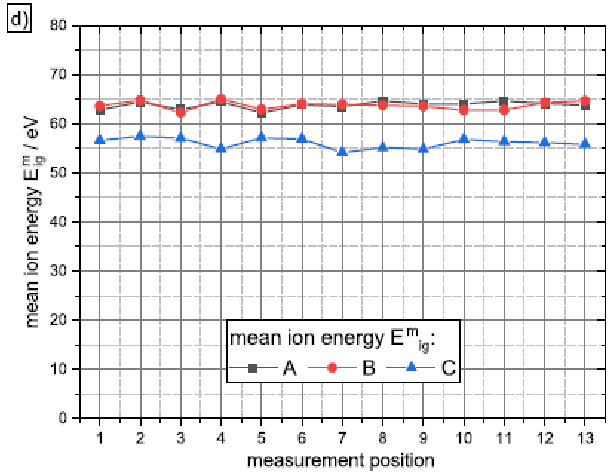




Experimental setup and schematic of the RFEA array with its 13 sensors [Front and Back side].
Schematic cross section of a Semion sensor.

Calibration routine for an array of retarding field energy analyzer sensors





Mean ion energy at each measurement position at the grounded electrode for all three sensor arrangements.

Ion velocity distribution as a function of the ion energy at each of the 13 measurement positions at the grounded electrode for (a) sensor arrangement A, (b) sensor arrangement B, and (c) sensor arrangement C.

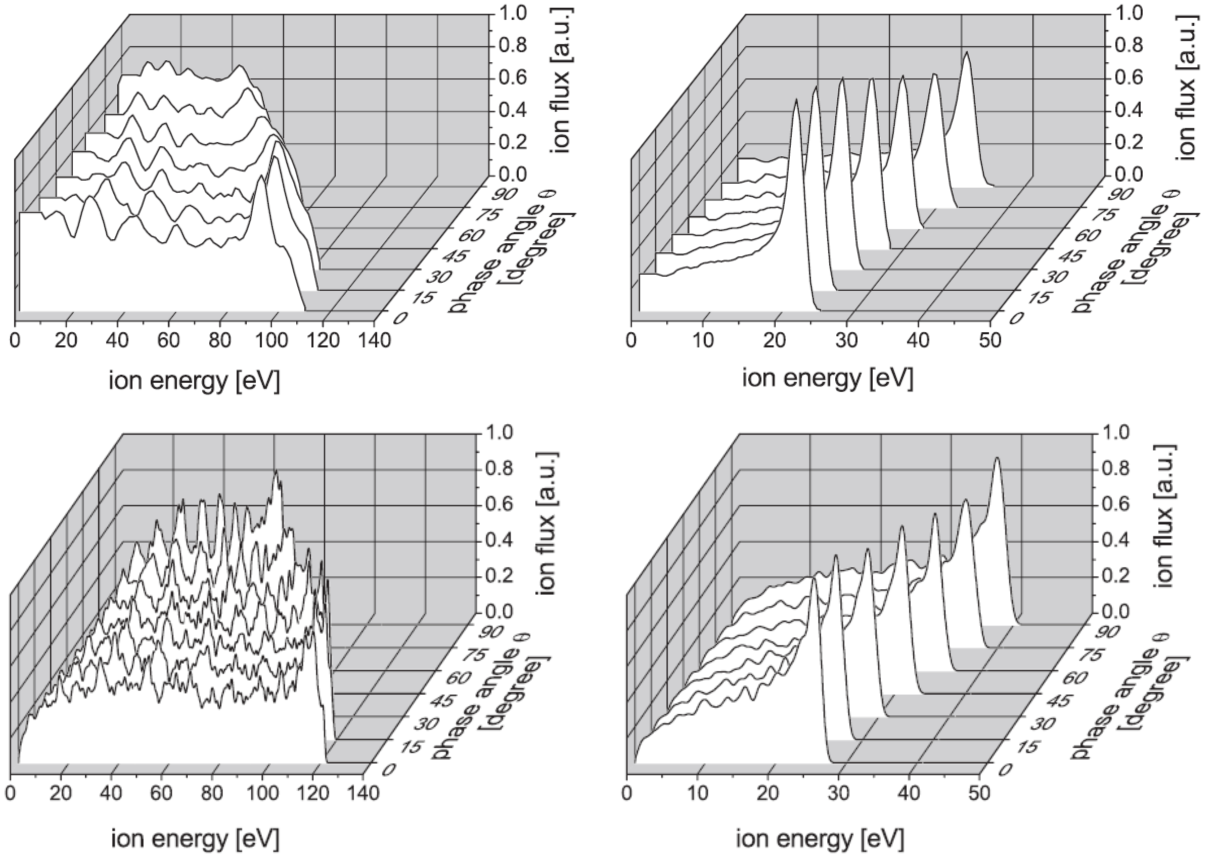
Investigation of geometrically and electrically asymmetric capacitively coupled dual frequency discharge

