Plasma Analysis
Application Note 272

ESP*ION* Langmuir Probe

ESP*ION* Time Resolved Measurements

Summary

ESPION from Hiden is the most advanced, accurate and reliable Langmuir probe available. From years of experience in the field of plasma diagnostics, Hiden has incorporated high speed features into the ESPsoft control hardware/software to improve performance specifically for time resolved measurements in pulsed plasma.

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Introduction

Thin film deposition is employed to modify the surface properties of materials. The stability of the deposition processes and the properties of the deposited films can be improved by using modulated plasmas. The data presented in this application note is from a modulated plasmas generated by a pulsed DC power supply, working at frequencies up to 100kHz, with a voltage change from – 400V to + 200 V in a transient time in the order of microseconds. This fast modulation influences the plasma conditions in the discharge and therefore the intrinsic plasma parameters.

It is in the DC power supply reverse part of the modulation cycle, when the voltage from the power supply is biased positive in a few microseconds, that the ions gain enough energy to modify the properties of the depositions. Hiden's ESP*ION* Langmuir probe has ultra fast data acquisition speed to measure the plasma parameters in the microsecond time frame of the modulation cycle. This application note includes data that illustrates the use of the high speed ESP*ION* Langmuir probe system.

Experiment

The experiment was performed in a Hollow cathode discharge and the gas used was Argon and Oxygen. In the results presented here only the measurements performed with Ar are presented. The discharge was created with an Advanced Energy Inc. (AE) Pinacle Plus power supply and the measurements were obtained with a Hiden Analytical ESP*ION*. The ESP*ION* probe was used in its standard DC configuration, with a wire in place of the RF blocking inductor used in the ESP*ION* system for RF plasma applications.

The gas pressure was 50 mTorr. The plasma parameters were measured with the plasma DC modulation as follows:

Expt.1 100kHz freq, 2*μs* reverse time, 30W

Expt 2 60kHz freq, 3*μ*s reverse time, 46W

Expt 3 45kHz freq, 6*μ*s reverse time, 30W

System set-up:

A trigger signal is required from the modulated power supply to synchronise ESP*ION* data acquisition with the pulsed plasma. The ESP*ION* has a TTL trigger input that is triggered with the pulse from the power supply. A 100x Voltage probe was used to reduce the signal from the AE power supply, to provide signal to trigger the ESP*ION*, the voltage probe signal was converted to a TTL signal with a rise time of less than 1 microsecond. A schematic set up is show in figure 1.

A pulse generator triggered from the power supply was used to produce the TTL trigger pulse. In order not to introduce signal measurement time delays, the signal generator TTL pulse was required to have a step edge or rise time of less than 1 microsecond and a duration of 100 microseconds.

In order to have a successful time resolved measurements it is necessary to:

a) Check timing with oscilloscope

b) Supply a TTL-level signal to ESP*ION*

c) Generate TTL-level signal from driving voltage waveform.

Signal Acquisition Time

ESP*ION* starts data acquisition on receipt of the TTL signal. The ESP*ION* system responds to steps in the 100mA waveform steps within less than 500ns. Additional time of up to 62.5ns for recognition and a fixed 125ns for analog to digital conversion (ADC) is required. The ADC then captures the applied voltage within 350ns. It can be assumed that midpoint of the time interval at which the ESP*ION* 'sees' the change in the current is when the external trigger is applied to the ESP*ION*.

