Plasma Metrology System

Hercules® PMX

Operator Manual

Edition: February 2008

plasmetrex
plasma metrology experience

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II. PREFACE

Please read the Operator Manual carefully. If you have any questions, please call the Plasmetrex service number +49-30 63 92 50 44.

For proper operation of Hercules® a sufficient RF grounding of the chamber wall is required (please see Chapter 1.4) !

The sensor should be located in the chamber wall above the wafer level in process position and not screened from by chamber parts, e.g., a liner.

Please make sure that sensor and sensor cable are separated by at least 30 cm (1 ft) from the RF power cables to avoid electromagnetic interference.

Disassembling of sensor or sensor parts will void the warranty.

Please check the DC bias voltage / RF peak voltage measurement point and compare the Hercules® value to the displayed value at the tool monitor.

Information concerning the Hercules® Viewer and the Hercules® LotViewer can be found in the corresponding manual.

For further operations, refer to the Application Data Base (http://plasmetrex.com/adb/home.html) and Application Guide (http://plasmetrex.com/ag/home.html).

Always disconnect power before opening the instrument or changing the fuse!

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Chapter 1
Fundamentals

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1. FUNDAMENTALS

This chapter describes the fundamental principles of a partially ionized, chemically reactive plasma discharges upon which the Plasma Metrology System Hercules® is based.

Plasma processing

Plasma based surface processes are indispensable for manufacturing very large-scale semiconductor integrated circuits (ICs) used in the electronics industry.

Plasma process

The plasma generates ions and etching or deposition species from the process gas in the chamber. The species impact with the surface layer (semiconductor). Reaction products are generated and pumped out. There is always a combination of physical and chemical reactions.

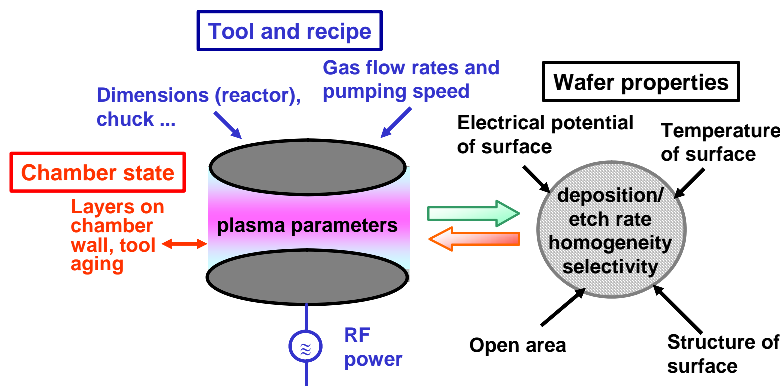

Fig. 1.1: Influence of plasma parameters, tool, and recipe on chamber state and wafer properties

The wafer properties also affect plasma parameters. Many parameters (tool and recipe, wafer properties, and chamber state) interact. An unambiguous relationship is not possible for all plasma process steps.

1

1.1 Characterization of RF Discharge

Plasma

Plasma is often called the fourth state of matter. Plasma is a collection of free charged particles moving in random directions and is usually electrical quasi-neutral (see Fig. 1.2). This state is characterized by a common charged particle density $n_e \approx n_i \approx n$ particles/cm^3.

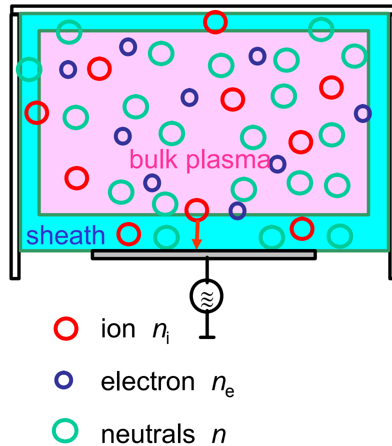

Fig. 1.2: Schematic view of a plasma

RF discharge

The capacitive driven radio frequency (RF) discharge is commonly used for materials processing. However, the required processing (etching, deposition) of such discharges is generally the result of poorly understood physical and chemical processes, which occur in the gas phase and at the gas/solid interface. In this respect, the role of the sheaths in front of the electrodes is of fundamental importance for understanding the discharge physics of the asymmetrical capacitively coupled RF discharge. Due to their small mass (large mobility) and high temperature, the electrons strive to leave the bulk plasma. The sheath (dark space) keeps the electrons within the bulk plasma (shielding) by a retarding electric field build-up when electrons leave the outer regions of the plasma. The electrons-neutrals collisions take place in the bulk plasma where ions and electrons are created. The radicals for etching are formed in the bulk plasma. The ions move to the sheaths. The acceleration of ions provides energy for etching. This energy can be increased by external (RF) potentials.

1.2 The Self Excited Electron Resonance Spectroscopy (SEERS) Method

Using a hydrodynamic approach for the plasma bulk, the inert mass of the electrons can be treated as an inductance and the collisions with neutral particles, including power dissipation in the expanding sheath, as a resistance (see Fig. 1.3). Taking into account the capacitive behavior of the space charge sheath, the plasma can be described as a damped circuit oscillator circuit. The nonlinear sheath capacitance excites the plasma by causing damped oscillations close to the geometric resonance frequency, which lies well below the plasma frequency (Langmuir frequency). For asymmetrical discharges and sinusoidal discharge, the current is known to be the sum of a saw tooth shaped part plus a damped oscillation (please see Jap. J. Appl. Phys. 36(1997), 4625-4631).

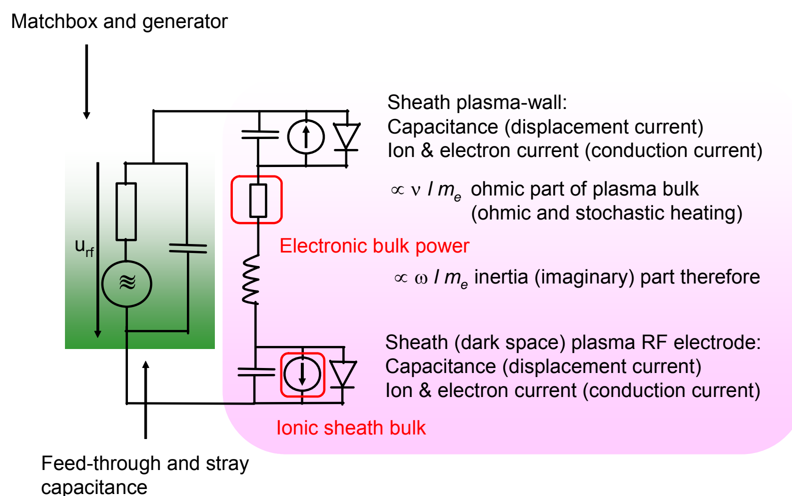

Fig. 1.3: Equivalent circuit of the RF discharge

The Plasma Metrology System Hercules® is based on the Self Excited Electron Plasma Resonance Spectroscopy (SEERS).

1

1.3 The Plasma Metrology System Hercules®

1.3.1 Basic setup of Plasma Metrology System Hercules®

No calibration of Plasma Metrology System Hercules® needed!

For the installation of the Plasma Metrology System Hercules® are necessary:

- AC power cable
- Sensor cable
- Sensor
- Keyboard with trackball
- Network cable (optional).

For additional details please see capter 6.

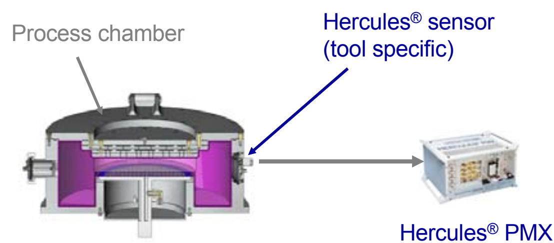

Fig. 1.4: Plasma Metrology System Hercules® in connection to a plasma tool

The Hercules® sensor head is mounted flush to the wall of the chamber and must be properly grounded. The sensor does not affect plasma or process conditions. The Hercules® sensor measures a small component of the RF current. An insulating layer on the sensor can be treated as a large capacitance and adds a negligible serial impedance (<< 50 Ω). The current ratio of the measured current and the real discharge current is be determined by the nonlinear model.

For further details, see the Chapter 2 or visit http://plasmetrex.com/sdb/home.html .

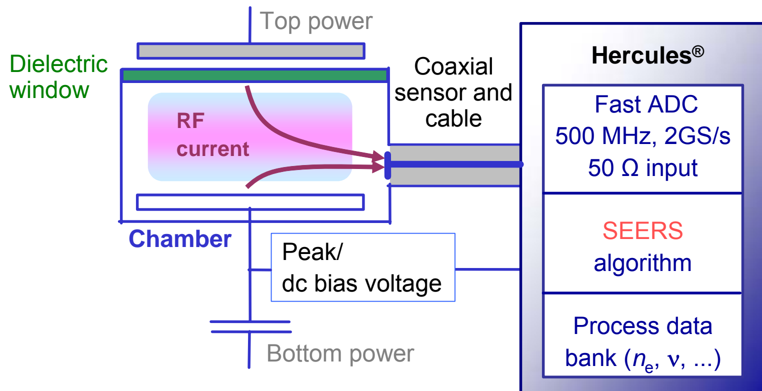

Fig. 1.5: Basic setup

The Plasma Metrology System Hercules® provides a high temporal resolution, using a fast numerical algorithm. The RF peak voltage or DC bias voltage is measured by using a capacitive or resistive voltage divider, respectively.

1.3.2 Determination of Plasma Parameters and their Influences on Tool and Process Parameters

SEERS allows the determination of the volume-average electron plasma density n_e, the effective electron collision rate υ_{eff}, and the power dissipated by electrons in the plasma body P_B.

Note: **Please note: Due to 1/n averaging, ranges of lower density get a higher weighting!**

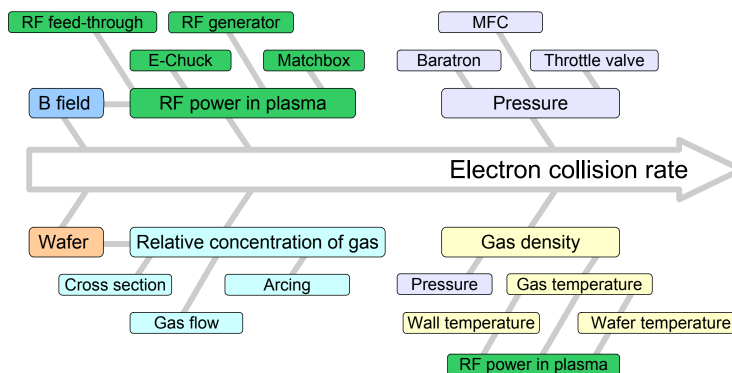

Fig. 1.6: The influence of etch tool parameters on the electron collision rate.