The electrical asymmetry effect in geometrically asymmetric capacitive radio frequency plasmas

DOI: https://doi.org/10.1063/1.4747914

In this work, the Electrical Asymmetry Effect (EAE) is investigated experimentally and via PIC simulation in geometrically asymmetric CCRF discharges for the first time. Low pressure dual-frequency discharges with different electrode areas were operated in argon at 13.56 MHz and 27.12 MHz.

Some example data is shown to the right



Semion RFEA

PIC simulatio
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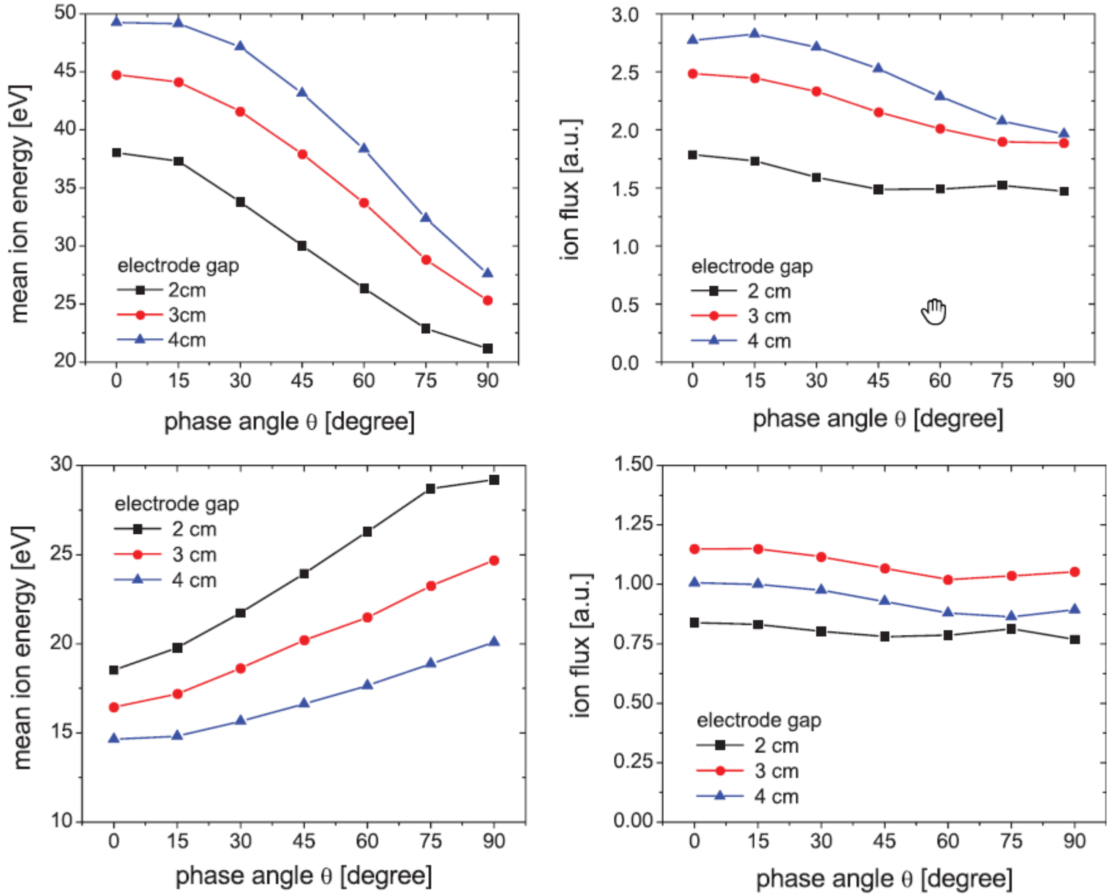
Experimentally measured and simulated ion velocity distribution function at the powered (left) and grounded (right) electrode of a geometrically and electrically asymmetric dual frequency discharge operated at 4 Pa, d=4 cm, and voltage 150 V.