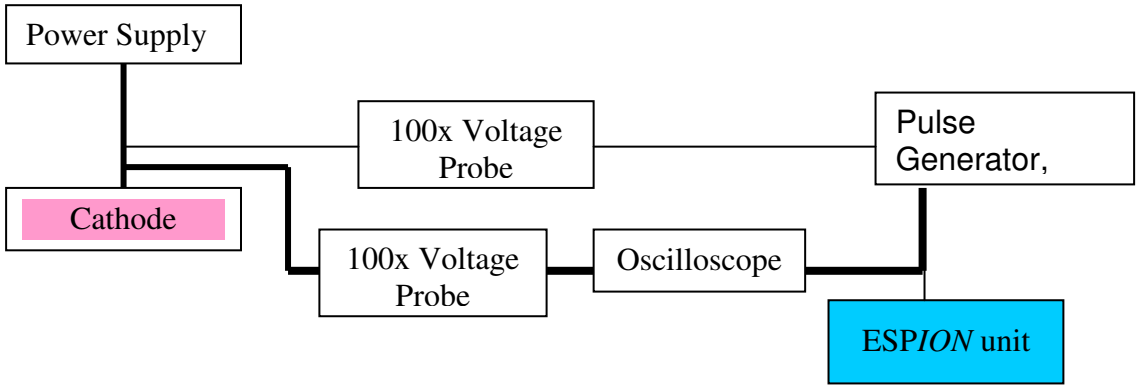
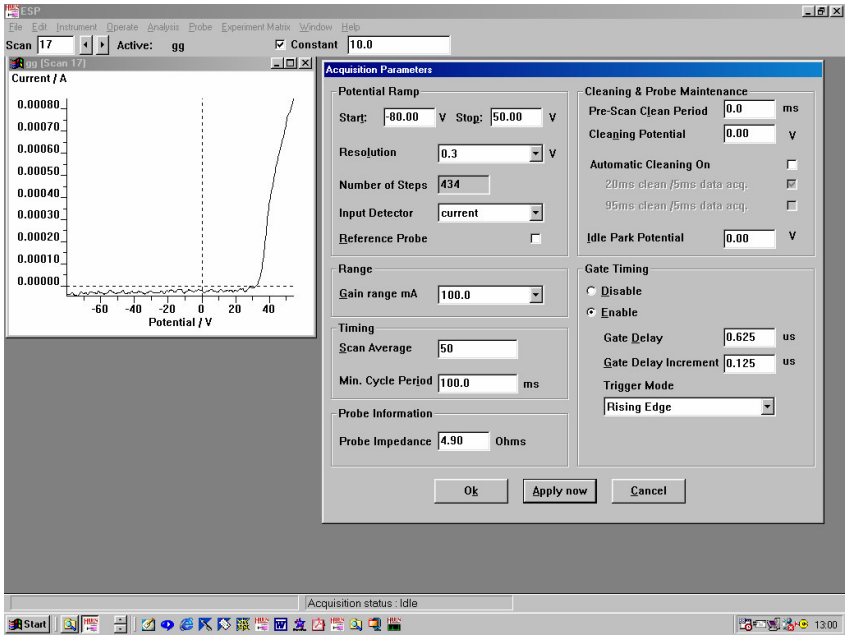


Figure 1. ESPION probe trigger input from Advanced Energy Power supply

The ESPION probe can obtain data ~ 30kHz sample speed, and automatically triggers on the next available trigger edge, should the trigger frequency > 30kHz and thus capable of data acquisition from pulsed plasma at >>30KHz. 100KHz modulation was used in experiment 1 detailed below.

The advantage of the ESPION is fast data acquisition capability, to within 0.125 microseconds of interval between each data measurement, it is not necessary to supply an external delay generator for the acquisition of the data.

An example of the data acquisition settings for the reverse time period from the voltage waveform is shown in Figure 2.



