Octiv VI Probe

RF Measurement and Plasma Control Sensors

https://impedans.com/octiv-mono-rf-wattmeter

https://impedans.com/octiv-poly-vi-probe

https://impedans.com/octiv-suite-vi-probe

The Octiv VI Probe

Precision RF Measurement

The Octiv VI Probes are a range of compact sensors for RF measurements. They are completely pulse-compatible and have a wide variety of communication options for easy use in the field.

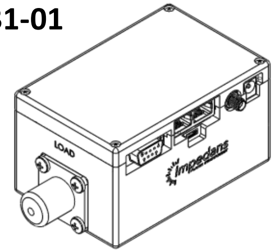
Parameters Measured:

- ✓ Voltage, Current, Phase
- ✓ FWD, REF (50 Ω region), Delivered Power
- ✓ Impedance, SWR
- ✓ Choose any 5 frequencies from 400 kHz to 240 MHz, all on the one sensor
- ✓ Frequency agility (will track frequency tuning)
- ✓ Harmonic Content (Poly/Suite)
- ✓ Monitor Multiple frequencies simultaneously (Poly/Suite)
- ✓ Voltage and Current waveform reconstruction (Suite Only)
- ✓ Realtime Ion flux measurements (Suite only)
- ✓ Harmonic Phase (Suite Only)

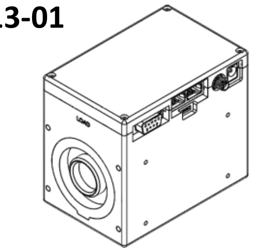
Lab RFx Calibration

- ✓ Calibration is done with the best reference standards available on the market
- ✓ RF Power is calibrated by a Calorimeter
- ✓ Impedance is calibrated with a Vector Network Analyzer (VNA)
- ✓ Sensor are calibrated for temperatures up to 80C
- ✓ If better calorimeter or VNA standards come on the market, the Octiv will improve with that standard

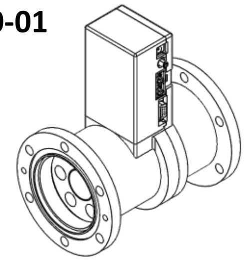
02-0231-01



02-0313-01



02-0320-01



Impedans PLASMA MEASUREMENT

The Octiv VI Probe

Precision RF Measurement

Pulsed RF Monitoring

- ✓ Detects RF pulsing automatically and begin to report the pulse frequency and duty cycle in real time
- ✓ Integrates over the pulse shape to accurately measure average power, voltage, current, impedance while pulsing
- ✓ Example:1kW CW, then turn on a 1kHz pulse at 50% duty cycle, the Octiv will still report 1 kW power, plus the pulse frequency and duty cycle.
- ✓ All automatic, so just one mode for technicians to use for all RF purposes

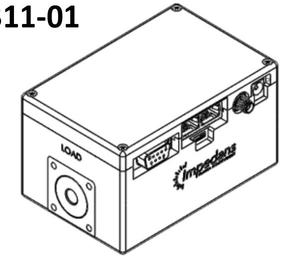
Communication Protocols

- ✓ USB
- ✓ Ethernet
- ✓ EtherCAT
- ✓ RS232
- ✓ Full APIs available for all.
- ✓ LabView interface also available
- ✓ Smart Phone display available
- ✓ Fully field upgradable

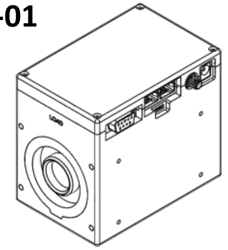
Meter View

Voltage	Power	Current	Forward Power
52.25 V	24.16 W	0.92 A	48.16 W
Pulse Period	Pulse On Time	Pulse Frequency	Pulse Duty Cycle
999.97 μs	501.87 μs	1000.03 Hz	50.19 %

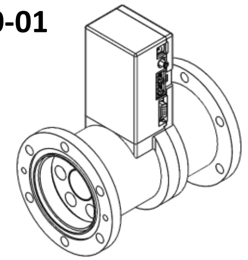
02-0311-01



02-0313-01



02-0320-01



Impedans PLASMA MEASUREMENT

Key Features

All-in-one RF Sensor
One compact sensor with up to 5 fundematal frequencies calibrated and fully pulse-compatible

Communication Protocols
USB, Ethernet, EtherCAT and Serial with full APIs and code libraries available

Harmonic Monitoring
Calibrated with up to 64 harmonic frequencies, enabling advanced plasma process applications

Customised Sensors
Special form factors for tool integration available, with power capabilities up to 90 kW

Pulsed RF Monitoring
Automatically report the pulse parameters such as pulse frequency and duty cycle

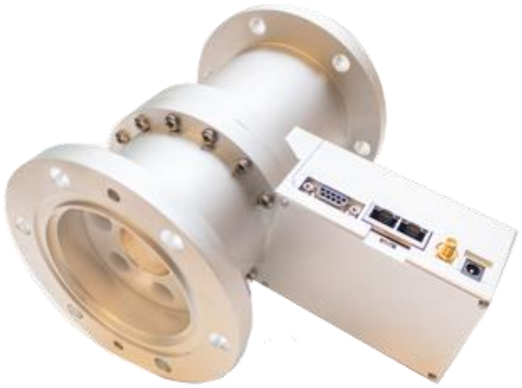
Fault Detection
Characterise faults such as wafer displacement, air leaks and hardware degradation

Endpoint Detection
Clean and Etch endpoint detection demonstrated via plasma impedance and harmonic monitoring techniques

Advanced Software
Data collection and overlay made easy, view real-time Smith Charts