Investigation of geometrically and electrically asymmetric capacitively coupled dual frequency discharge

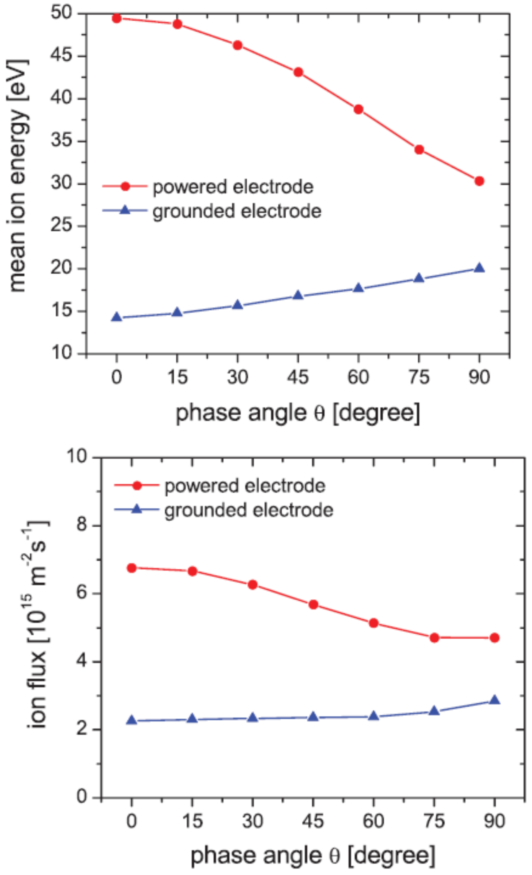
Semion RFEA



Towards the powered electrode

Towards the grounded electrode

PIC simulation



Mean ion energy and total ion flux in a geometrically and electrically asymmetric dual frequency discharge operated at 4 Pa and voltage 150 V (Experimental and simulation results).