Expt. 1.0: Pulsed Plasma 100kHz, 2μs reverse time, 50mTorr, 30W

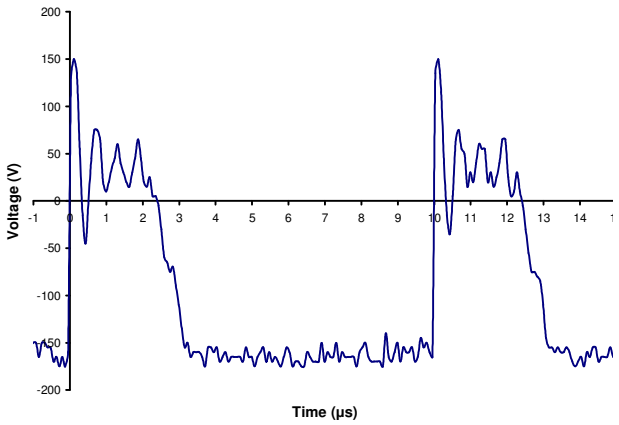


Figure 3. Voltage waveform

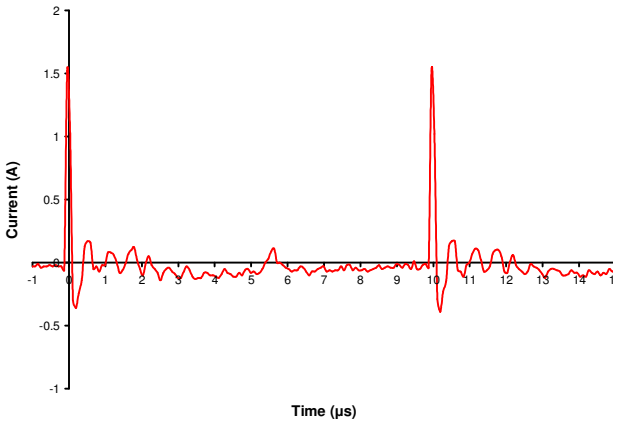


Figure 4. Current waveform

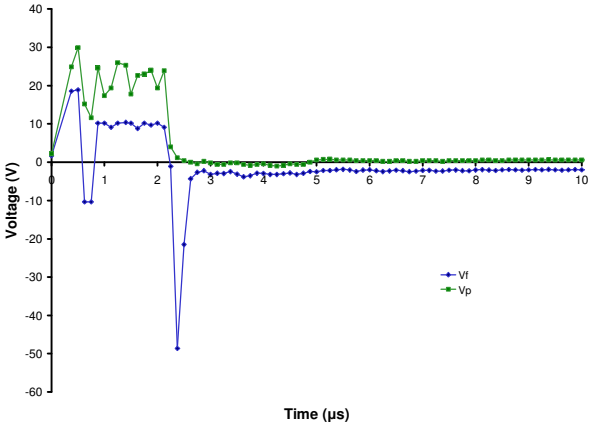


Figure 5. Plasma potential and plasma floating

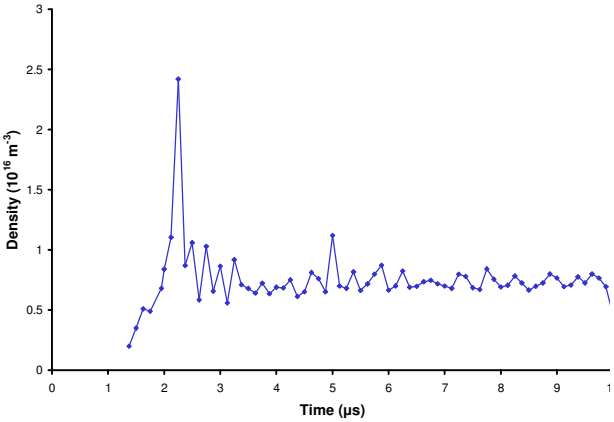


Figure 6. Plasma density

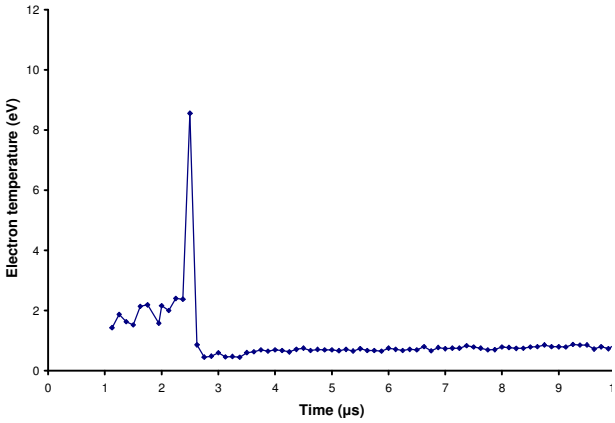


Figure 7. Electron temperature

Expt. 2.0 Pulsed Plasma 60kHz, 3μs reverse time, 50mTorr, 46W

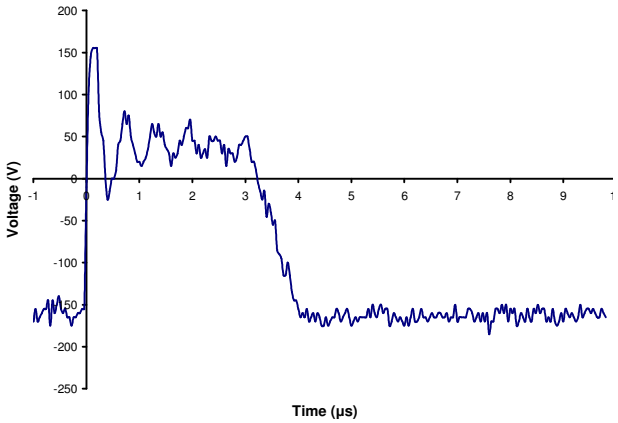


Figure 8. Voltage waveform

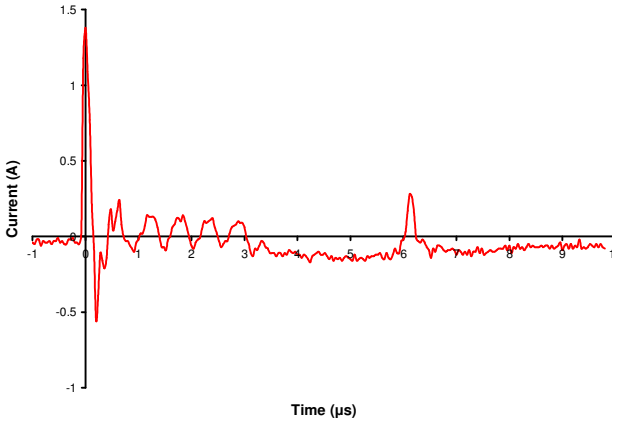


Figure 9. Current waveform

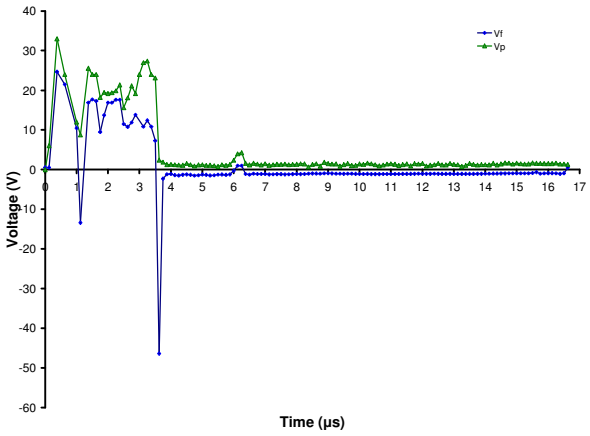


