Plamsa Diagnostics
Application Note 527

Plasma Diagnostics

ESP*ION* Advanced Langmuir Probe

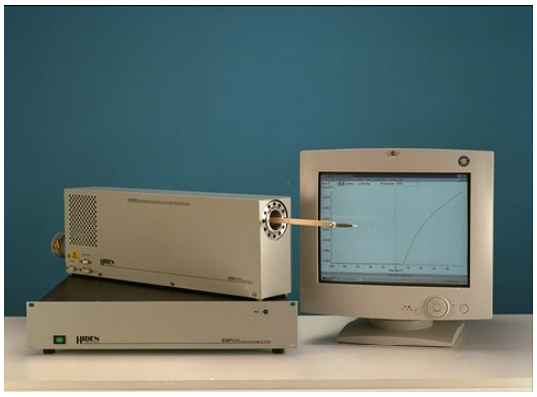
Summary

ESPION from Hiden Analytical is the most advanced, accurate and reliable Langmuir probe available to the researcher today. Developed by an experienced team of scientists and engineers drawn from academia and leading semiconductor equipment manufacturers, the **ESP**ION is designed to meet the demanding needs of both industrial and academic users who require fast, reliable and accurate plasma diagnostics. Independent evaluation using techniques which include the Plasma Oscillation Probe, Microwave based measurements and Hiden's EQP mass/energy analyser ensure the best ESPION TI 527-5_espion.doc confidence factor available in Langmuir probe measurements.

Manufactured in England by:

HIDEN ANALYTICAL LTD
420 Europa Boulevard, Warrington, WA5 7UN, England
t: +44 (0) 1925 445225 f: +44 (0) 1925 416518
e: info@hiden.co.uk w: www.HidenAnalytical.com

ESPION is controlled by ESPsoft, a powerful WindowsTM software package which eliminates the need for a detailed understanding of Langmuir probe theories. The software automatically adjusts the acquisition parameters and returns the full set of calculated plasma parameters from a range of advanced analysis routines (OML-Laframboise, ABR, Druyvestyn-EEDF). ESPsoft features a Design of Experiment (DOE) Interface, a unique experiment management tool which permits the user to organise and set-up experiments ahead of time and collect Langmuir probe data more efficiently.



MEASURED PLASMA PARAMETERS

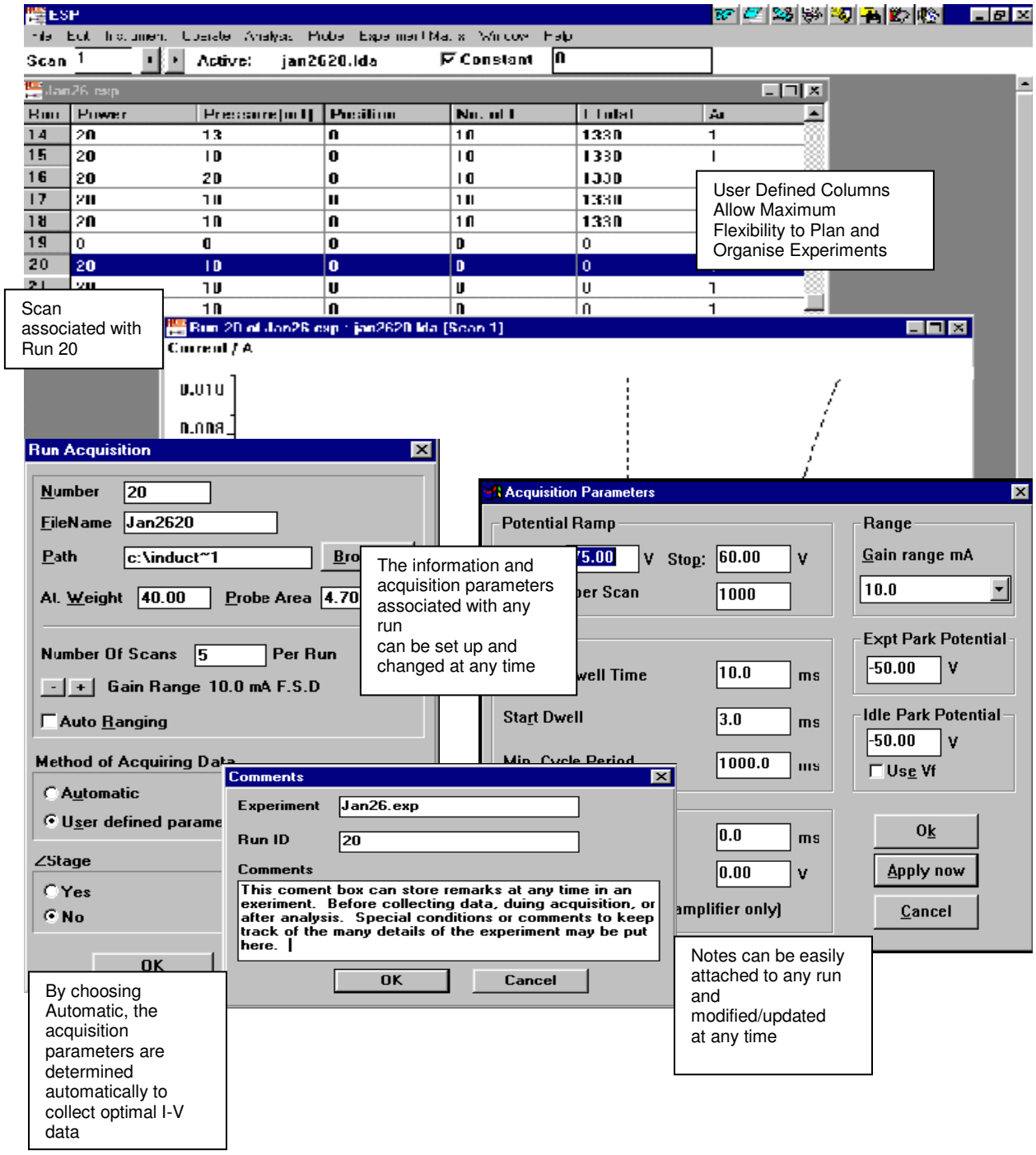
- Electron temperature up to 10 eV
- EEDF
- Plasma potential
- Floating potential
- Debye length
- Ion and electron density over the range 1014 - 1019 m-3