Technical Specifications

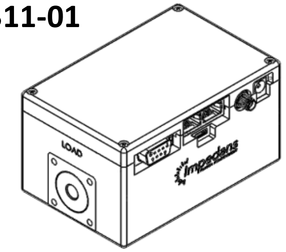
Parameters Measured	Range
Frequency Range (Fundamental)	$40\ kHz \rightarrow 400\ kHz$ $350\ kHz \rightarrow 240\ MHz$
Frequency tracking range	$\pm 10\ \%\ or \pm 2\ MHz$, whichever is less
Power Resolution	$0.25\ W$
Power Uncertainty	± 1 % for f_0: $2 \rightarrow 60\ MHz$ ± 2 % otherwise
Voltage Range (typical)	0.3 V to 3000 V_{rms} custom available to 20 kV_{rms}
Voltage Resolution	0.1 V_{rms}
Voltage Uncertainty	± 1 % or 1 V_{rms} whichever is larger for f_0: $2 \rightarrow 60\ MHz$ ± 2 % or 1 V_{rms} otherwise
Current Range (typical)	2.5 mA_{rms} to 25 A_{rms} custom available to 120 A_{rms}
Current Resolution	2.5 mA_{rms}
Current Uncertainty	± 1 % or 0.1 A_{rms} whichever is larger for f_0: $2 \rightarrow 60\ MHz$ ± 2 % or 0.1 A_{rms} otherwise
Phase Range	$\pm 180°$
Phase Resolution	$0.02°$
Phase Uncertainty	$< \pm 1°$



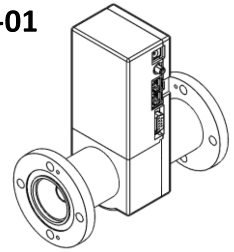
Technical Specifications

Parameters Measured	Range
Pulse Frequency Range	$10\ Hz$ to $100\ kHz$
Pulsed RF Time Resolution with TTL sync	$1\ \mu s$
VSWR Range for 1% Power Accuracy Verified	$6:1$
Uncertainty Confidence Interval	$95\%\ (2\sigma)$
Absolute Unit to Unit Uncertainty	1.4% for current and voltage
Run to Run Repeatability – Frequency	$0.3\ Hz$
Run to Run Repeatability – Power	$0.1\ \%$ or 0.05 W, whichever is greater
Run to Run Repeatability – Voltage	$0.05\ \%$ or 0.01 V, whichever is greater
Run to Run Repeatability – Current	$0.05\ \%$ or 0.01 A, whichever is greater
Run to Run Repeatability – Phase	0.005 degrees