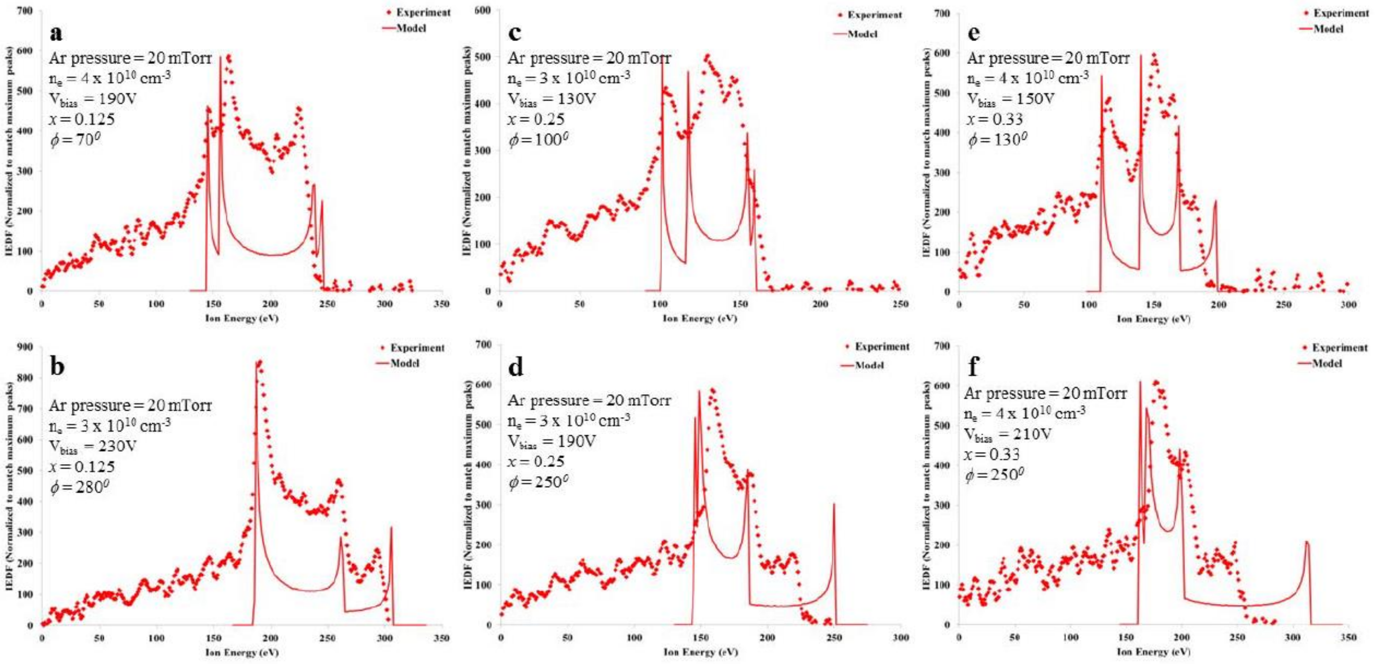
First demonstration of controlling a dual-frequency system with a digital frequency and phase-locking scheme

Ion Energy Distribution Skew Control Using Phase-Locked Harmonic RF Bias Drive

DOI:
http://dx.doi.org/10.1109/TPS.2014.2326600

This paper presents a modification to multi-frequency drive for ion energy control by exploiting a digital frequency and phase controller that enables modification of the higher order moments of the distribution, specifically, controlling the skew of the distribution.