Figure 10. Plasma potential and plasma floating

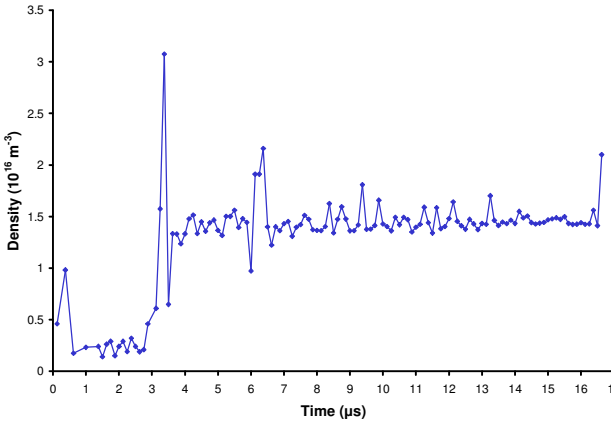


Figure 11. Plasma density

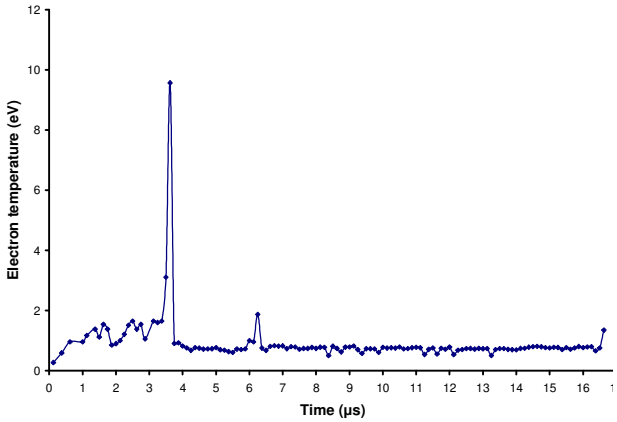


Figure 12. Electron temperature

Expt. 3.0 Pulsed Plasma 45kHz, 6μs reverse time, 50mTorr, 30W

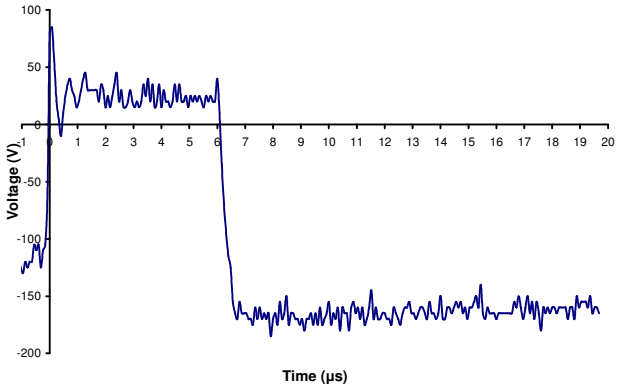


Figure 13. Voltage waveform

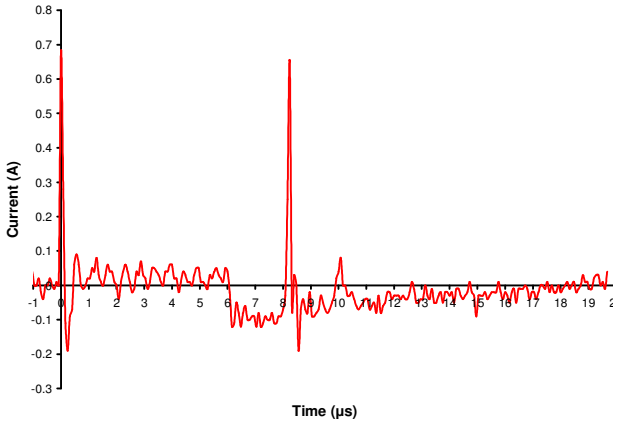


Figure 14. Current waveform

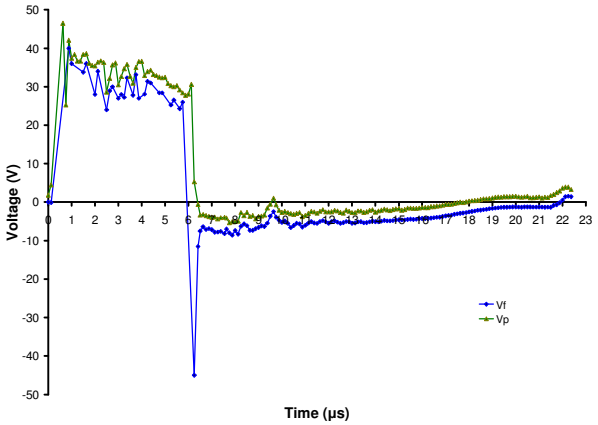


Figure 15. Plasma potential and plasma floating

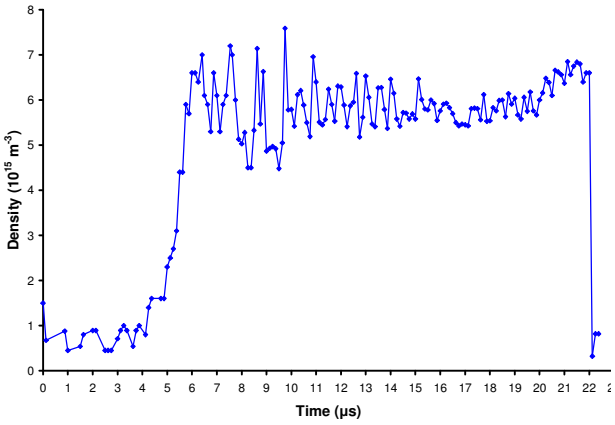


Figure 16. Plasma density

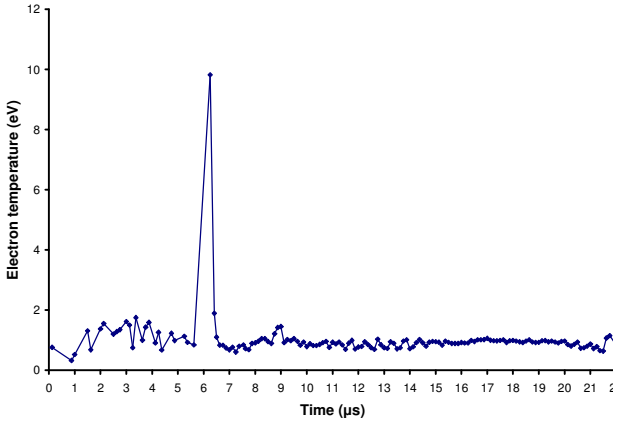


Figure 17. Electron temperature

Conclusion

The three experiment data sets illustrate that ESPION measures the key plasma parameters with a time resolution to 0.125 microseconds. From the data obtained it was shown that the plasma parameters (figures 5-7, 10-12 and 15-17) respond to the measured waveform of the Advanced Energy Inc. power supply (figures 3, 8 and

13) as expected.

The advantage of Hiden's ESPION is the fast data acquisition of the data measured to within 0.125 microseconds of interval between each measurement further it is not necessary to supply an external delay generator for the acquisition of the data due to the automatic time resolved data acquisition features of the ESPION system