02-0311-01

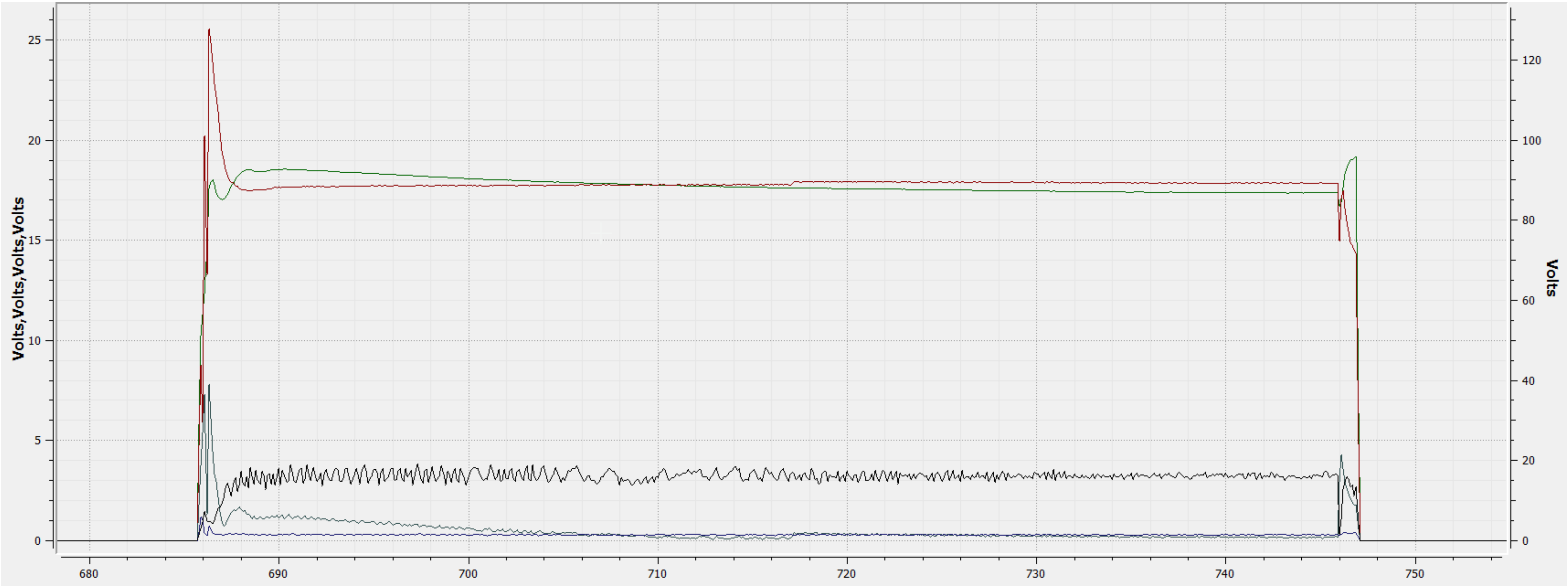


02-0318-01



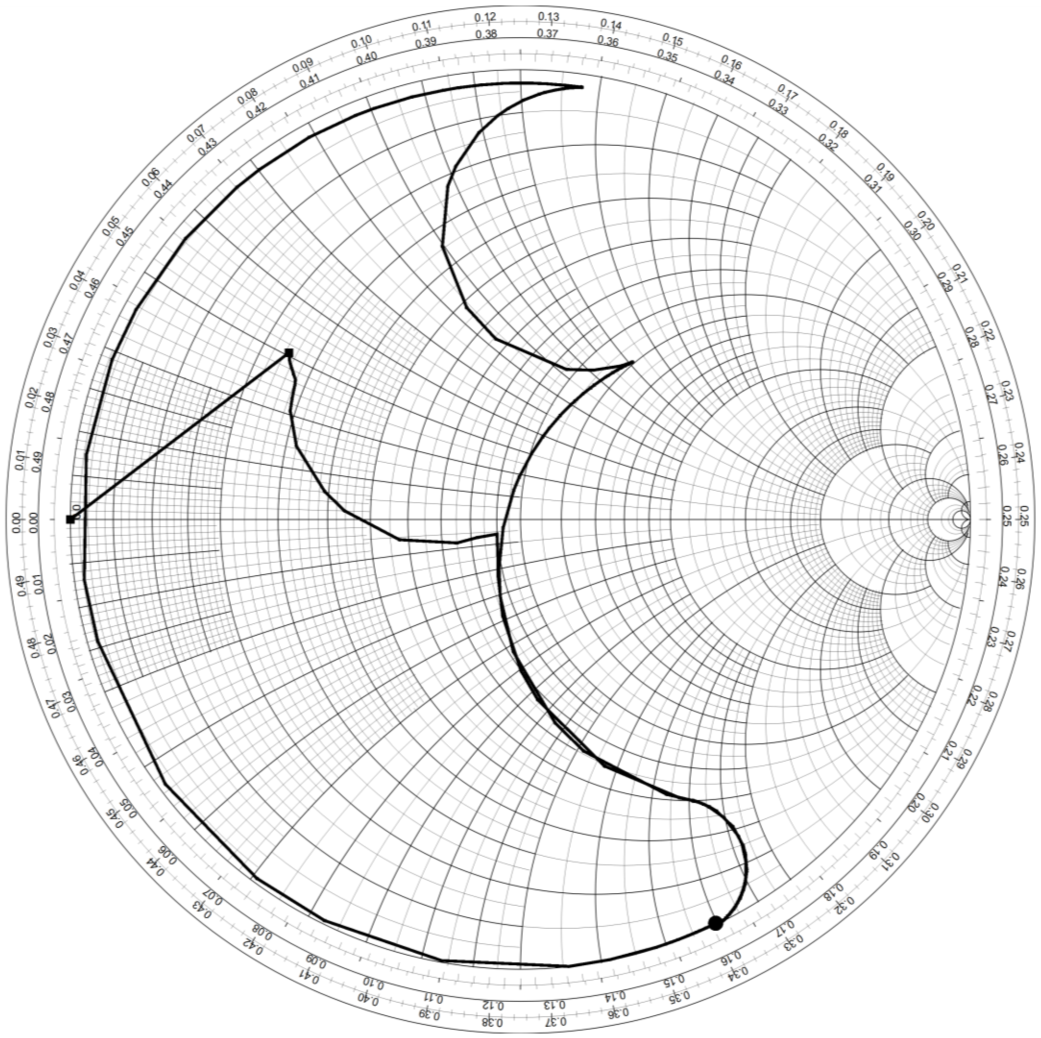
- ✓ Octiv data has been published in nearly 100 papers, see https://impedans.com/octiv-publications
- ✓ To arrange a technical discussion, contact support@impedans.com

Example Data: Voltage Data



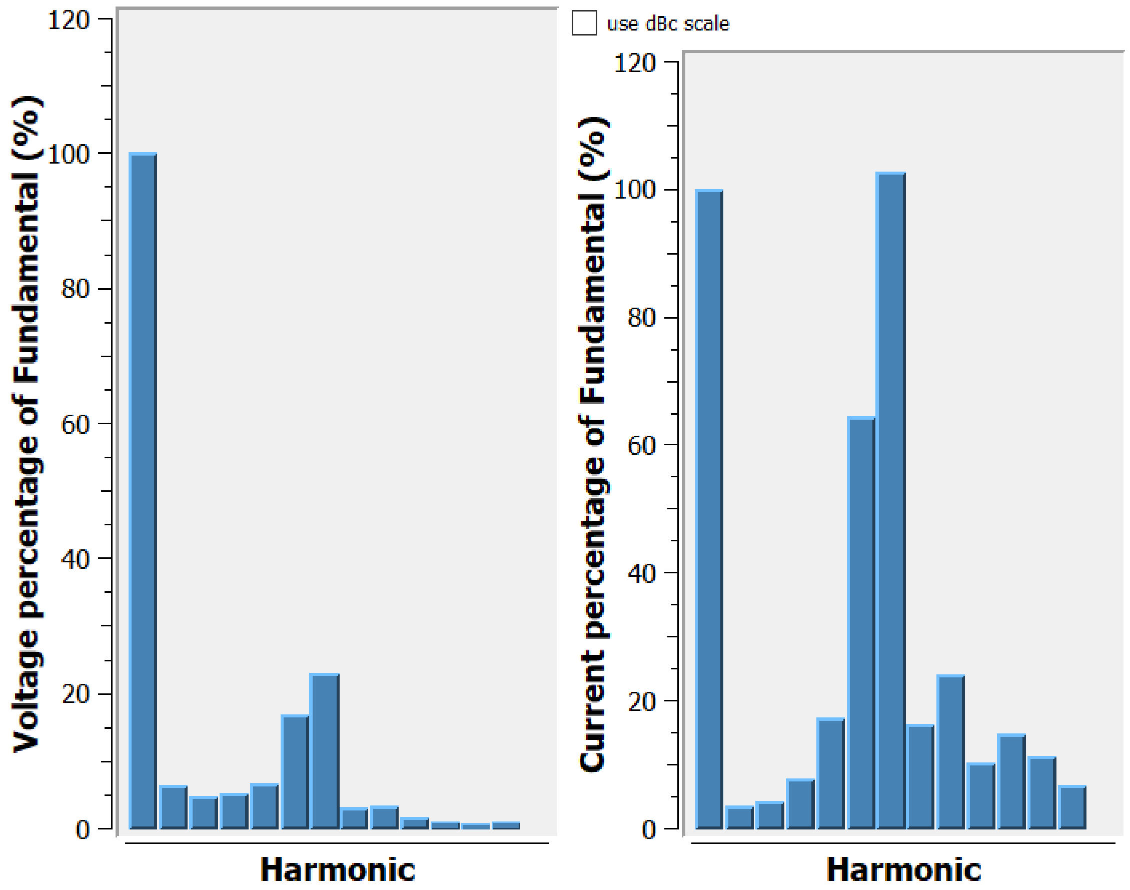
Example of Fundamental (right axis) and the Harmonics 2-5 (left axis) being plotted in the Octiv software