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Electron collision rate

The collision rate of electrons υ (please see Fig. 1.7) depends on:

- Power and pressure (recipe)
- Gas mixture (recipe)
- Impact of electrons on chemistry
- Feedback from chemistry via cross sections and relative concentration of species

and can be calculated for magnetic field $B = 0$:

$$\nu = \nu_{eff} \approx \nu_{stoch} + \frac{p}{kT_n}\left[\left(\frac{p_1}{p} + \frac{p_2}{p} + \ldots\right)\sigma\left(\frac{1}{v_e}\right) v_e\right]$$

(1a)

and for a weak magnetic field $B < 30$ G:

$$\nu_{\perp} = \nu_{=} \cdot \left\{1 + \frac{\omega_{ce}^2}{\omega^2 + \nu^2}\right\}$$

with $\omega_{ce}^2 = eB / m_e$

$\nu_{=} = \nu \; (B = 0)$ → collision rate parallel to the B-field

$\nu_{\perp}$ → collision rate perpendicular

(1b)

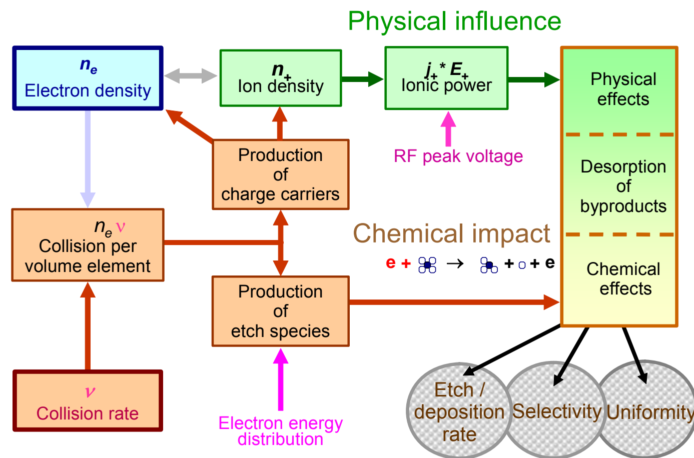


Fig. 1.7: Influence of electron density and collision rate on the etch process.

For magnetically enhanced plasmas, the scaling law of electron density is given by

$$n_e \propto B_0{}^2 U_{peak} \tag{2}$$

Please see M. A. Lieberman, A.J. Lichtenberg, Principles of plasma discharges and materials processing, John Wiley & Sons, Inc., 2005.

The stochastic heating is a collisionless electron heating mechanism at the interface between bulk plasma and sheath.

Bulk power

The bulk power P_B is:

$$P_B = R_B \sum_k I_k{}^2 \tag{3}$$

with:

I_k: harmonics of discharge (plasma current)

R_B: plasma resistance.

Plasma resistance

The plasma resistance R_B (ohmic part of the plasma bulk resistance) is:

$$R_B = \frac{\nu_{eff} \cdot m_e \cdot l}{e^2 \cdot n_e \cdot A} \tag{4}$$

with:

1

n_e: electron density

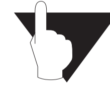
υ_{eff}: effective collision rate of electrons

m_e: electron mass

A: electrode area

l: effective length of plasma (approx. electrode gap).

Note: **The process window for each etch tool must be specifically defined. This is due to the influence of the numerous parameters, e.g., RF power in plasma, pressure, B-field, wafer, relative concentration of gases, and gas temperature.**



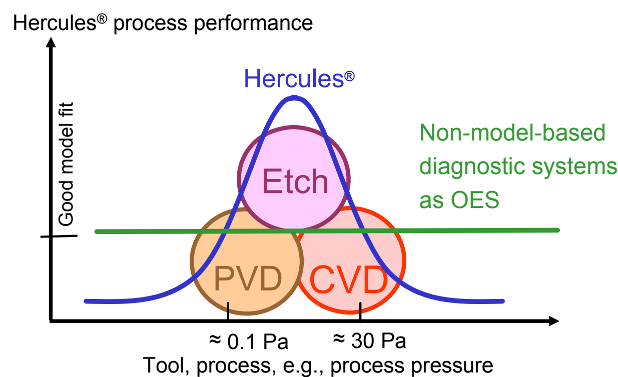


Fig. 1.8: Hercules® process performance

Hercules® process performance

Fig. 1.8 shows the optimal pressure range in which the Plasma Metrology System Hercules® operates.

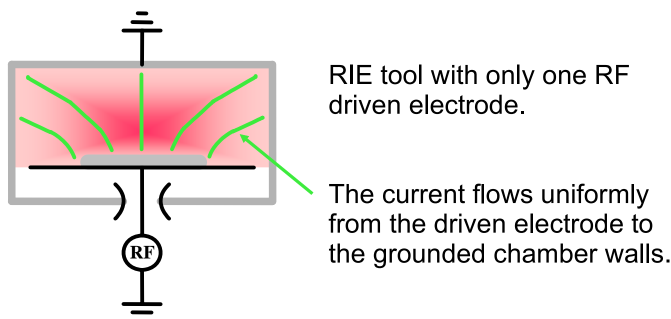
1.3.3 Setup for different Discharge Modes

There are different types of RF power dissipation - capacitive and inductive. This leads to different chamber designs with different RF current distributions.

icpmode = 0:

RIE: Pure capacitive excitation with axial and radial RF current. This is called icpmode = 0 in the setup file (please see also table 5.1 in Capter 5.2).

Examples for this mode: Lam® Rainbow, Applied Materials® E-MAX®, HART™, SUPER-E™



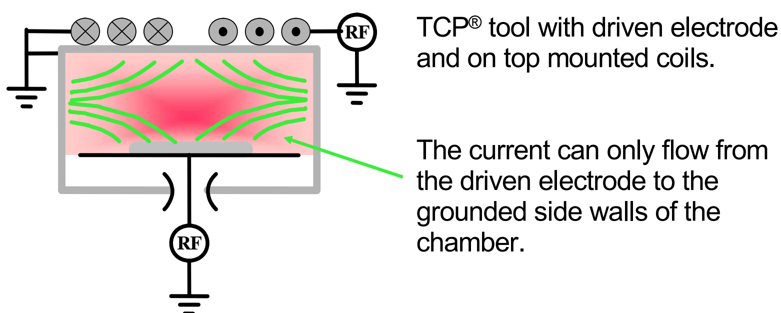
icpmode = 0

Fig. 1.9: Principle for discharge mode: icpmode = 0.

icpmode = 1:

ICP/TCP®: Additional inductive RF power dissipation on top of the chamber.

Examples for this mode: Lam® TCP®, Applied Materials® DPS I/II



icpmode = 1

Fig. 1.10: Principle of discharge mode: icpmode = 1.

icpmode = 2:

ICP at side wall: In comparison to the RIE case additional inductive excitation at the (now dielectric / insulating) side wall. This results in a zero radial current at the dielectric side wall.

Example for this mode: Oxford Plasma Technology Plasmalab system 100, ICP 300

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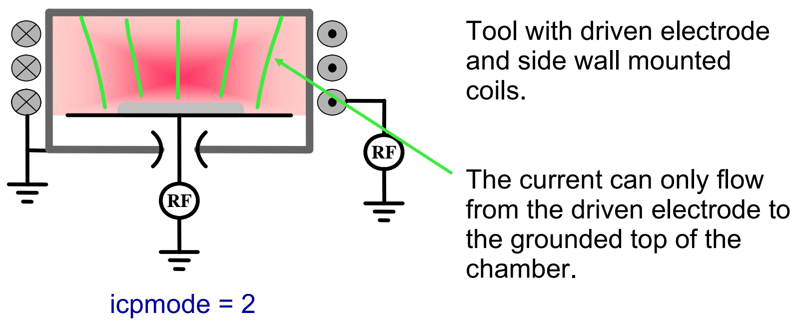


Fig. 1.11: Principle of discharge mode: icpmode = 2.

1.4 Specifications of the Plasma Metrology System Hercules® PMX

The Plasma Metrology System Hercules® operates under the following conditions:

Application: Process development, production monitoring, maintenance.

Model: Non-iterative SEERS algorithm.

Core parameters: Electron density, collision rate (effective collision rate for momentum transfer including stochastic heating).

Other parameters: Bulk power, sheath width, RF peak voltage (DC bias), plasma resistance, and harmonics of RF current.

Chamber setup: Cylindrical geometry, capacitive and/or unshielded inductive RF power coupling.

Pressure range: Depending on gas, reactor geometry, and RF power.
Upper limit: typical 35 Pa (260 mTorr), 133 Pa (1Torr) for electropositive gases.

Frequency: 10 - 100 MHz, also dual frequency applications.

Bandwidth: 1 GHz.

Sampling rate: 2 GS/s.

Number of channels: 1 channel, expandable up to 4 channels.

Pre-conditions:

- 1. Sensor flange above wafer level in process position, not in shadow of other chamber parts.
- 2. Sufficient RF grounding of chamber wall and liner.
- 3. RF peak voltage measurement point recommended.

Weight: 10 kg.

Dimensions: H: 188 mm, D: 315 mm; W: 345 mm.

Technical data:

- AC power input: 100 - 240 VAC
- Frequency: 50 - 60 Hz
- Power consumption: max. 250 W
- Main fuse: T2L/250 V, IEC 60127-2/III.

1

Temporal resolution: 70 to 600 ms depending on number of channels and cycles.

Hardware: Controller unit: Windows^{TM}; Compact PCI, 2 x network adapter 10/100, digitizer card Acqiris DP 214.

Software: ScopeServer for hardware control. Hercules® PMX as SEERS implementation.

CommServer: Communication to APC, SPC or other data base systems.

Interfaces: SECS/HSMS, SilverBox^{TM}, Brookside (LamStation^{TM}), Lam 2300^{TM} (Domino); TICS, and customized interfaces on request.

Data Analysis Tools: HercViewer (single or lot analysis) and HercLotViewer for mass data (lots) anaysis.

For complete and up-to-date specification, visit the Plasmatrex website (http://plasmetrex.com/dl/home.html).

Technical details subject to revision!