STANDARD FEATURES

- Reference probe actively tracks and compensates for plasma potential drifts in systems with poor or no ground reference
- Fully integrated & software controlled gate circuitry for pulsed plasma operation
- Gas cooled probe for high temperature applications
- 1A auto switching current range for high density applications
- -200 V to +100 V scan range with opto-isolated probe drive and measurement electronics
- RS232/LAN PC comms.

DESIGN OF EXPERIMENT (DOE) INTERFACE

The ESPION Design Of Experiment (DOE) Interface is a powerful experiment management tool, which allows the user to plan and set-up experiments ahead of time. Acquisition parameters and experimental conditions are associated with each run beforehand. Any deviation from these conditions can be noted in the associated run dialogue box at any time during the acquisition.


ESP
Scan 1
Active: jan2620.lda
Constant
User Defined Columns Allow Maximum Flexibility to Plan and Organise Experiments
Scan associated with Run 20
Run Acquisition
Number 20
FileName Jan2620
Path c:\induct~1
At. Weight 40.00
Probe Area 4.70
Number Of Scans 5
Per Run
Gain Range 10.0 mA F.S.D
Auto Ranging
Method of Acquiring Data
Automatic
User defined parame
Stage
Yes
No
OK
The information and acquisition parameters associated with any run can be set up and changed at any time
Acquisition Parameters
Potential Ramp
Stop: 60.00 V
1000
Range
Gain range mA
10.0
Expt Park Potential
-50.00 V
Idle Park Potential
-50.00 V
Use Vf
Start Dwell 3.0 ms
1000.0 ms
0.0 ms
0.00 V
Ok
Apply now
Cancel
Comments
Experiment Jan26.exp
Run ID 20
Comments
This coment box can store remarks at any time in an exeriment. Before collecting data, duing acquisition, or after analysis. Special conditions or comments to keep track of the many details of the experiment may be put here.
OK
Cancel
Notes can be easily attached to any run and modified/updated at any time
By choosing Automatic, the acquisition parameters are determined automatically to collect optimal I-V data

MEASURED PLASMA PARAMETERS

• Ion and electron density over the range

• 1014 - 1019 m-3

• Electron temperature up to 10 eV

• EEDF

• Plasma potential

• Floating potential

• Debye length

Plasma models used - Orbital motion Limited (OML) and Allen Boyd Reynolds (ABR)

GENERAL

- Voltage range -200V to +100V
- Current range 20µA to 1 A
- Opto-isolated probe drive and measurement electronics.