Example Data: Smith Chart



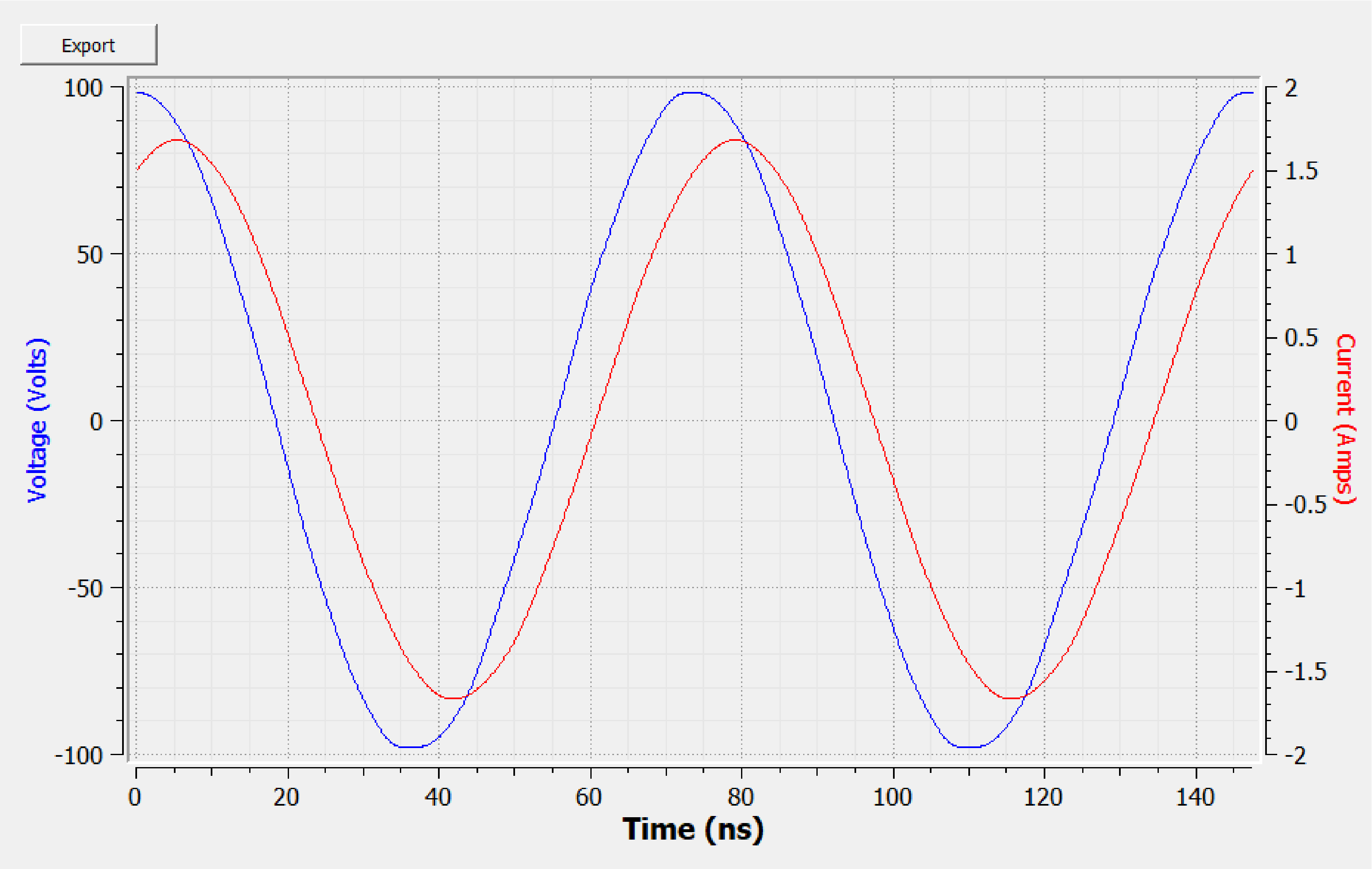
Example of Smith Chart showing the characterisation of a match box.