Table 1.1: Ambient requirement

	Operation	**Shipment and Storage**
Temperature	5 °C to 40 °C	- 20 °C to 60 °C
Relative humidity	20 % to 80 %	10 % to 90 %
Vibrations - MEN F14 - DP214	5 to 500 Hz: 0.5G 5 to 500 Hz: random MIL-PRF-28800F	5 to 500 Hz: 1G
Shock - MEN F14 - DP214	IEC 68-2-27 15G/11ms 30 G, half-sine pulse, MIL-PRF-28000F	IEC 68-2-27 15G/6ms

Table 1.2: Standards

	Norms
Product safty guideline	**SEMI S2-93A**
Safty requirements for electrical equipment	**EN 61010 - 1 / IEC 61010 - 1**
Electro**M**agnetic **C**ompatibility	**Emission: Class B** **EN 61326 -1 : 1997 A1: 1998, A2: 2001 A3: 2003,** **EN 55011, EN 55022, EN 61000-3-2: 2000,** **EN 61000-3-3: 1995 A1: 2001,** **Immunity: Class B** **EN 61326 -1 : 1997 A1: 1998, A2: 2001 A3: 2003,** **EN 61000-4-11, IEC 61000-4-2, IEC 61000-4-3,** **IEC 61000-4-4, IEC 61000-4-5, IEC 61000-4-6**

Table 1.2: Standards

	Norms
Tested by TÜV Rheinland Product Safety GmbH TÜV Rheinland Group	**Report Reference No`s.:** **21118673_002 dated 2005-02-04,** **21118029_001 dated 2005-02-21,** **21116873_003 dated 2005-02-21.**

Standards

Standards
General Board Standards

- CompactPCI® Core Specification PICMG 2.0 R3.0
- CompactPCI® Expres Specification EXP0 R1.0

EMC

EMC
Emission:

- EN 55011
- EN 55022

Immunity:

- EN 61000-4-2(ESD)
- EN61000-4-4(burst)

Enviremental Specifications

Enviremental Specifications

- Temperature range (operation): 0 ... + 35°C
- Temperature range (storage): 0 ... + 35°C
- Relative humidity (operation): max. 90 % non-consensing
- Relative humidity (storage): max. 95 % non-consensing
- Airflow: min. 150 m^3/h
- Altitude: - 300 m to + 3,000 m
- Shock: 15 g / 11 ms
- Bump: 10 g / 16 ms
- Vibration (sinusoidal): 1 g / 10 ... 150 Hz

Technical Data

Technical Data

Industrial Micro Processor Card

Industrial Micro Processor Card

CPU

- ULV Pentium® M 760
- 1.0 processor core frequency
- 400 MHz front-side bus frequenc
- Chipset
  Northbridge: Intel® 915GM
  Southbridge: Intel® ICH6M

1

Memory

- Up to 2GB SDRAM system memory
  Soldered DDR2
  400 MHz memory bus frequency
  Dual-channel, 2 x 64 bits
  4 Mbits boot Flash
  Serial EEPROM 2 kbits for factory settings
  CompactFlash® card interface
- Via on-board IDE
  Type I
  True IDE
  DMA support

Graphics

- Integrated in 915GM chipset
- Analog CRT DAC interface support
- Supports max. DAC frequency up to 400 MHz
- 24-bit RAMDAC support
- Maximum resolutions: 2048 x 1536 pixels 16 M colors @ 75 Hz refresh rate analog); 1600 x 1200 pixels 16 M colors @ 60 Hz (digital)
- Incorporates PanelLink Digital technology (Silicon Image)
- VGA connector at front panel

I/O

- USB
  Two USB 2.0 ports via Series A connectors at front panel
  Four USB 2.0 ports via side-card connector
  Two USB 2.0 ports via rear I/O on request
  UHCI implementation
  Data rates up to 480 Mbits/s
- Ethernet
  Two 10/100/1000Base-T Ethernet
  RJ45 connectors at front panel
  Ethernet controllers are connected by two x1PCIe lanes
  On-board LEDs to signal activity status and connection speed

Hard disk

- MHW2080BH: 80GB
  Rotational Speed 5,400 rpm
  Average seek time 12 ms
  Interface ATA-8, Serial ATA-2.5 (1.5Gb/s)
  Buffer size 8 MB

Digitizer

Digitizer

- 1 channel
- 1 GHz (PMX 1000) or 500 MHz (PMX 500) bandwidth

- 2 GS/s sampling rate
- Acquisition memory from 256 kpoints up to 16 Mpoints (optional)
- 50 Ω and 1 M Ω input impedance
- Full front-end amplification with internal calibration
- Mezzanine front-end
- Complete pre- and post-triggering
- Low dead-time (< 800 ns) sequential recording with time stamps for up to 8000 segments
- Built-in 5 ps Trigger Time Interpolator (TTI) for accurate timing measurements

2

Chapter 2

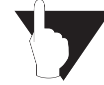
Sensor Installation

Edition: February 2008

2. SENSOR INSTALLATION

2.1 Overview

Note: **Additional information about our sensors and sensor installation can be found on the Plasmetrex website (http://plasmetrex.com/sdb/home.html).**



Make sure all delivered parts match your order.

Make sure the process chamber is in a "down" state and properly vented before installing the sensor.

The ideal time to install the sensor installation is during preventive maintenance.

Each RF plasma tool requires a specific sensor. Installation instructions are provided with the sensor. They can also be found on the Plasmetrex website
(http://plasmetrex.com/sdb/home.html).
Read the instructions carefully before installing the sensor.

Compare the geometrical dimensions of the view port and the sensor before installation.

The sensors for general applications are made from aluminum with a hard anodized surface.

2

2.2 Custom sensors

Custom sensors for special applications and/or special chambers are designed on request.

The following information are needed:

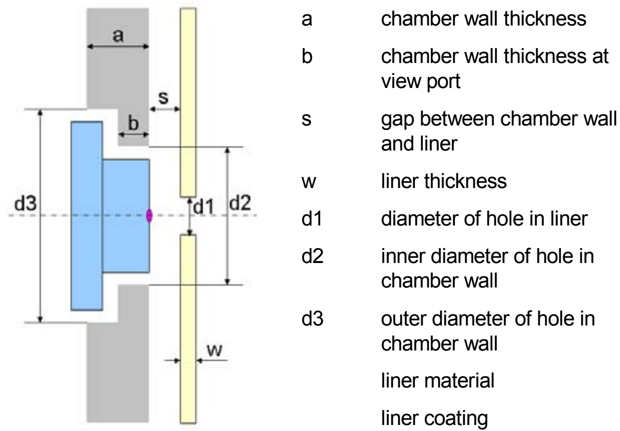


Fig. 2.1: Chamber wall and liner

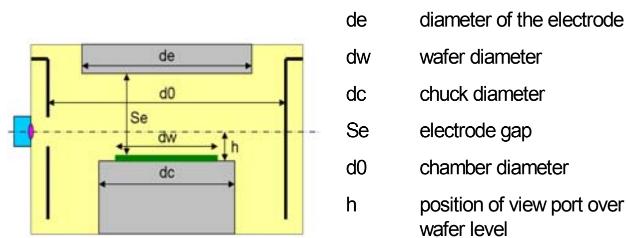


Fig. 2.2: Chamber dimensions

Contact the Plasmetrex technical support for questions regarding custom sensors (http://plasmetrex.com/contact.html).

3

Chapter 3
Hardware

Edition: February 2008

3. HARDWARE and SAFTY

Note: **Make sure all delivered parts match your order.**

Caution: **Make sure you disconnect the AC power cord prior to cleaning the Plasma Metrology System Hercules®. For cleaning, only use a lint-free cloth with Ethanol or DI water.**

Technical Data:

- AC power input: 100 - 240 VAC
- Frequency: 50 - 60 Hz
- Power consumption: max. 250 W
- Main fuse: T2L/250 V, IEC 60127-2/III.

To change the fuse:
1. Turn off power and disconnect power cord from instrument.
2. The fuse is located in the fuse drawer at the power inlet. Pull out the drawer and replace the fuse, then re-insert the fuse drawer.

The central unit of the Plasma Metrology System Hercules® is a compact PCI system (see Fig. 3.1).

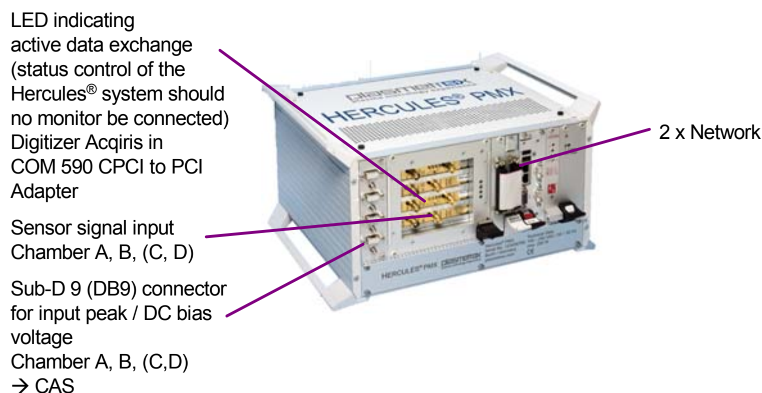


Fig. 3.1: The Plasma Metrology System Hercules®

The Sub-D 9 (DB9) female connector at the bottom of the rearside provides for the RF peak / DC bias voltage input.

The cable adapter set (CAS, see cChaper 4.2) connects the inputs to

- the test point of the matchbox so as to provide either the RF peak or DC bias voltage (< 10V).

The figure 3.2 shows the pin assignment for the Sub-D 9 (DB9) connector. Refer to Chapter 4 for additional

3

information.