Some example data is shown to the right



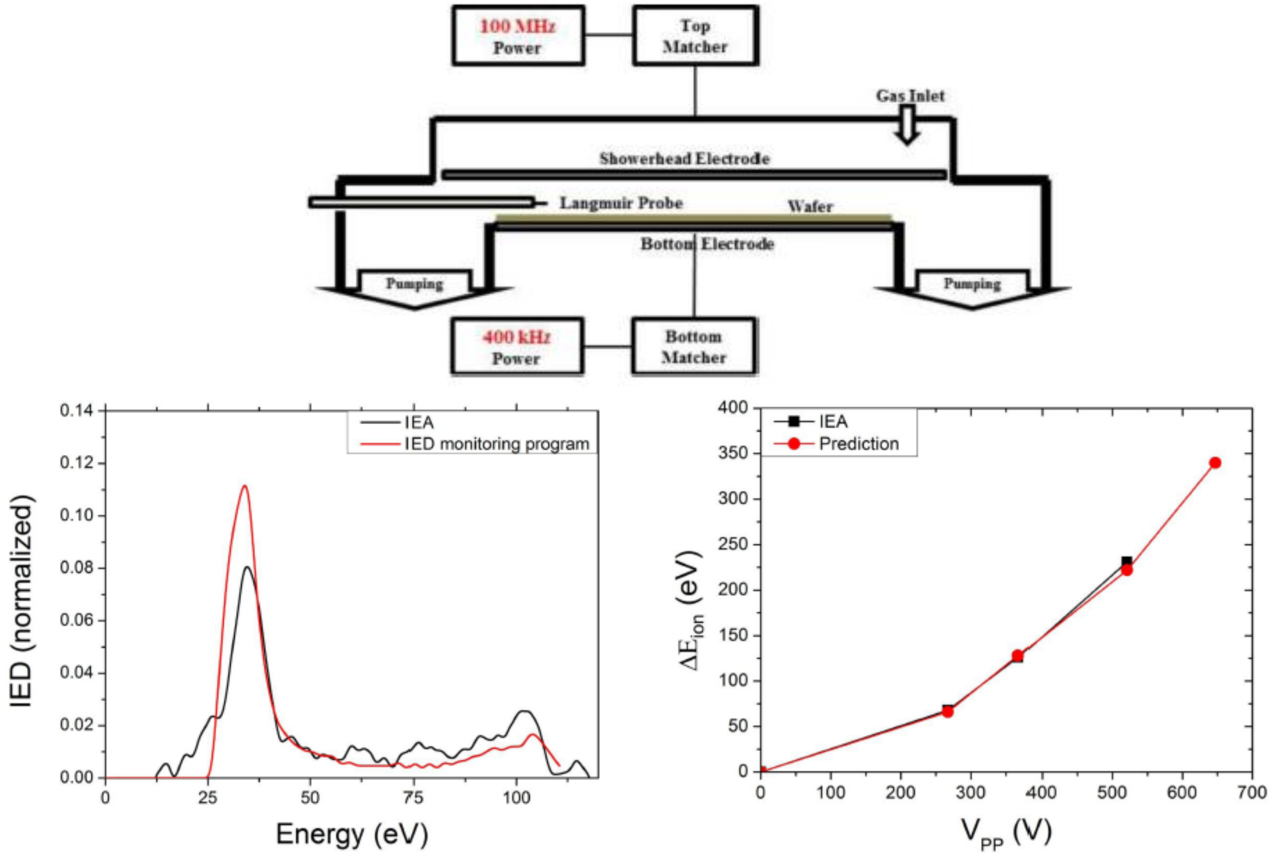
Comparison of measured and modeled IEDFs at the minimum and maximum skew values observed for the three mixing cases run. (a) Minimum and (b) maximum skew for x = 0.125. (c) Minimum and (d) maximum skew for x = 0.25. (e) Minimum and (f) maximum skew for x = 0.33.

Non-invasive method for ion energy distribution measurement at a RF biased surface

Monitoring Ion Energy Distribution in Capacitively Coupled Plasmas Using Non-invasive Radio-Frequency Voltage Measurements

DOI:
http://dx.doi.org/10.5757/ASCT.2014.23.6.357

In this work, a non-invasive method for ion energy distribution measurement at a RF biased surface is proposed for monitoring the property of ion bombardments in capacitively coupled plasma sources. The method was developed based on plasma electrical equivalent circuit model and successfully demonstrated monitoring of ion energy distribution in the dual-cathode CCP source.



Experimental setup and IED taken from the ion energy analyzer (IEA) and measured using the proposed non-invasive method. Also shown energy spread of ion energy distribution as a function of peak-to-peak voltage of 400 kHz bias applied to the bottom electrode.