Example Data: Harmonic Profiles



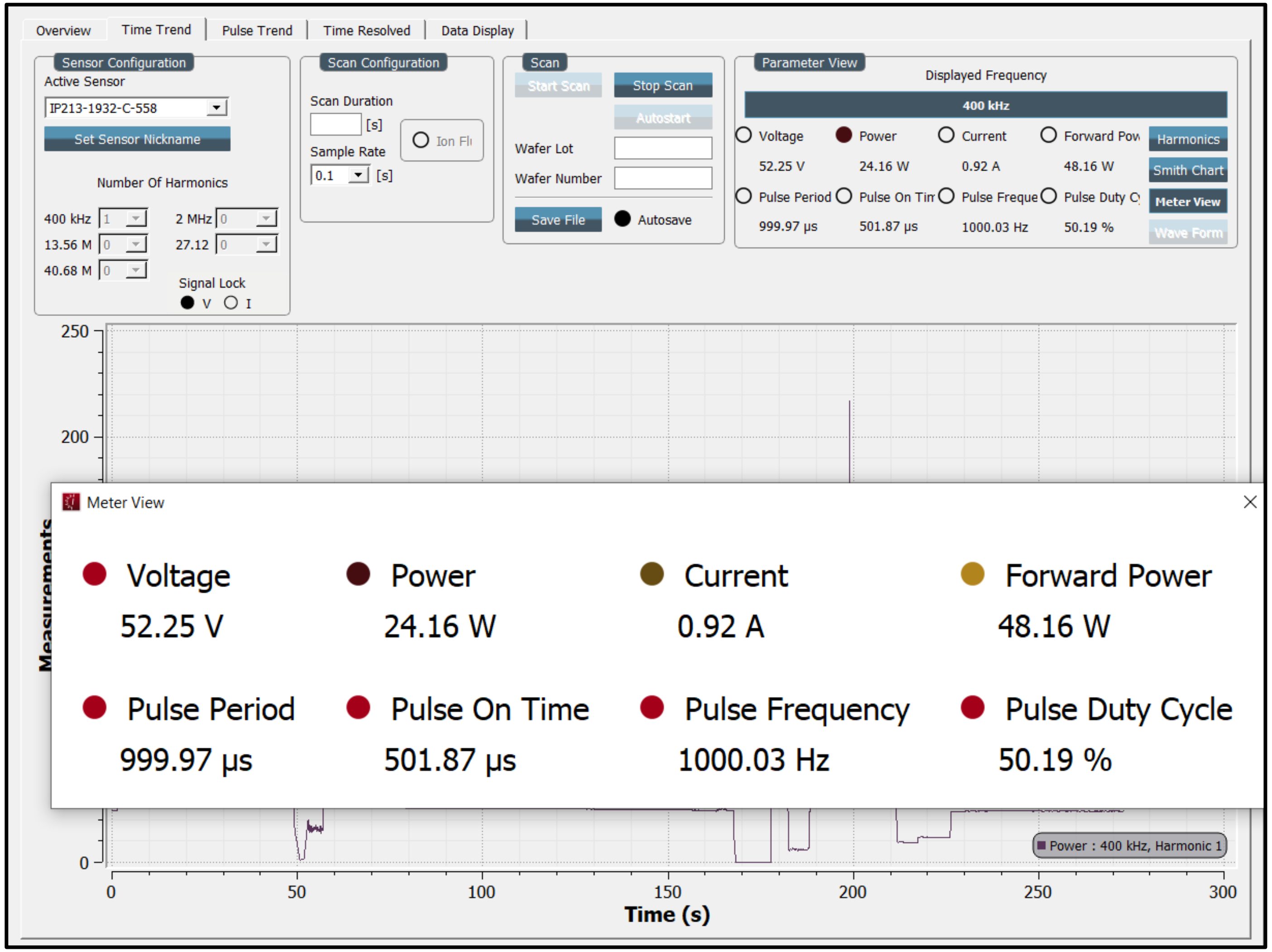
Example of the harmonic profile for voltage and current as shown in the Octiv software

Example Data: Waveform Reconstruction



Example of the Waveform reconstruction of the Voltage and Current

Example Data: Pulsed RF Parameters



Example of live pulse frequency and duty cycle monitoring

Octiv Applications

Ion flux and DC Self-Bias measurement in an asymmetric CCP

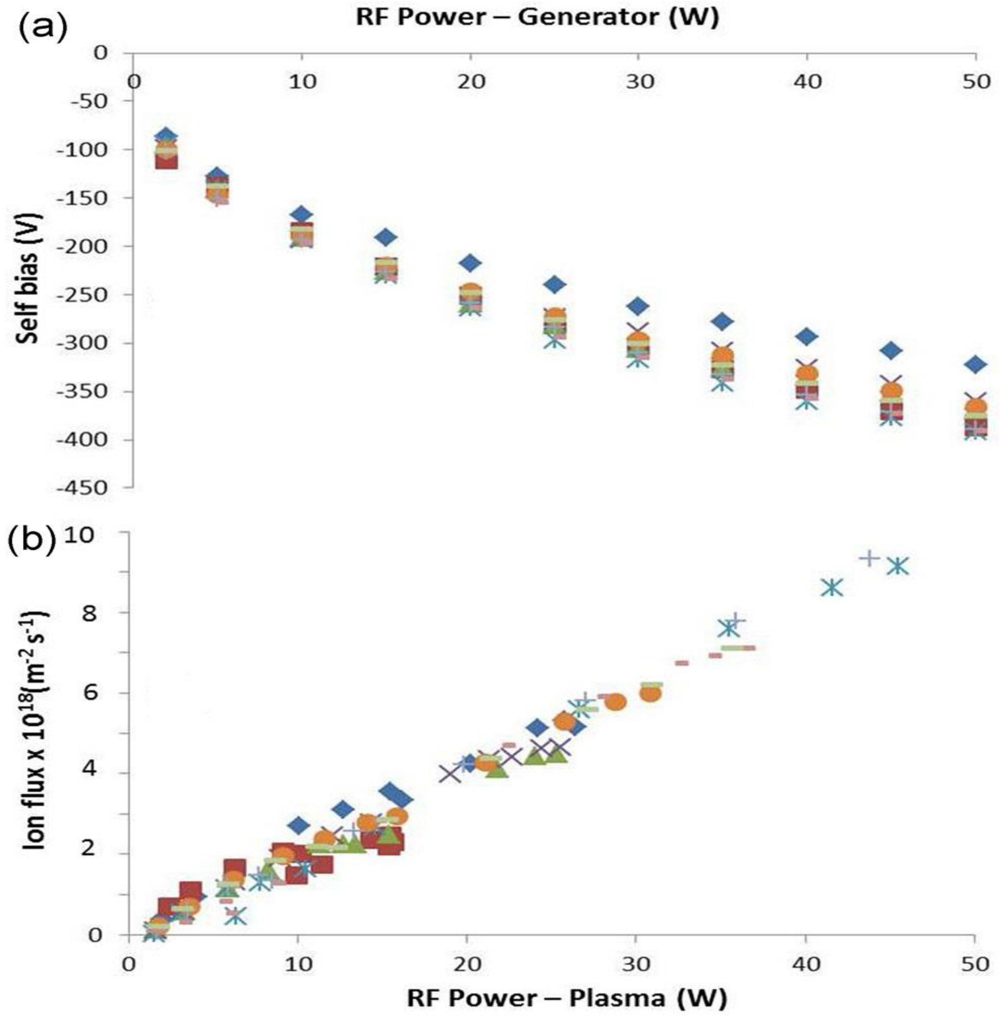
An experimental and Analytical Study of an Asymmetric Capacitively Coupled Plasma Used for Plasma Polymerisation

DOI: 10.1002/ppap.201400026im

The objective of this paper was investigate the effects that gas composition had on the DC self-bias and the Ion flux.