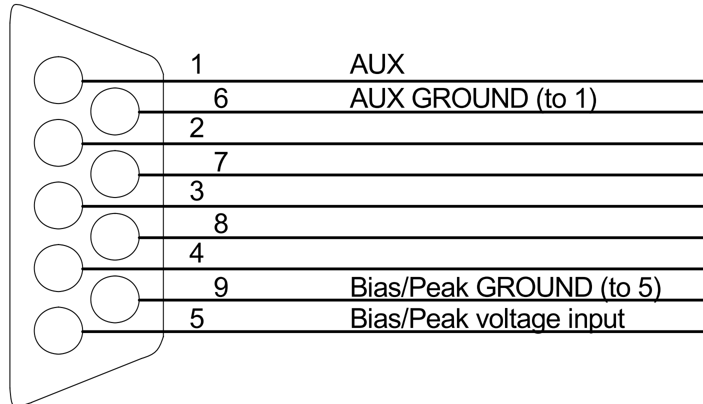


Fig. 3.2: Sub-D 9 (DB9) Pin Assignment

Table 3.1: Overview of accessories of Hercules® PMX

Part name	Product	Description/application
Accessories depend on tool configuration and application		
IMC-KEYB-USUSBT (KB)	Keyboard Cherry-mini G84-4400-LUBUS-USB with trackball	
CSERG2236645	Low damping cable (50 Ω) with taff tolerated (or ± 0.5 %) wave impedance for Hercules® sensor, BNC-SMA, Length: 4.5 m with square loop ferrite	Sensor cable
CSERG2236630F	Low damping cable (50 Ω) with narrow tolerance (or ± 0.5 %) wave impedance for Hercules® sensor, BNC-SMA, Length: 3.0 m with square loop ferrite	Sensor cable
CSERG2236615	Low damping cable (50 Ω) with narrow tolerance (or ± 0.5 %) wave impedance for Hercules® sensor, BNC-SMA, Length: 1.5 m with square loop ferrite	Sensor cable
CAAD-SET-AM (CAS/AM)	Adapter Set for APPLIED MATERIALS® [Matchbox **phase IV**, Sub-D 25 (DB25)] consisting of 1.) sub-D 9 (DB9) extension cable 5 m 2.) adapter cable Sub-D 25 (DB25) (matchbox phase IV) / Sub-D 9 (Hercules®)	normally for APPLIED MATERIALS® MxP™, Mark II™, MxP+™, DPS™

Table 3.1: Overview of accessories of Hercules® PMX

Part name	Product	Description/application
CAAD-SET-AMHE (CAS/AMHE)	Adapter Set for APPLIED MATERIALS® [Matchbox **high efficiency**, Sub-D 9 (DB9)] consisting of 1.) Sub-D 9 extension cable 5 m 2.) adapter cable plug Sub-D 9 [DB9) (matchbox High Efficiency) / plug Sub-D 9 (DB9) (Hercules®)	for APPLIED MATERIALS® eMxP+™, SUPER e™, eMAX™
CAAD-SET-PTX (CAS/PTX)	Adapter Set for LAM® TCP® 9X00/ PTX including peak voltage/dc bias test point connection on 131P2/ 131J2	for LAM® TCP® 9X00/PTX, Connector at 131P2/131J2
CAAD-SET-LAM2300 (CAS/2300)	Adapter Set for LAM® 2300™, peak voltage test point on plug 1b3p45	for LAM® 2300, Connector at the bottom matchbox at the plug 1b3p45
CAAD-SET-HART (CAS/HART)	Adapter Set for APPLIED MATERIALS® HART™, BNC connector at matchbox “Navigator”	for APPLIED MATERIALS® HART™
CAAD-SET-SCCMDD (CAS/SCCM/DD)	Adapter Set for TEL™ SCCM™, RG 174	for TEL™ SCCM™ OXIDE, Connector at upper matchbox, Sub-D 25
CAAD-SET-SCCMK (CAS/SCCM/KO)	Adapter Set TEL™ SCCM™, (200 mm), screened line 9 pin, Type: LiYCY/ RG 174	for TEL™ SCCM™ POLY
CAS	Customized adapter set (RF peak voltage/DC bias measurement point)	

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Chapter 4
Installation

Edition: February 2008

4. INSTALLATION

4.1 Configuration

The basic setup and the measurement principle are shown in Fig. 4.1.

After installing the sensor head, connect it (SMA connector) to the input of the digitizer (BNC jack) of the Hercules® system. Use the special coaxial sensor cable. The channel labeled as chamber A should be connected to the sensor of chamber A, etc. If the Hercules® system has not been equipped with four inputs at the rearside, the chamber sequence parameter "chamber order" has to be set in the ini-file. To modify of the Hercules® system to an individual plasma tool use the ini-file (see Chapter 5.1). The ini-file for special etch tools are in D:/herc/setup/.

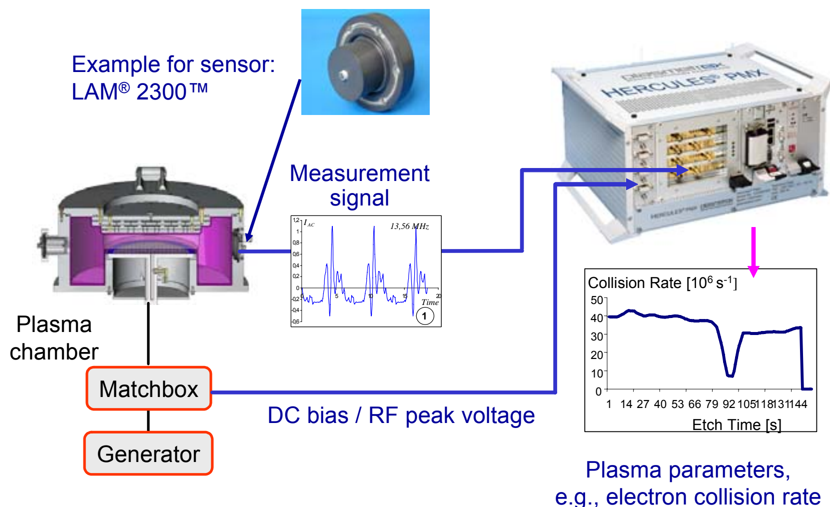

Fig. 4.1: Basic setup of Hercules®, example for the sensor: LAM® 2300™

Should you have any queries, please contact the Plasmetrex service (http://plasmetrex.com/contact.html).

The next step is the installation of the DC bias / RF peak voltage measurement test point (see next section).

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4.2 DC Bias or RF Peak Voltage Measurement

The DC bias or RF peak voltage are used for electron density calculation. If available these data are stored in Herc data file and will be shown as parameter in the Hercules® Viewer.

Note: **An anodized inner chamber wall or an ESC (electro-static chuck) require the RF peak voltage measurement point!**

Either the DC bias or RF peak voltage can be used by the model-based algorithm as scaling parameter.

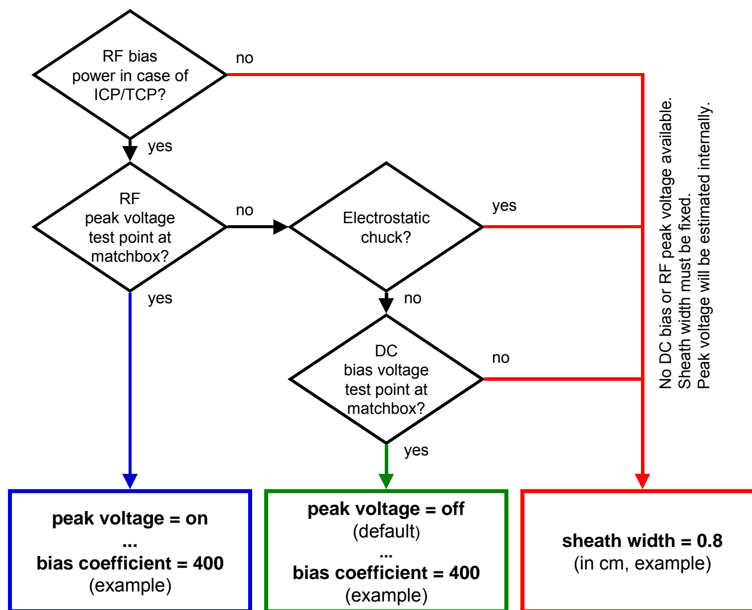

Fig. 4.2: DC bias / RF peak voltage setup

The application of DC bias or RF peak voltage is listed in the ini-file. A correct setting of the bias coefficient is needed because DC bias and RF peak voltage are provided by a voltage divider.

Caution: **Compare the DC bias or RF peak voltage with the value displayed at the tool.**

The so called "bias coefficient" is the ratio between the real DC bias or RF peak voltage to the corresponding voltage at the test point (voltage divider). The value is usually in the range between 100 and 1000. Please see the Matchbox supplier´s manual.

If neither DC bias nor RF peak voltage is available, the RF peak voltage is estimated based on a given, fixed sheath width (dark space thickness). For details, see Fig. 4.2.

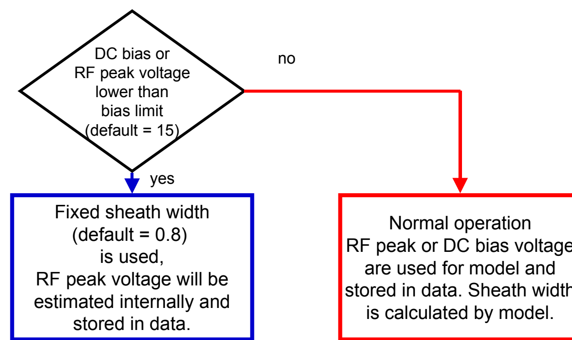

Fig. 4.3: Automatic setup change for low measuring point value

The Hercules® algorithm can switch between two calculation modes automatically. If the DC bias or RF peak voltage is lower than the value listed for bias limit the fixed sheath width is used for RF peak voltage estimation (see Fig. 4.3).

4.2.1 APPLIED MATERIALS® MERIE Chambers

The APPLIED MATERIALS® chambers MxP™, MxP+™, eMxP+™, Super-E™ and E-MAX® are Magnetically Enhanced Reactive Ion Etchers (MERIE) with several matchboxes.

Matchbox Phase IV

The cable set CAS/AM consists of:

1. Sub-D 9 (DB9) extension cable 5 m
2. Adapter cable Sub-D 25 (DB25) (matchbox phase IV) to Sub-D 9 (DB9) (Hercules®).

High Efficiency Matchbox

The APPLIED MATERIALS® E-MAX®, SUPER-E™ are usually equipped with so called high efficiency matchboxes. The cable set CAS/AMHE consists of:

1. Sub-D 9 extension cable 5 m
2. Adapter cable plug Sub-D 9 (DB9) (matchbox high efficiency) to plug Sub-D 9 (DB9) (Hercules®).

Navigator Matchbox

The APPLIED MATERIALS® chambers HART™ are equipped with a navigator matchbox from Advanced Energy. The cable set CAS/HART consists of:

1. Cable with BNC connector to the matchbox and Sub-D 9 (DB9) connector to the Hercules® system.

4.2.2 APPLIED MATERIALS® DPS™, DPS+™

On the APPLIED MATERIALS® chambers DPS™ and DPS+™ a measurement point is not available. Therefore, a fixed sheath width of 1 cm has to be set in the ini-file (sheath width = 1).

4.2.3 LAM® TCP® 9400/9600 SE

On the LAM® TCP® 94000/9600 SE chambers, a measurement point is not available. Therefore, a fixed sheath width has to be set in the ini-file, usually 0.1 cm.

4.2.4 LAM® TCP® 9400/9600 PTX

The LAM® TCP® 9400/9600 PTX provides a test point at the bottom matchbox at the connection 131P2/131J2. The cable set is Y-cable version.

Note: **The chamber must be down while the cable set is being installed.**

Check the entry for the bias coefficient in the ini-file:
bias coefficient = 400

4.2.5 LAM® 2300™

The LAM® 2300™ provides a measuring point at the bottom matchbox at the plug 1b3p45. The cable set is a Y-cable.