Some example data is shown to the right

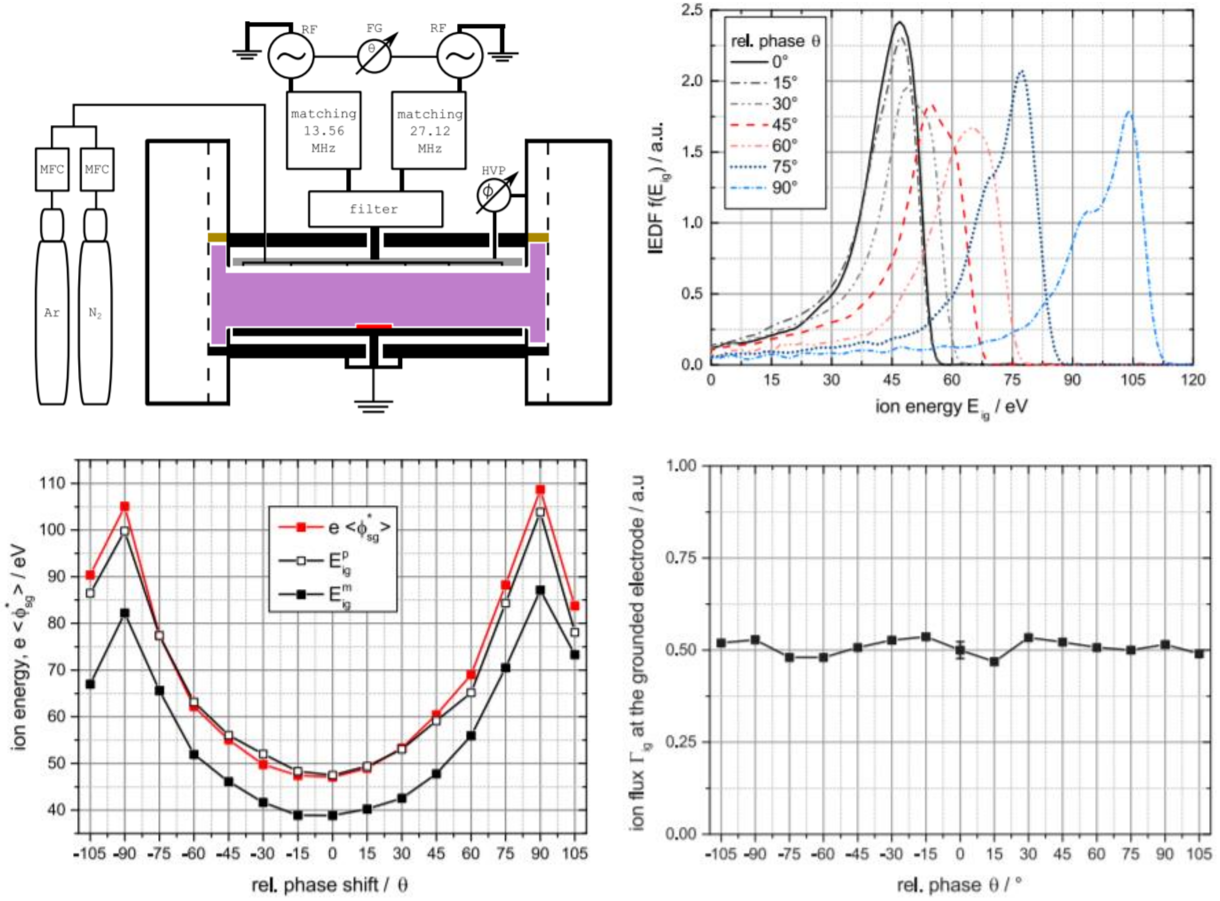
Multi-frequency CCPs as a highly flexible coating and sputtering system

Ion energy control via the electrical asymmetry effect to tune coating properties in reactive radio frequency sputtering

DOI: https://doi.org/10.1088/1361-6595/ab504b

In this work, the Electrical Asymmetry Effect in a multi-frequency capacitively coupled plasma is investigated to control the ion energy at the substrate without affecting the ion-to-growth flux ratio by adjusting the relative phase between two consecutive driving harmonics and their voltage amplitudes.

Some example data is shown to the right



Experimental setup and measured IEDF at the center of the grounded electrode for different phase shift between the two harmonics i.e. θ [Ar/N_2 (8:1) plasma at 0.5 Pa]. Also shown ion energy (peak and mean) and ion flux for different relative phases θ.