Some example data is shown to the right

https://www.impedans.com/octiv-suite-20-application-note-oc12



The self bias, ion flux and plasma power for a variety of gases. (◊) Argon, (▪) Oxygen, (*) Allylamine, (+) Heptylamine, (-) HMDSO, (∘) Diglyme, (Δ) Acrylic acid and (x) Propionic acid

Microsecond measurement of the evolution of pulsed RF plasmas

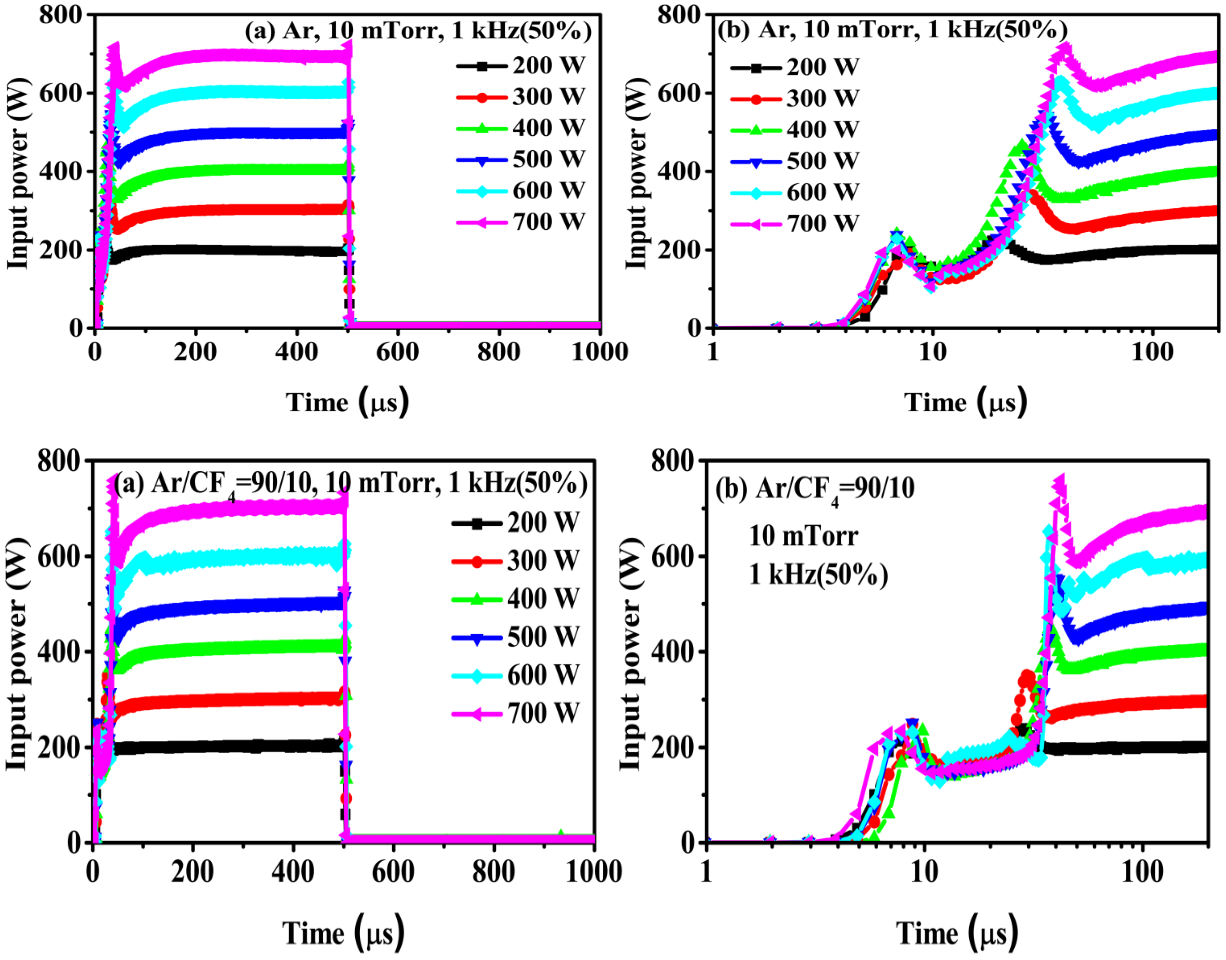
Complex transients of input power and electron density in pulsed inductively coupled discharges.

DOI: 10.1063/1.5114661

The objective is to investigate the effects of the Power and Pressure (not shown here) on the evolution of the input power on a microsecond timescale for Ar and Ar/CF_4.

