Multifunctional Probe Plasma Analyzer

Operation modes and specifications

1. **High resolution EEDF measurements.**

This mode is applicable to stationary and periodically pulsed plasmas (with the plateau duration > 1 ms). In this mode, the instrument performs EEDF and plasma parameters measurements that are displayed in real time. The best measurement quality is achieved when the main measuring probe is supplemented with the reference probes. The standard Plasma Sensors probe combines those two probes and also includes built-in wide band RF compensation. Alternatively the instrument can be interfaced to any custom or user-built probe with or without the reference probe.

The range of the plasma density N measurements depends on the probe tip size, and for all practical purposes covers $N = 10^8$ to 10^{14} cm^{-3}.
The plasma electron temperature range $T_e = 0.05 – 20$ eV.
The probe saturation current range, $I_s = 100$ μA – 200 mA.

The plasma potential range for the standard instrument configuration is V_p = –300 and +300 V.
This range can be extended to +1000 V with our optional extension block.

The acquisition time of a single probe scan $t_{acq} = 0.5$ ms allows the EEDF energy resolution $\Delta\varepsilon = 0.1\ T_e$.
The acquired data can be averaged over longer time intervals, while raw data can be stored for further analyses.

Output display are real time high resolution EDDF, the plasma parameters N and T_e, the plasma space potential $V_{s,}$ and the probe saturation current, I_s
The instrument assures reliable EEDF measurement within the dynamic range of 50–80 dB.

The probe cleaning by ion bombardment is initiated before each acquisition cycle every 0.5–1 ms. The probe can also be continuously heated by the electron current to prevent the build-up of contaminants.

EEDF acquisition mode can be single, automatic or triggered by an external pulse.

Coupling of small reference probes to plasma can be increased by the bias from the instrument’s internal current source.

2. **Pulsed EEDF measurements**

This mode allows EEDF measurements of periodically time-varying plasmas with the time resolution of 2.5 μs. Single EEDF acquisition time equals $t_{acq} = k/f$, where k is the number of the energy points per scan (50-500) and f is the plasma modulation frequency.
The instrument characteristics in this mode are the same as in the High Resolution configuration.

The trade-off in the probe design for the pulsed mode is often application-specific. Plasma Sensor offers the custom probe design for particular applications.

3. **Ion Flux Measurements with uncontaminated probes**

Obtaining full probe V/I characteristics may not be possible when the grounded processing chamber is covered with low-conductance material. In this case, the plasma parameters N and T_e are calculated from a truncated probe characteristic.

In this mode the plasma space potential, V_p can be in the range between –1000 to +1000 V with optional extension to 2000V. The probe current range is 5 μA to 5 mA which allows the plasma density measurement in the range $N = 10^9$ to 10^{13} cm^{-3}. The acquisition time of a single probe voltage sweep is 100 μs. The ion flux can be measured in time-varying plasmas and triggered by an external pulse.

Users should be aware of the inherent problem in the plasma parameters calculations shared by all instruments measuring the ion flux.
When the plasma parameters are derived from the ion and truncated electron parts of the probe characteristic, it is incorrectly assumed that the electron and ion velocity distributions are Maxwellian which, augmented with other imprecisions in theories for the probe ion current, often leads to significant errors.

4. Ion Flux Measurements with probes coated by low-conductivity deposits

In this mode, the instrument is configured to measure the probe current response to the voltage pulse. When the pulse is short, the driving voltage is applied to the probe sheath, yielding undistorted measurements of the ion part of the probe I/V applied to the plasma density calculations. This method, similar to the one used by the Ion Flux Probe®, can be applied to the flat probe at the chamber wall that monitors the plasma conditions.

The probe pulse response can also be interpreted for calculation of the deposition film thickness and indication of the process endpoint.
An optional ion probe with wide-band RF filter allows spatial plasma density measurements in ICP and CCP with high RF potential.

In this mode, the probe current range is between 10 μA and 10 mA with 2 μA resolution, which yields plasma density calculations in the range of $N = 10^9 – 10^{12}$ cm^{-3}. The plasma space potential, V_s can be in the range between – 1000 and +1000 V.

5. Built-in Probe Imitator

The Probe Imitator is a built-in electronic network which has I/V characteristics similar to the Langmuir probe and is useful while learning and testing MFPA performance or developing new applications.

6. Data Acquisition and I/O

The instrument data acquisition is based on an embedded National Instrument DAQ device with 16 bit resolution and USB communication port.

MFPA analog I/O can be connected to custom-built extension blocks; its digital I/O provides capability for communication with peripheral devices.

7. Software options, guarantee and customer support

The design of MFPA software gives users the option of creating their own custom plug-ins for motor drives, electrostatic energy analyzers, probe arrays multiplexing, and other peripheral devices; grants access to output data, which allows user-built real-time analyses routines.

The instrument is fault protected from the probe current overload and the plasma voltage spikes. The instrument has two-year hardware guarantee and two-year free software updates. MFPA hardware and software options can be customized on request. Plasma Sensor personnel are available to assist with any instrument applications and probe design.

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