Impedans PLASMA MEASUREMENT

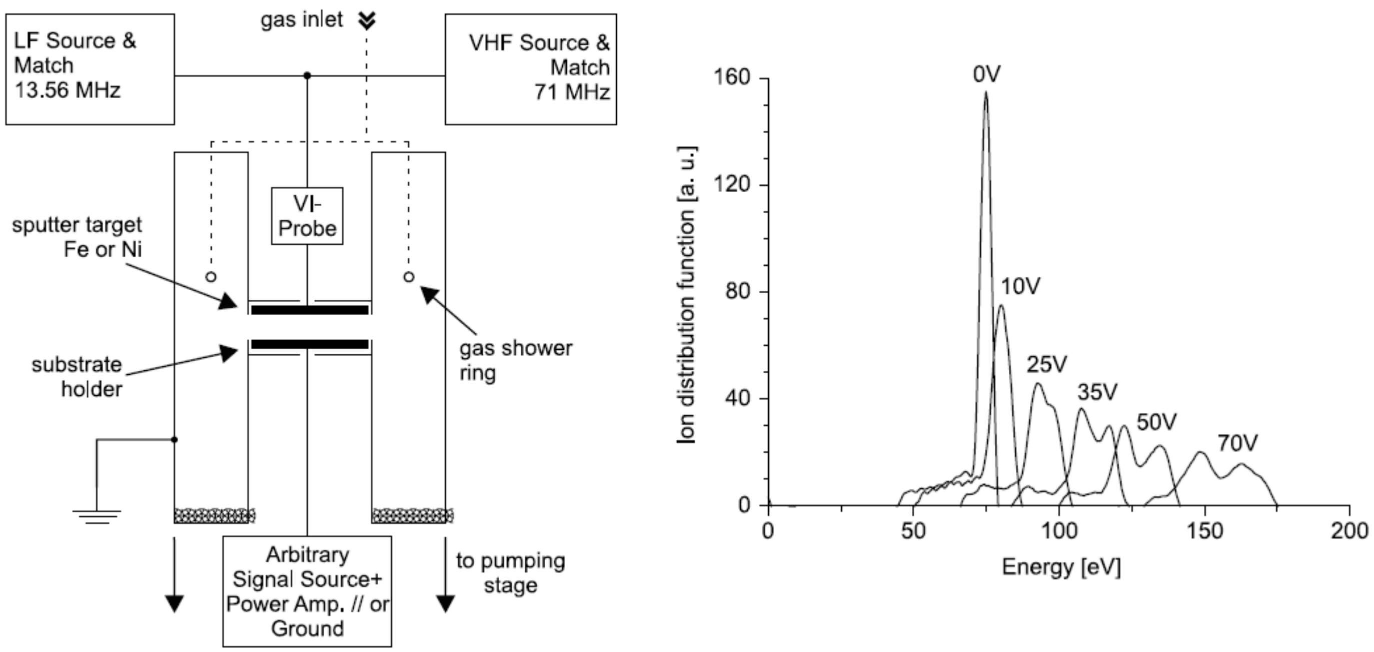
Influence of strong frequency coupling with respect to deposition in Dual Frequency Capacitively Coupled Plasma

Dual frequency capacitive plasmas in Fe and Ni sputter applications: correlation of discharge properties on thin film properties

DOI: https://doi.org/10.1088/0963-0252/21/1/015010

In this work, the influence of complex frequency coupling in dual frequency discharges on Fe and Ni film deposition behavior was studied. By performing deposition experiments it was found that by following simple tuning guidelines a very good degree of separability is achievable.

Some example data is shown to the right



Experimental setup with an example of measured IEDF at varied 13.56MHz voltage at a constant high frequency (67.8 MHz) voltage setpoint equivalent to 50 W. A shift to higher mean ion energies as well as a drop in ion density is clearly visible.

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