Some example data is shown to the right

https://impedans.com/langmuir-and-octiv-application-note-lp15-oc08



Examples of the effect of the power in pulsed Ar and Ar/CF_4 *on a microsecond timescale*

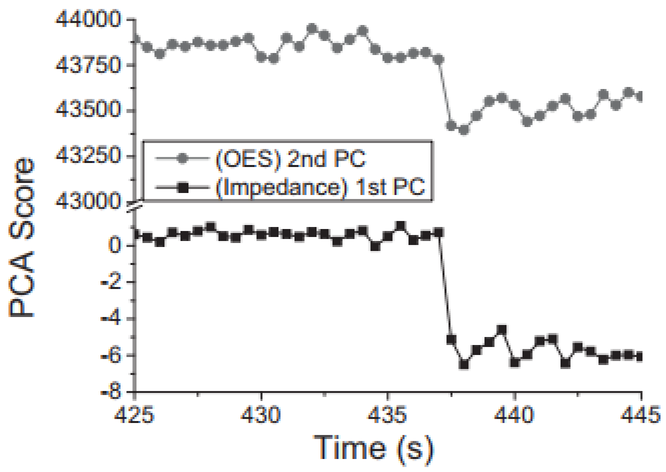
Application - Clean and Etch Endpoint Detection

Real-Time Endpoint Detection of Small Exposed Area SiO_2 Films in Plasma Etching Using Plasma Impedance Monitoring with Modified Principal Component Analysis

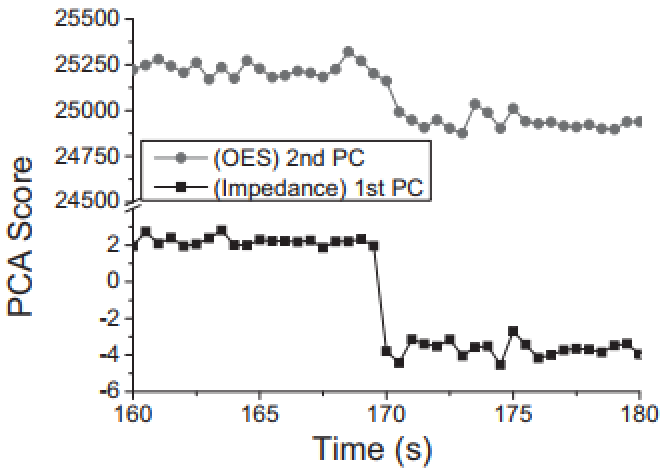
Principle component analysis (PCA) was used to combine all the data from an Octiv sensor vs all the optical channels from an OES.

Etch endpoint was measured for various open areas, from 2% down to 0.5%

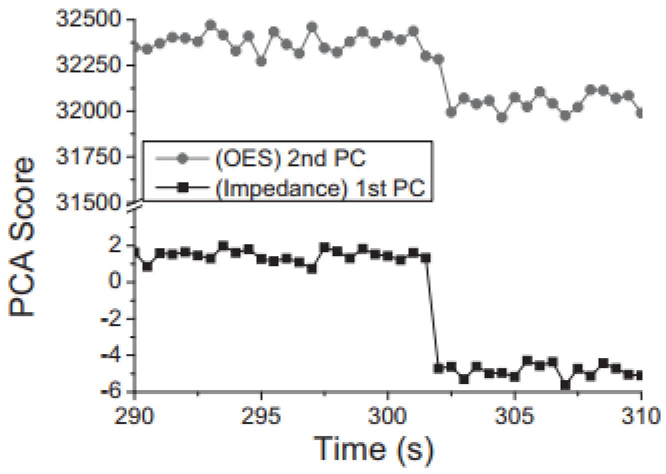
Monitoring RF had at least twice the sensitivity compared to multivariate OES techniques