TIME RESOLUTION FOR PULSED PLASMA

- Edge (rising/falling) or level (high/low) triggered
- Trigger edge resolution - 62.5 nanosecond
- Max. trigger pulse frequency - 3 MHz

DATA ACQUISITION

- Minimum resolution -12 bits
- Fastest sample time - 15 scans/s
- Acquisition speed approx. - 69,000 points/s
- 2 data channels - tip current, ref. voltage.
- Acquisition system bandwidth-1MHz

system response

- Rise/fall time - 0.5useconds with RF
- See note 1 - compensated probe 0.375useconds with uncompensated probe

CLEANING

- Clean potential - -200V to 100 V
- Inter-scan cleaning* - variable

20ms cleaning and 5ms acquire on 25 ms cycle, or 100ms cleaning and 5ms acquire on 105ms cycle. Probe is toggled between clean/acquire.

DIMENSIONS

- Tip length - 10mm standard
- Tip diameter - 0.15mm standard (options available)
- Probe diameter - 8.0mm
- Insertion length - 316.5mm standard (other insertions available)

Mounting flange

- DN-35-CF (70mm/2.75” OD) is standard

(flange adapters optional)

Interface module - (19” rack mounting)

- Height - 2U (89mm/3.5”)
- Depth - 458mm/18” (including cable connectors)

System power requirements

220/240, 110/120 VAC, 50/60 Hz <1.0 KVA

PROBE CONSTRUCTION

- Body - alumina
- Compensation - hard anodised
- Electrode - aluminium
- Tip materials - tungsten / tantalum/ molybdenum / nickel

(others on request)

- Reference electrode - stainless steel

Z TRANSLATORS

Fully automatic, software controlled z motion drives are offered for spatial mapping of plasma parameters

- Stroke - 300mm, 600mm, 915mm
- Speed - 12.7mm/s standard (25.0mm/s option)

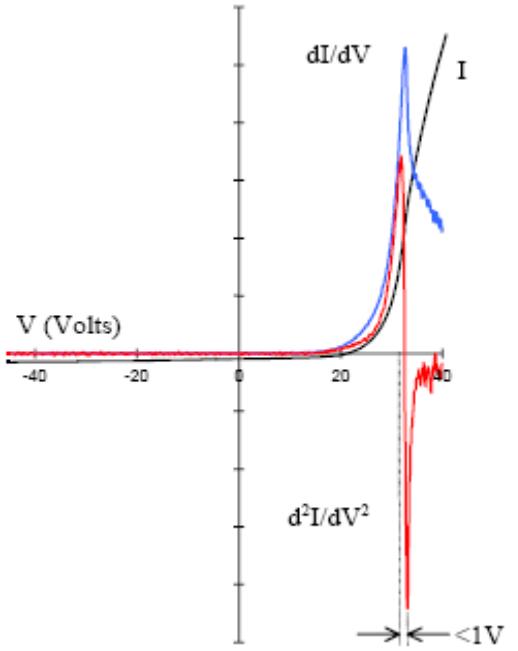
faster operation possible (consult Hiden)

PC INTERFACE

- RS232 / 10 base 2 LAN
- WindowsTM 3.1x / 95 / 98

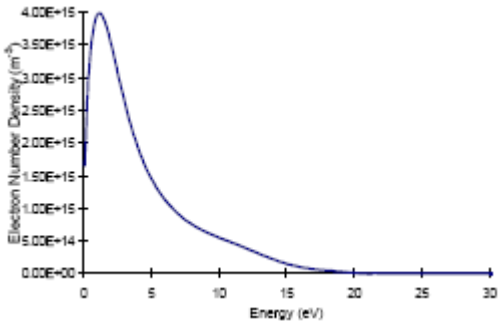
Note 1. Rise and fall times stated are the ESPION system response to voltage step inputs at the probe tip, measured with and without the RF compensation components fitted. Effects due to the plasma are not included in these values. The ESPION RF compensation components should not be fitted unless the plasma has RF stimulation, and for RF modulation rates greater than 10 KHz, the interaction between the plasma and the compensation system must be taken into account.

RF COMPENSATION



A good indication of a well compensated probe is that the peak of the EEDF occurs near zero energy as it should for a Maxwellian plasma. The use of Langmuir probes in plasmas generated by rf power requires provision to remove the AC bias voltage component which arises between the plasma and the probe tip. A perfectly compensated probe would measure the current as a function of the difference between the tip and background plasma potentials without any time averaging of the rf fluctuations. A very simple way of assessing the quality of rf compensation is by evaluating the peak separation of the second derivative of the I-V characteristic (see figure above). Perfect compensation would show no displacement between the positive and negative going peaks (both occurring at Vp) in the second derivative of the I-V trace. The peak separation increases with increasing fluctuations and as a

practical limit, a difference below 1 Volt is considered excellent.



The data illustrate the excellent RF compensation included with ESPION Langmuir probes.