Note: **The chamber must be down while the cable set is being installed.**

Check the entry for the bias coefficient in the ini-file:
bias coefficient = 400

4.2.6 TEL™ SCCM OXIDE

The TEL™ SCCM OXIDE tool provides a measuring point at the upper matchbox (60 MHz). The cable point set is a Y-cable with Sub-D 25 (DB25) to Sub-D 9 (DB9) .

Chapter 5
Software

Edition: February 2008

5. SOFTWARE

5.1 Basic Setup

Plasmetrex recommends to avoid the installation or usage of additional software on the Hercules® system. The installation of additional software as an antivirus program or updates of the operating system - in particular if not authorized Plasmetrex - leads to immediate loss of warrenty.

The Hercules® software package consists of the Hercules® main program, the ScopeServer, and optionally CommServers.

The CommServers is a software for the equipment coupling. A detailed description can be found in Chapter 7.

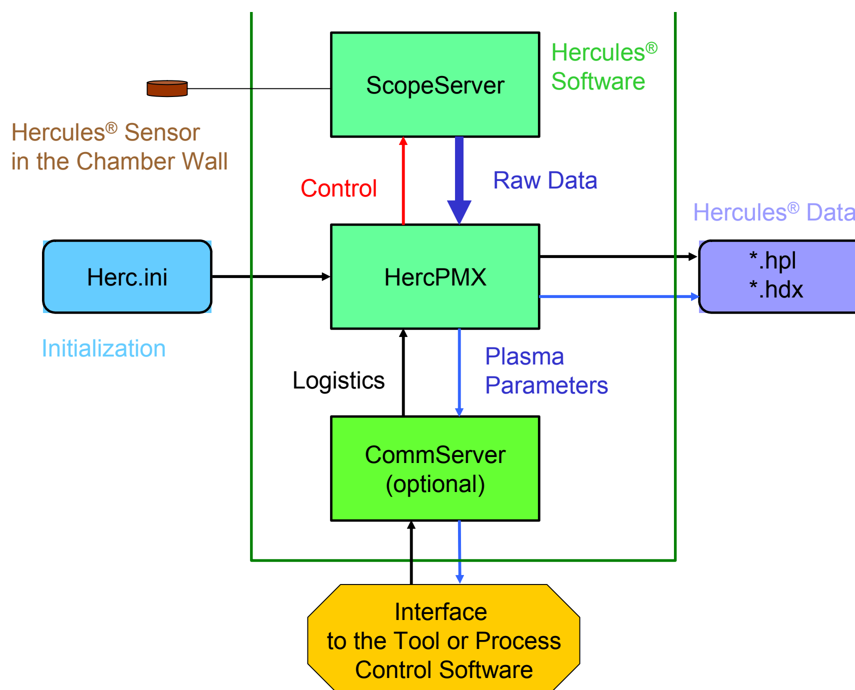

Fig. 5.1: The interaction of Hercules® program parts

Hercules® main program

The Hercules® main program is hercpmxXXX.exe. XXX denotes the version number. These executable files are always in the directory D:/herc.

Setup file

The setup file contains important information as chamber geometry are always in D:/herc/setup. Please see also Start of Hercules® below and table 3.1.

ScopeServer

The ScopeServer controls the digitizer, thus it acts as a high-level driver. All adjustments for acquisition the RF current data are done automatically. The HercPMX and ScopeServer communicate with each other. An entry in the ini-file (see below) defines which ScopeServer file is loaded. The default

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is "scopeserv."

Start of Hercules®

The Hercules® main program starts when the startup script "startherc.bat" is executed. The script must be modified when updating the software.

The setup file loaded automatically when starting the Hercules® system. The default file name is herc.ini. If herc.ini does not exist, a pop-up window appears that lets you choose the desired file.

The ScopeServer controls the digitizer and sends digitized raw data to HercPMX. Setup and control information needed by ScopeServer for data acquisition are send by HercPMX.

Stop of Hercules®

If there is a communication problem between Hercules® and ScopeServer, an error message is displayed and the program will stop.

Measurement

Only if both HercPMX and ScopeServer are running, is the system in an operating state. Hercules® generating plasma parameters as soon as the digitizer recognizes a signal from the sensor head. The plasma data are stored even when the plasma has been turned off for a specific time. This time is called the "plasma wait time." The measurement itself is triggered by the plasma and there is no further need to interact with the system. The correct setting of the "plasma wait time" (time should be set in between the wafer exchange time and the duration of plasma less process steps) is essential for a correct storage of the plasma data. The plasma data will be stored as one file in the Hercules® data files (*.hdx and *.hpl) if the plasma is turned off for a period of time longer than the plasma wait time.

Hercules® will trigger on the event "wafer processed" only if there is a LAM® plug-and-play sensor interface. In any case, the plasma data will be stored if the plasma is off for a time longer than the plasma wait time.

Standard file name format

The file *.hpl contains the raw data in a binary format. To access the data in the *.hpl file, a second file with the same filename and extension *.hdx is generated. For example, if the raw data file is 020306_cha.hpl, the corresponding hdx file will be named 020306:cha.hdx. This hdx file contains the pointers to the data of the hpl-file. Therefore, one set of data consists of the two files *.hdx and *.hpl. Both files are always needed for proper data analyses.

By default, file name are derived from current data and chamber number. For example, data created on March 6,2007 at chamber A would be stored in a corresponding hpl file 070306_cha.hpl. Please note that dates are encoded as yymmdd.

File identifiers

If logistics as LotID and PPID (recipe) are transferred to the Hercules® system via SECS/HSMS or Lam's PnP sensor

interface, the data are saved lot-wise and the file name equals the LotID.

Example:
The current LotID is XY1234 and the process is running at chamber A. Therefore the pair of Hercules® files are XY1234_cha.hpl and XY1234_cha.hdx (see. Fig. 5.2).

All drivers needed to run the additional hardware are installed in the directory d:/driver. It is not recommended to make any changes in this driver directory.

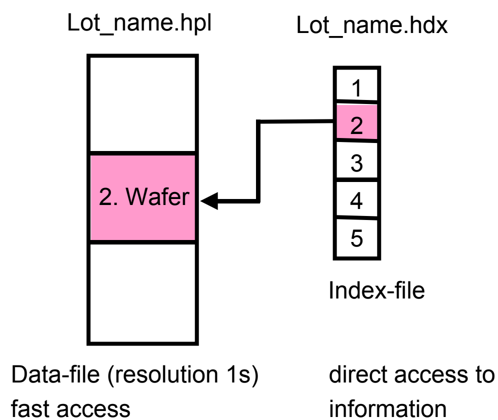

Fig. 5.2: Pointer based format of Hercules® data

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5.2 Software update

The update files will be provided by Plasmetrex in a zip file. Copy the zip file to the directory D:\herc and unzip the archive. Executing the batch file “update.bat” starts the update procedure.

5.3 Software Setup Overview (ini-file)

The adaption of the SEERS method to the plasma tool occurs with the setup of the ini-file.

Note: **The ini-file for specific plasma tools is in D:/herc/setup/.**

An initialization file is required for proper operation of Hercules®. By default, herc.ini will be loaded automatically. If herc.ini cannot be found, the user is prompted to enter a different file name.

Table 5.1: The ini-file parameters

Parameter	Options	Default value	Comment
electrode gap			value in cm
electrode diameter			value in cm
chamber diameter			value in cm
frequency		13.56	value in MHz
max. process time	15	15	value in min
scopeserver	name of the scopeserver file	scopeserv	without ".exe"
commserver	name of the comserver file	commserv	without ".exe
rank of filter	integer value	2	0: filter off. For display only
mean time		0.18	*
peak voltage	off, on	off	for test point providing bias voltage: off default: off
sheath width		0.8	mean sheath width if no DC bias / RF peak voltage is available, value in cm
plasma wait time		10	value in s, time to wait after the plasma was switched off until data set (process) will be closed and saved, then waiting for new process
icpmode	-1, 0, 1, 2	0	0: RIE (parallel plate) 1: TCP (coil on top insulator) -1: algorithm for RIE used by version 2.3 or lower (compatibility mode) 2: insulated chamber wall (no radial RF current, see Fig. 1.9 - 1.11)

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Table 5.1: The ini-file parameters

Parameter	Options	Default value	Comment
bias coefficient			must be specified, ratio between real DC bias or RF peak voltage and measuring point voltage
bias limit		15	in V of DC bias or RF peak voltage if the DC bias or RF peak voltage is lower than the bias limit the system will measure with fix sheath width
bandwidth		500	must be specified, value in MHz, 500 MHz recommended
covarb1 threshold		100	*
signal threshold		2	value in mV
delta t		1000	temporal resolution in ms
chamber order		ABCD	changes the relation between input and chamber

* Please change the default value only after consultation with Plasmetrex.

Additional comments to the keywords

electrode gap, electrode diameter, chamber diameter: dimensions of the process chamber connected to Hercules®.

electrode gap. electrode diameter, chamber diameter

frequency: frequency of the RF generator.

frequency

bandwidth: the default value is 500 MHz. For generator frequency of 40 MHz or above the bandwidth should be set to 1000 MHz.

bandwidth

max. process time: plasma data acquired during this time period will be temporarily stored in the memory. After this period has expired, the data will be written to the hard disk and Hercules® will start again. Max. process time should be greater than the longest plasma process time.

max. process time

scopeserver: after starting Hercules®, the program ScopeServer will be initiated. The name of the program can be set if different to the default value.

scopeserver

commserver: after starting Hercules®, the program CommServer will be initiated. The name of the program can be set if different to the default value in the configuration file.

commserver

peak voltage: if the system is connected to a RF peak voltage measuring point, set this keyword to ON.

peak voltage

sheath width: if neither DC bias nor RF peak voltage measuring point is available, the model requires a fixed width of the sheath (dark space, space charge sheath thickness). A virtual DC bias voltage is calculated, and will be displayed as DC bias voltage.
Please remember, this voltage is calculated from the discharge current only and is an estimated value.

sheath width

plasma wait time: indicates how many seconds the plasma process has to be off before the acquired data will be stored to disk and Hercules® will initiate a new measurement.

plasma wait time

Note: **Please note that plasma steps of the same process could be separated by shortening the plasma wait time.**

icpmode: is zero for capacitive coupled plasma with parallel plates and one for an insulated top plate with additional inductively coupled excitation, e.g., LAM® TCP®.

icpmode

bias coefficient: ratio of the DC bias / RF peak voltage and the testpoint voltage. This coefficient depends on the matchbox used with the plasma tool. The factor could be calculated from the known bias voltage of the tool.
Set the bias coefficient in the ini-file to 100 and start the Hercules® system. Click on the "extended" button and check the indicator of bias voltage. Divide the DC bias voltage obtained from the tool by the voltage indicated in the extended window. Then the result has to be multiplied with 100 and used as the new value for the bias coefficient.

bias coefficient

bias limit: if the measured DC bias or RF peak voltage is lower than the value set as "bias limit," Hercules® calculates the bias from the fixed sheath (dark space, space charge sheath thickness). The sheath (dark space, space charge sheath thickness) is fixed by the parameter "sheath width." This feature is useful in case of an additional RF excitation which is inductively coupled, e.g., TCP®. If the process runs without bottom power, no DC bias or RF peak voltage will appear and the RF peak / DC bias voltage will be calculated from fixed sheath width automatically.

bias limit

signal threshold: threshold voltage (in mV) of the sensor signal to indicate the plasma ON state. If this voltage is set too high, no measurement will occur.

signal threshold

delta t: time temporal resolution of the stored data in ms.

delta t

chamber order: each digitizer refers to one process chamber. The digitizer number one (at the bottom) is the input

chamber order

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of chamber A, etc. If fewer digitizers than chambers are installed, it is possible to set the chamber name by keyword "chamber order," e.g., to measure the chambers B and C, set chamber order = BC. In the case of first digitizer should be plugged to chamber B and the second to chamber C.