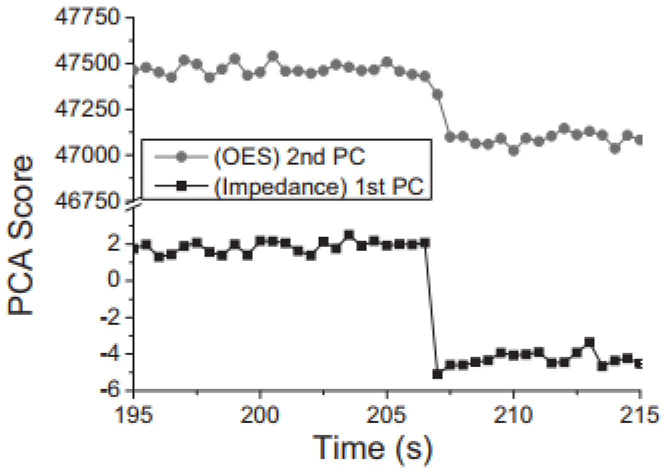
(a) 2.0% oxide area target wafer



(c) 1.0% oxide area target wafer



(b) 1.5% oxide area target wafer



(d) 0.5% oxide area target wafer

Impedans PLASMA MEASUREMENT

Application - Fault Detection – Air Leak Detection

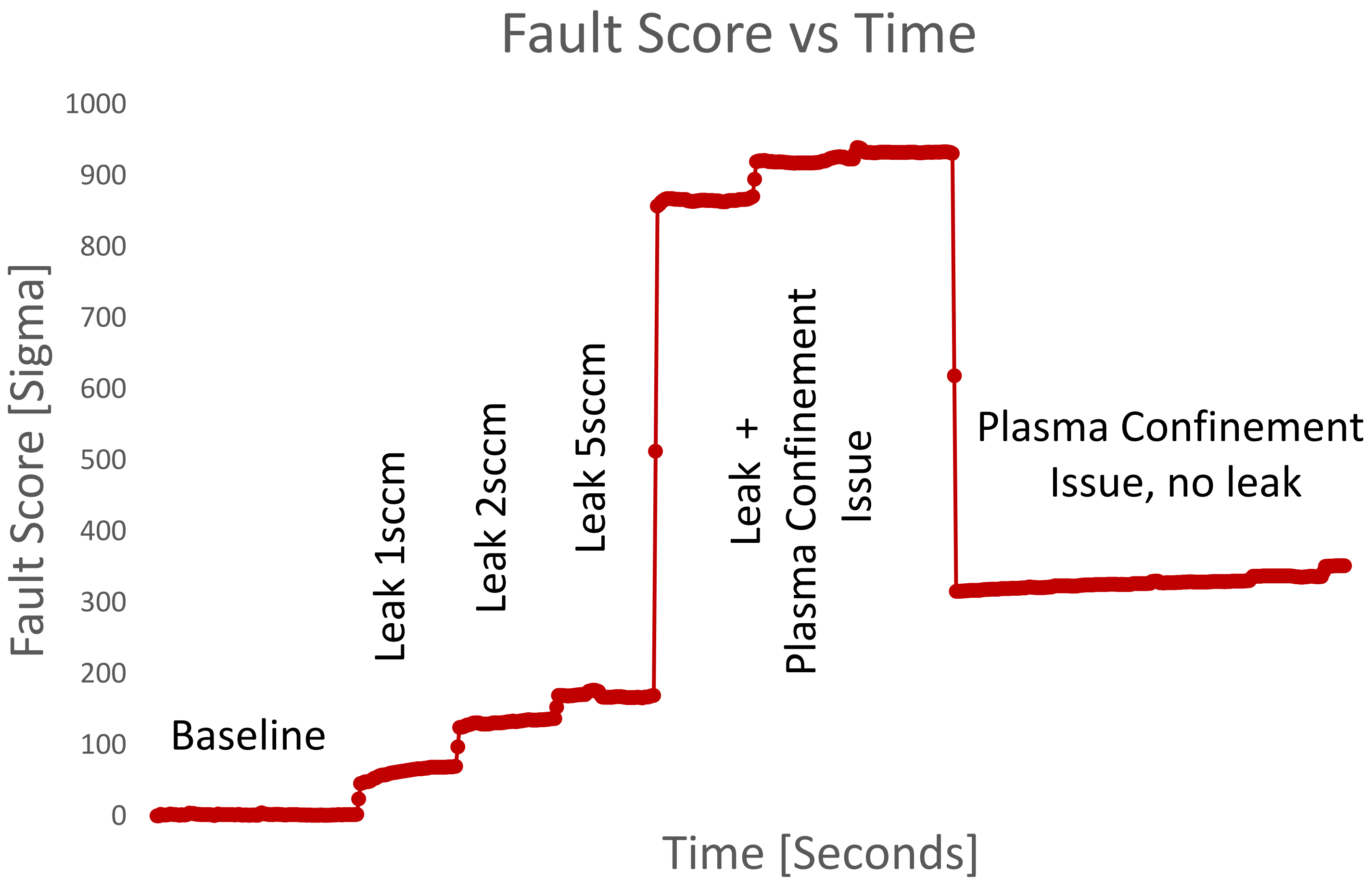
Detection of air leak

Real time detection of a change in gas, here due to an unwanted air leak into the chamber

Some example data is shown to the right

When a large amount of extra air was present, the plasma expanded out into the windows, hence the very large jump in the Fault Score. The extra plasma remained after the air leak was removed

This is detectable due to the change in the plasma impedance and in the plasma harmonic emissions



Examples of the effect of the introduction of an air leak on the statistical score

Impedans PLASMA MEASUREMENT | CASE STUDY

NASDAQ 100 Technology Company

Reduces Production Costs Using the **Octiv** RF Sensing Platform

The **Challenge**

Needing to improve the performance, and extend the lifetime, of an aging fleet of plasma etching tools, this long-time Impedans client sought a solution with the following requirements:

- Monitor the vital-signs of each plasma etching tool
- Determine the health of the RF power delivery subsystem
- Identify if the substrate was properly positioned by the robotic arm
- Communicate data seamlessly to the factory host
- Prevent product scrappage and reduce maintenance costs

Our **Solution**

The ***Octiv*** RF sensor was integrated in the etching tool RF path, at the output of the matching network. The key RF parameters were measured and streamed over the network to the factory host. Data was recorded, time-stamped and stored in the customer's data base along with the tool context data. The data captured during fault events were later analysed. Correlations between RF data and fault conditions were established. Control limits were then applied to relevant parameters, excursions from which are used to indicate faults and initiate corrective action.

The **Process**

Impedans' RF and mechanical design teams identified the optimum location for ***Octiv*** RF sensor installation. A custom sensor form factor was designed. A first unit was then manufactured and installed. Data was captured while the tool was in production over a predefined period. Product was inspected off line in the usual way. The time stamps for defective products were correlated with RF data from ***Octiv***. Impedans experts analysed and modelled the RF data and identified fault signatures. Corrective action procedures were implemented based on Impedans recommendations. ***Impedans*** software experts worked closely with the customer's software team to implement a simple, robust Ethernet protocol to communicate sensor data to the factory host. Once the first few product scrap events were prevented, roll out across the entire fleet was initiated.

Achievements

RF Power Subsystem Health

The first problem to be solved was product scrappage due to stress in the power delivery subsystem. Impedans experts discovered that certain plasma etch processes were operating at the edge of the matching unit's impedance range. This caused the matching unit to become unstable, occasionally. The RF data collected by the ***Octiv*** sensor was used to identify the onset of this unstable mode. The problem was solved by restarting the process.

Substrate Misplacement

Substrate misplacement on the electrostatic chuck, due to component wear and tear, was periodically leading to wafer scrappage. This fault was undetectable from the pre-existing tool feedback i.e. forward and reflected power showed no error. Thus, several hours of scrappage could go undetected. ***Octiv*** provided a clear signature of the substrate misplacement fault enabling corrective action to be taken.

Reduced Maintenance Time

Due to the reliability of the RF data provided by ***Octiv***, test wafer qualifications were reduced by 70%, enabling higher throughput of production wafers.

Results at a glance

70% REDUCTION
in Tool Maintainence time

SEVERAL HOURS
Scrap Prevention Per Fault

10% INCREASE
in Product Throughput

>1000% RETURN
On Investment in 1 year

>$1Million
Projected saving in maintenance and Scrap Reduction per tool per annum diretly attributed to the integrationof **Impedans' Octiv Sensing Platform**

www.impedans.com | +353 1 842 8826 | info@impedans.com

Impedans Ltd

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

Ph: +353 1 842 8826
Fax: +353 1 871 2282

Web: www.impedans.com
Email: support@impedans.com