5.4 Hercules® Graphical User Interface

The following tabs are available at the Graphical User Interface (GUI):
Diagram shows plasma parameters.
Extended displays additional parameter.
Conditioning View indicates the progress of chamber conditioning.
Init Parameters displays the configuration parameter from ini-file.

Diagram

One parameter (electron collision rate, elctron density, DC bias/peak voltage, ...) can be selected independently at the display. The button under the diagram indicates the selected parameter (see Fig. 5.3).

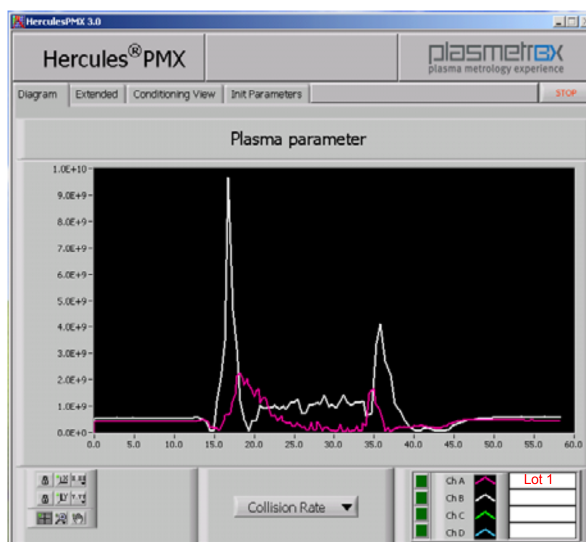

Fig. 5.3: Graphical User Interface (GUI) of Hercules®

Extended

The tab "Extended" opens a window, which shows a diagram of the discharge current and some additional parameters. Before clicking the "Extended" tab, the actual chamber should be selected. Then open the "Extended" window (opens only if the process is running).

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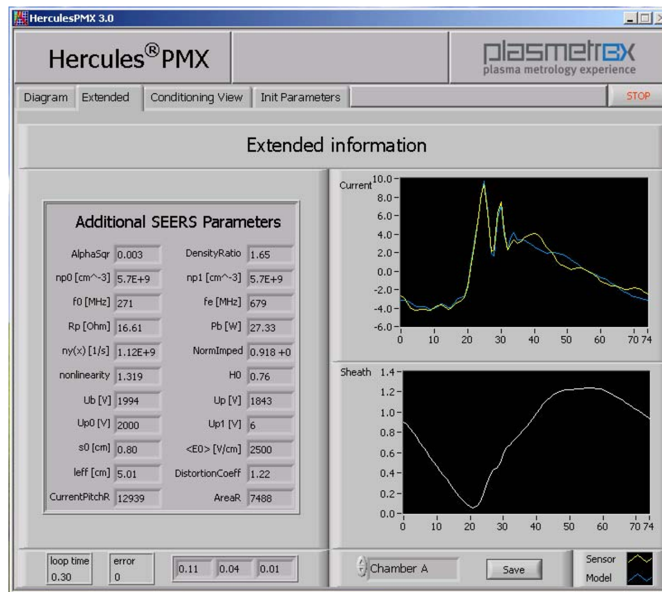

Fig. 5.4: Graphical User Interface (GUI) of Extended

The raw data - the high frequency current - and detailed information are shown in the “Extended” folder Hercules® window. This data can also be used for troubleshooting.

Conditioning View

The conditioning viewer shows the processed and the current conditioning process (wafer) and provides an indication of conditioning state.

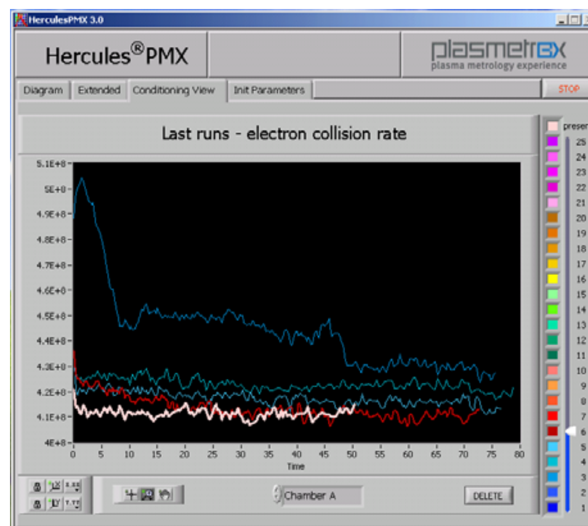

Fig. 5.5: Graphical User Interface (GUI) of Conditioning Viewer

Init Parameters

The recent configuration can be checked at the tab "Init Parameters."

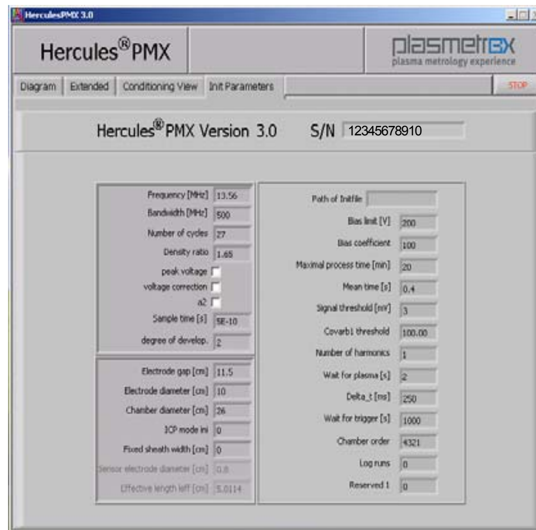

Fig. 5.6: Graphical User Interface (GUI) of ini-file

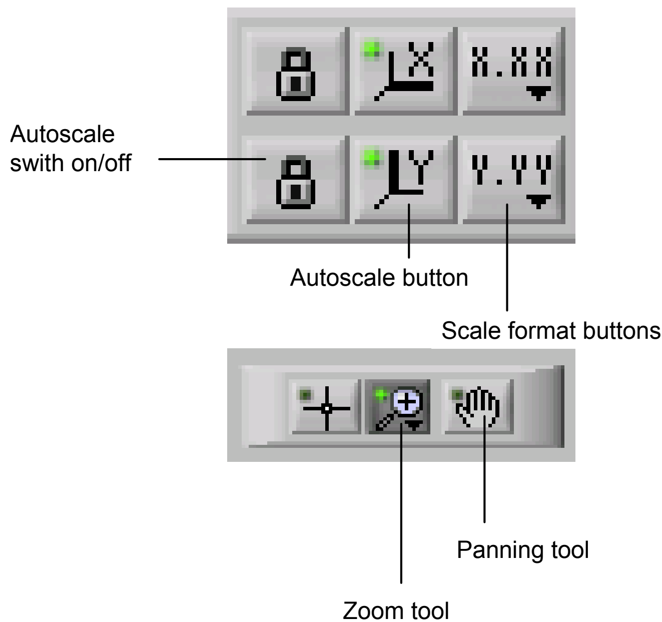

Fig. 5.7: Scale options of diagrams

5.4.1 ScopeServer

After the ScopeServer is launched by Hercules®, the digitizers will be initialized. The ScopeServer has full control over all digitizers. The data will be acquired automatically. The indicator labeled "temperature" shows the temperature of each digitizer in degrees Celsius. The temperature should not

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exceed 65 degrees Celsius.

The digitizer with index zero is connected to chamber A and index one to chamber B, etc. The view of the index can be changed by clicking on the selection arrows.

The wait time for the trigger time set by the ini-files is also displayed, but cannot be changed here.

The number of data sets, which have yet to be processed, will be shown in the buffer indicator. The buffer will be cleared after finishing the process.

A red trigger indicator shows no trigger signal is available (see Fig. 5.8).

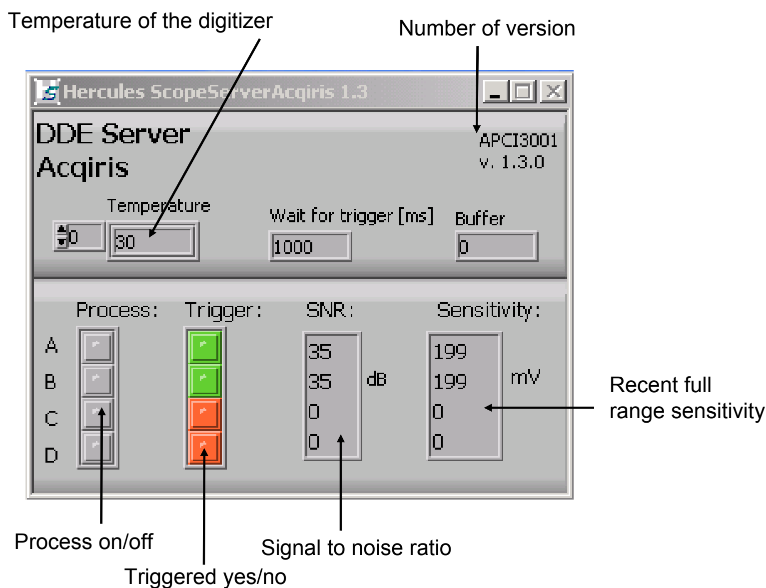

Fig. 5.8: Graphical User Interface (GUI) of ScopeServer

Sensitivity displays the full-scale range the autorange function has selected.

Chapter 6
First Start

Edition: February 2008

6

6. FIRST START AND TROUBLESHOOTING

6.1 First Start

6.1.1 Sensor installation

Sensor head installation (see Chapter 2. and http://plasmetrex.com/sdb/home.html) should be performed during a preventive maintenance (wet clean).

6.1.2 System power-up

The standard version of Hercules® does not include a monitor. It is up the user to provide a suitable monitor before tuning on the system. The system is switched on by the green line switch loced at the backside of the unit.

Note: **Please take care that the power cable is protected by a special strain relieve for the AC power line plug.**

6.1.3 Logging on to the System

Two users are alredy in the system. These are the "administrator" with the password left blank and the "herculesuser" with the password "hercules."

Auto log-on is enabled to allow automatic start up of the system. Auto log-on will be disabled by pressing the shift key during the systems boot procedure. Auto log-on prompt will be displayed.

6.1.4 Running Hercules® without Keybord and Mouse

The system is equipped with USB keyboard with integrated trackball. So the USB keyboard can be always removed or the system can generally run without.

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6.2 Start-up procedure

Note: **First system start-up is normally performed by the Plasmetrex service engineer.**

Step 1: Connection of Hercules®

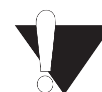
Connection cable to of Hercules® system

- The AC power cable
- Keyboard monitor, if needed
- A network cable (LAN 1), if available
- The sensor cable (on BNC input chamber A, B, C, and/or D)
- Connect the bias measurement point and make sure to use the correct bias coefficient (see Table 5.1).

Connect the Hercules® AC power plug into a tool outlet to avoid potential problems due to different ground potentials.

Step 2: Turn on Hercules® system

Note: **Than the Hercules® system will be automatically restarted after AC power cut. Please do not run the Hercules® system as Administrator !**



Step 3: Stop the Hercules® program

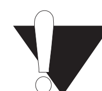
Stop the Hercules® program with the stop button on the Graphical User Interface (GUI).

Step 4: Disable the current ini-file

Select and rename the “Herc.ini” into “test.ini” in the directory D:\herc\setup.

A collection of ini-files for several tools is available at D:\herc\setup. The required geometrical dimensions and the technical specifications of the chambers, the setup, are described in these ini-files.

Caution: **Important: Select “all files” in the Windows editor “save as” prompt before saving. This prevents the files for getting the .txt extension. Please do not change the default encoding ANSI (8bit ASCII). UTF16 encoding files can not be read by Hercules® properly.**
Close the editor.



Step 5: Setting up the ini-files

Start Windows Explorer and select directory **D:\herc\setup**. From the list of files, click the file name that matches your chamber type (e.g., DPS200.ini, eMax.ini, etc.). Create a copy of the selected file by simultaneously pressing **Ctrl-C** and then **Ctrl-V**. Select the copy of the file by clicking the file name. Rename the selected file by pressing **F2** and then entering the text **herc.ini**, then press **Enter**. The Hercules® program automatically searches and loads **herc.ini** during startup. If no **herc.ini** file is found, a dialog box prompts the user to enter a different ini file.

Step 6: Starting the Hercules program

On the Windows desktop, double-click the icon HercPMX to start the program.

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6.3 Troubleshooting guide

The Hercules® system does not start and power on indicator (switch) and all LED's are off.

Check the following:

- The fuse is not blown
- The power switch is in the ON position
- The AC power cord is plugged into Hercules® system and a power outlet of the tool.

Automatic login does not work.

If the last user was not *herculesuser*, the Hercules® system can not boot automatically!
In this case boot system manually and change to the user *herculesuser* ! Hold the shift key until the login window appears. Next time the system will boot regularly.

The measured data are noisy or out of range. Hercules® system is slow.

Make sure the SMA connectors of the sensor cables are firmly tightened (spanner / wrench) and the BNC connectors locked.

Check the running programs:

- VNS server (remote desktop)
- Antivirus protection software
- Other additional software.

Check the ini-file at D:\herc\setup\herc.ini or at init parameters of the Hercules® GUI.
(diameters, gap, frequency, bias coefficient, bias threshold, signal threshold, chamber order, ...).

Check the sensor position in the chamber. The sensor should be located above the wafer and not be obstructed or covered by chamber parts.

Make sure the sensor and the sensor cable are kept at a distance of at least 30 cm (1 ft) from the nearest RF power cable.

Only if test point is applied: Check the bias coefficient by comparing the bias / peak voltage displayed by the tool and the voltage measured by Hercules®. Both voltages should be equal.

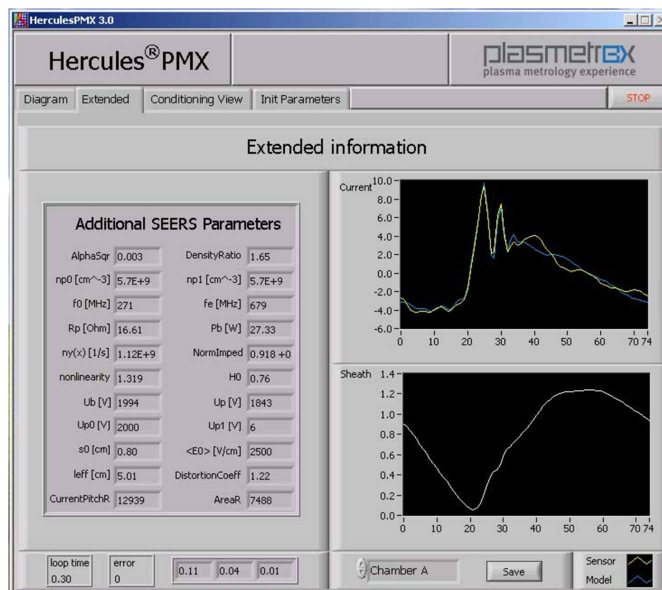


Fig. 6.1: Screen shoot of “Extended” window (example)

The raw data - the high frequency current - and detailed information are shown in the Extended tab of the Hercules® window (Fig. 6.1).
This data can be used also for trouble shooting.

- Copy the “Extended” window into the Windows clipboard by pressing Ctrl and Print Screen concurrently. Open the WordPad editor and paste the clipboard by pressing Ctrl-V.
- Save the file by using the “Save” button.

Send the herc.ini and the “Extended” screen capture file to Plasmetrex technical support
(http://plasmetrex.com/contact.html).

Chapter 7

Equipment Coupling

Edition: February 2008

7. EQUIPMENT COUPLING

Equipment coupling enables the exchange of information between the plasma tool and the Hercules® system. This information includes the logistic data, such as:

- lotID
- waferID
- recipeID, etc.,

and the events such as:

- recipe_start
- step start
- recipe end.

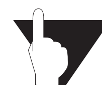
Due to the large amount of data generated in high volume production, equipment coupling is strongly recommended. An automatic analysis of the data is only possible if the lotID and/ or recipeID are known.

Basic types of modules

Three basic types of modules for equipment coupling are available:

- Interface based on the Semiconductor Equipment Communication Standard (SECS).
- Proprietary Interface TICS (Infineon standard, not described here).
- Plug and play sensor interface for LAM® 2300™ (Domino).

Note: **It is necessary to have host applications for the first three solutions.**



Hercules® software starts the CommServer module if the CommServer executable program has the name "commserv.exe." It is also possible to change the default name of the CommServer by adding the keyword "commserver" to ini-file. It is recommended to select the CommServer via the ini-file in order to easily switch between different communication protocols.

7.1 Graphical User Interface of the CommServer

The table "Lotinfo" displays all the information sent to the CommServer. Each column corresponds to a chamber. The column with the index zero relates to chamber A, etc.

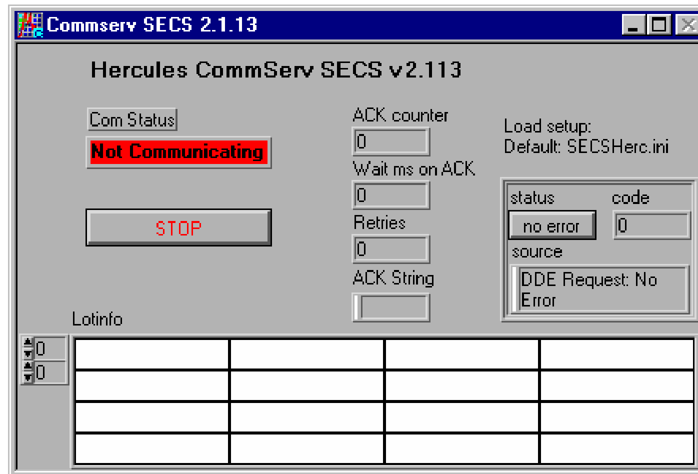


Fig. 7.1: Graphical User Interface (GUI) of the CommServer

One column - one chamber. Each row shows logistic data:

0 - LotID

1 - WaferID

2 - RecipeID

3 - Step

5 - ToolID

6 - Hours since last wet clean

Note: **Pressing the “STOP” button stops the CommServer and does not affect the Hercules® program.**

The User interface displays also the state of data exchange between the Hercules® system and CommServer. The acknowledgement of received data and the time between data sending and receiving is displayed. If any error occurs, a message is displayed.

7.2 LAM Plug and Play Interface (PnP at LAM® 2300™)

The TCP/IP based interface provides a reliable means of transferring data between computing systems. The LAM® 2300™ creates a virtual circuit, a data path in which data blocks are guaranteed delivery to a target machine in the correct order. The computing systems within this virtual circuit are arranged as server system and client system. Both systems can send and receive messages. Messages are sent from the sender to the receiver until the receiver sends back a message stating that all the data blocks have been received in the correct order. Each server and client should have its own IP address to identify themselves in this virtual circuit and the server should specify a unique port number for establishing the communication.

In this communication configuration the generic sensor device operates as the client and the LAM® process module operates as server. Both the server and client run on separate computing processors with a unique IP address. The LAM® process module specifies a unique port number for this communication purpose. Both the LAM® process module and the generic sensor device are connected through the TCP/IP network. Once the generic sensor device is up and running, it sends a message requesting to be connected to the LAM® process module. After the connection is established, the server and client can now communicate using the predefined protocol. The synchronous command with reply is the chosen communication protocol for this configuration. The sender has an option to request an acknowledgement for the sent command message. If the sender expects a reply to the sent command message, the receiver has to reply with an acknowledgement message. If there is no reply to the sent command message within a reasonable time duration, e.g., five seconds, the same message will be sent again. After trying several times, e.g., 3 times, to send the same message and failing to receive a reply, the TCP/IP socket connection is considered interrupted. In this case, both the server and client may require operators action to reset their TCP/IP socket to be able to re-establish their connection. [For more details please contact Lam® Research Coporation]

7.2.1 Configuration of the ini-file "HercLAM.ini"

The network interface of the Hercules® system should be set to an IP address in the range 10.10.0.10 - 10.10.0.49 subnet mask 255.255.0.0.

For each process module (PM) linked to the Hercules® system, an IP address has to be inserted in the program section "connection", that means PM1 is chamber A, etc.

In general, the IP addresses for the process modules of the LAM® are assigned as follows:

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[connection]

IPaddressPM1 - 10.10.0.101

IPaddressPM2 - 10.10.0.102

IPaddressPM3 - 10.10.0.103

IPaddressPM4 - 10.10.0.104

Port=10001

Timeout=2000

Note: **It is important to set port to 10001 because the server is configured to listen to port number 10001.**

Timeout is the time in ms before reception via TCP/IP is considered as finished. It is recommended to set the timeout to 2000.

The next section is SensorData

[SensorData]

ack=0

NumberData=2

Keyword "ack"

The keyword "ack" sets the acknowledgement bit of the sensor data transfer. After receiving of sensor data, the server has to send an acknowledge message if ack=1. In practice, it was found that the server would become very busy if the ack bit was set. The ack bit should to be disabled with ack=0.

NumberData

NumberData limits the number of parameters transferred to the tool. The parameter will be transferred in the order: electron collision rate - electron density - DC bias/RF peak voltage - bulk power. If the NumberData is decreased, the parameter of lower order will not be sent, e.g., NumberData = 2 - only electron collision rate and electron density will be sent.

The CommServer periodically checks the connection to the tool. If the CommServer detects an interrupted connection, it will make an attempt after 15 minutes to reconnect. If the CommServer can not establish a connection, it will start another attempt after 15 minutes to reconnect, i.e. the connection will be established automatically without the user having to intervene if the plug and play interface is active.

7.3 Semiconductor Equipment Communication System (SECS)

The additional component CommServer enables the exchange of data between Hercules® and SECS host through a set of SECS messages. The plasma data obtained by the Hercules® Plasma Metrology System are linked to the logistic information of the processed wafer. The quality of the data analysis increases due to the lot, wafer, or product selection. The CommServer SECS is not a 100% SECS implementation and supports only the commands listed below.

7.3.1 Basic setup: CommServer SECS

The CommServer SECS provides SECS compliant services and can thus communicate with a host program which has to be implemented by the user. There are two main features:

- The host can initialize a trace data report to retrieve the data from the CommServer.
- The logistics (lot_ID, recipe...) could be set via equipment constants.

The CommServer SECS is able to communicate either via a serial interface (RS 232) or a TCP/IP connection (called also HSMS). It has to be configured by editing the file secsherc.ini which should exist in the same directory as the CommServer executable.

7.3.2 Main configuration parameters of HSMS

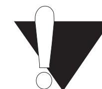
[swGEMSetup]
SocketLocalPort=5001 [TCP port used for the connection on local system]
SocketRemotePort=5001 [TCP port used for the connection on host system]

Protocol=1 [Protocol is TCP/IP]
CommMode=1 [Indicates that HSMS will be used]

SocketMode=0 [Mode of establishing a connection 0-active, 1-passive]

SocketLocalHost=192.168.168.244 [IP-Address of the local system]
SocketRemoteHost=192.168.168.11 [IP-Address of the host system]

Caution: **If the host listens (as server) for a connection the CommServer SECS should set to SocketMode=0, i.e., to active.**



The IP-addresses for both the local and the host system has to be set as well as their port numbers. Please check if the "Protocol" and "CommMode" are adjusted properly in the secsherc.ini.

7.3.3 Configuration for SECS I (RS232)

[swGEMSetup]
Protocol=0
CommMode=0
SerialPort=2
SerialSpeed=8

Protocol=0 means RS232, CommMode=0 SECS I, SerialPort=2 COM Port, and SerialSpeed=8 is 9600.

The serial port number has to be checked. Set "Protocol" and "CommMode" to zero.

The host should send to the CommSever SECS the command S1F13 (Establish communication) first. After receiving this command the Commsever will change to the "communicating" state indicated on the user interfece of CommSever.

7.4 Commands

CommServer can establish communication using HSMS or SECS I. The protocol is set through the ini-file.
The logistic information of the processed wafer will be transferred by setting equipment constants in terms of S2F15.

Supported commands:
S1F1, S1F3, S1F11, S1F13, S2F15; S2F23, S2F31

Hercules® initiated commands:
S6F1, S1F1

Examples:

a) S1F1 command - Heartbeat control

```
S1F1 W/*Host->Hercules*/
    S1F2 W/* Hercules ->Host */
    <L[2]
    <A"HercPL">
    <A"C2.001">>.
    S1F13W/*Host->Hercules*/
    S1F14
    <L[2]
    <U10>
    <L[2]
    <A"HercPL">
    <A"C2.001">>>.
```

b) S2F15 command - Transfer of logistics

```
    S2F15 W/*Host->Hercules*/
    <L[6]
    <L[2]
    <U2[1] 2000>/*LotID Chamber C*/
    <A[12]'D012080-0300'>
    >
    <L[2]
    <U2[1] 2001>/*WaferID Chamber C*/
    <A[13]'91431CTF159C0'>
    >
    <L[2]
    <U2[1] 2002>/*PPID Chamber C (recipe)*/
    <A[11]'RST®309AAAC'>
```

>

<L[2]

<U2[1] 2003>/*Recipe Step Chamber C*/

< A[18]'022000100212254163'>/
RecipeStep+<TIMESTAMP>/

>

<L[2]

<U2[1] 2005>/*ToolID*/

<A[4]'ET10'>

>

<L[2]

<U2[1] 2006>/*Hours since last wet clean*/

<A[3]'112'>>>.

7.4.1 Hercules® Equipment Constants

The equipment constant (EC) is given by the chamber number and the corresponding parameter. The EC is calculated from the ChamberNumber (beginning with 0) *1000+ParameterNumber.

Note: **In case of P5X00 (APPLIED MATERIALS®), e.g., Chamber A gets the ChamberNumber 0.**

The following ParameterNumbers are possible:

0: LotID

1: WaferID

2: PPID (recipe)

3: Recipe Step

4: Recipe End (version 2.1.14)

5: ToolID

6: RF-hours since last wet clean

See example above:

ECV:2002 - PPID Chamber C (Hercules' Chamber number =2)

ECV:0 - LotID Chamber A

The Recipe Step should be sent on the event "Recipe Step has changed". The format is ASCII based:

The Recipe Step as A[2] and <TIMESTAMP> as A[16] defined in SEMI standard (no delimiter).

For example '022000090212254163': The Recipe Step has changed into step 2 on Sep. 2, 2000; 12:25:54.163. If no timestamp is available,

<TIMESTAMP>='0000000000000000':

Note: **If the timestamp is available, the clocks of the Hercules® system and the host can be synchronized using S2F31 command.**
Please take care that the synchronization will not initiated during a process or an active measurement on the Hercules®, respectively.

7.4.2 Data Tracing

Hercules® sends data to the host system when a data trace was initialized using S2F23. Only one trace for each chamber can be initialized. Four status variables (SV) exist for each chamber. The data-sampling period should not be longer than five seconds. The report group size is always one.
SVID=ChamberNumber*1000+ParameterNumber

ParameterNumber:

100:collision rate [s^{-1}]

101:electron density [cm^{-3}]

102:bias/peak voltage [V]

103:rf current [A]

104:sheath width [cm]

S2F23 W

<L,5

<U40>

<A'000010'>

<U4®20>

<U41>

<L,4

<U4 2100>/*collision rate chamber C*/

<U4 2101>/*electron density chamber C*/

<U4 2103>/*bias/peak voltage chamber C*/

<U4 2104>/*bulk power*/

>

>

.

S2F24

<B0>.

Error codes of the S2F24 command:

0 - OK

1 - Number of SVID greater than four

2 - TRID for this chamber already exits

3 - DSPER>5 s

4 - Error in S2F23 command,

If Hercules® receives unknown streams and functions, it will respond with the corresponding S9-function.

7.4.3 Data Polling

Data can be requested by the SECS command S1F3. The maximum number of SVID is 20, i.e., 5 parameters per process chamber.

Example:

S1F3W
<L,2
<U4 100>, collision rate chamber A
<U4 103>, rf current chamber A
>.

S1F4
<F4 123456.8>
<F4 2.34>
>.

7.5 Operating

Start of CommServer

After starting Hercules® PMX, the ScopeServer and the CommServer will be launched automatically.

Stop of CommServer

CommServer stops when the user clicks the “Stop” button on the CommServer user interface.

If there is more than one CommServer available, the CommServer desired must be renamed to commserv.exe, and the initialization file "secsherc.ini" should be adapted to the special condition.

The ini-file has to be named secsherc.ini. If the CommServer cannot find a file name as described, an error will be displayed. If any error occurs, a log file "commerror.log" will be created. The most important entries are SocketLocalHost and SocketRemoteHost for the IP addresses if TCP/IP are present.

Example of a secsherc.ini:

```
[swGEMSetup]
LogCharError=1
LogCharEvent=1
LogCharReceive=0
LogCharSend=0
LogSecsiHsmsError=1
LogSecsiHsmsEvent=1
LogSecsiHsmsReceive=1
LogSecsiHsmsSend=1
LogSecsiiError=1
LogSecsiiEvent=1
LogSecsiiReceive=1
LogSecsiiSend=1
T3=4500
T1=1000
T2=10000

T4=45000
T5=10000
T6=5000
T7=10000
T8=5000
DeviceID=0
Rty=3
SerialPort=1
```

LinkTestTime=60000

SocketLokatPort=5000

SocketRemotePort=5000

IsHost=1/* set to "0" if the SECS server is configured as host

IsMaster=0

InterLeave=0

AutoDeviceID=0

MultipleOpen=0

AutoSystemBytes=1

Language=1

Protocol=1/* change to 0 for SECS 1 connection*/

CommMode=1/*change to 0 for SECS 1 connection*/

SerialBits=1

SerialStop=0

SocketMode=0

SerialSpeed=8

SerialParity=0

SerialBufferSize=5

SocketLocalHost=172.16.57.657/* set the IP address of the Hercules System*/

SocketRemoteHost=172.16.16.71/* set the IP address of the hoste*/

Communication status is "not communicating" until Hercules receives S1F13.

ACK information indicates the status of data transfer from Comm-Server to HercPMX.

The lotinfo displayed contains the data received by a S2F15 command.

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PLASMETREX GMBH

Schwarzschildstraße 3
12489 Berlin
Germany

phone:	**(+49-30) 63 92 50 40**
fax:	**(+49-30) 63 92 50 41**
E-mail:	**info@plasmetrex.com**
http:	**plasmetrex.com**