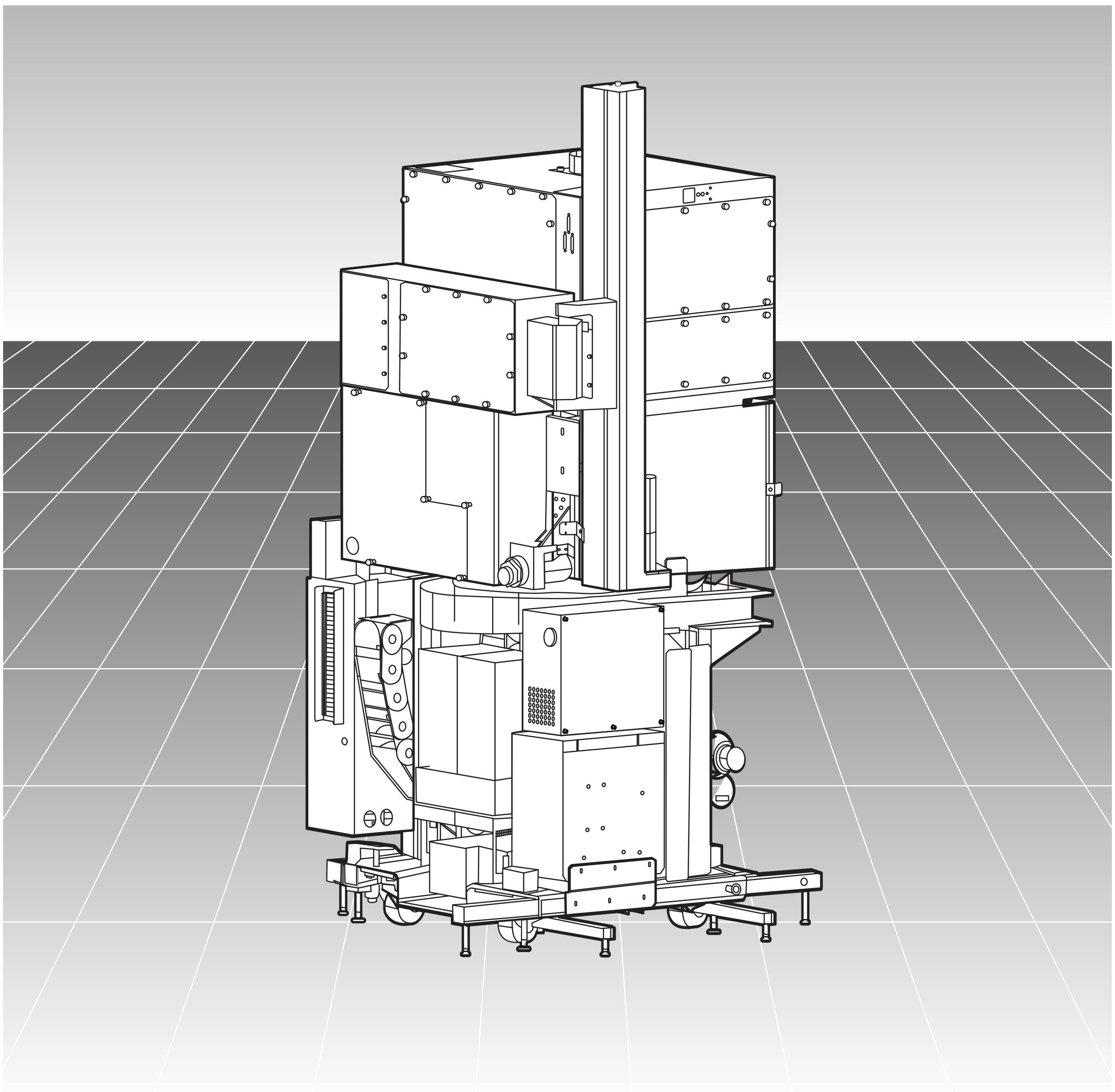
2300™ Versys™ Metal/Silicon PM

Installation Guide



Lam RESEARCH

Revision B

2300™ Versys™ Metal/Silicon Process Module

Installation Guide

PM BOM Version 571-800096-001

2300 Software Version 1.4.2

System Version 2300

Revision B
October 2001

Revision A April 2001—First Printing

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Part Number: 406-240340-201

Safety Preface

The safety guidelines for the equipment in this manual do not purport to address all the safety issues of the equipment. It is the responsibility of the user to establish appropriate safety, ergonomic, and health practices and determine the applicability of regulatory limitations prior to use. Potential safety hazards are identified in this manual through the use of words Danger, Warning, and Caution, the specific hazard type, and pictorial alert icons.

Hazard Levels

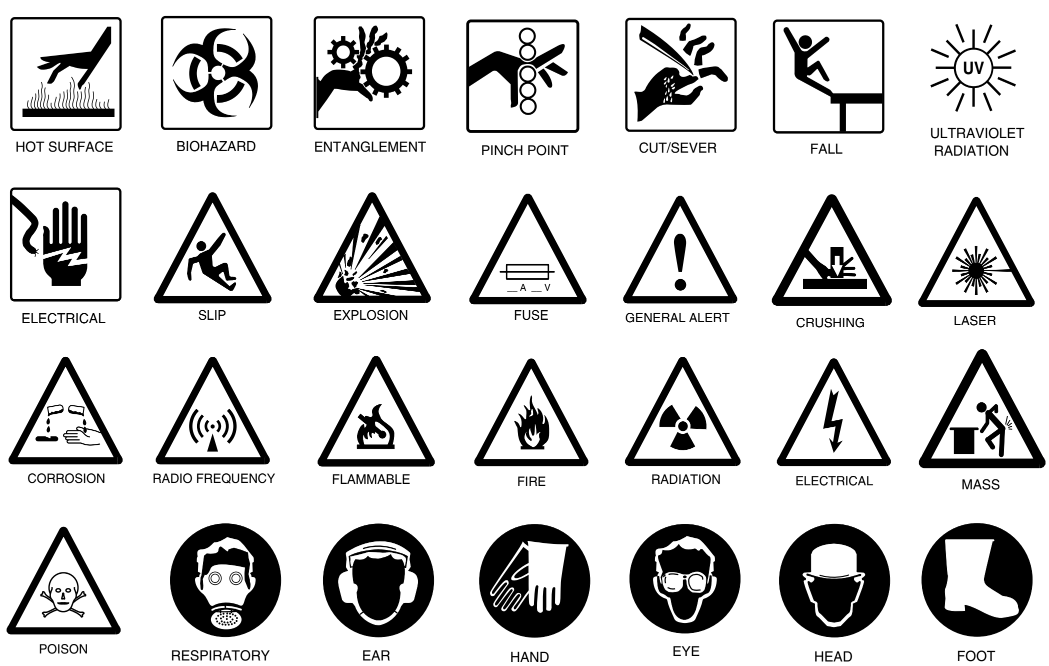
Danger: Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This is limited to the most extreme situations.

Warning: Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

Caution: Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury. It may also alert users against unsafe practices.

Notice: Indicates a statement of company policy (that is, a safety policy or protection of property).

Pictorial Alert Icons



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2300™ Versys™ Metal/Silicon Process Module

Installation Guide

PM BOM Version 571-800096-001

2300 Software Version 1.4.2

System Version 2300

Cleanroom Version

Revision B
October 2001

Revision A April 2001—First Printing

Revision B October 2001—Second Printing

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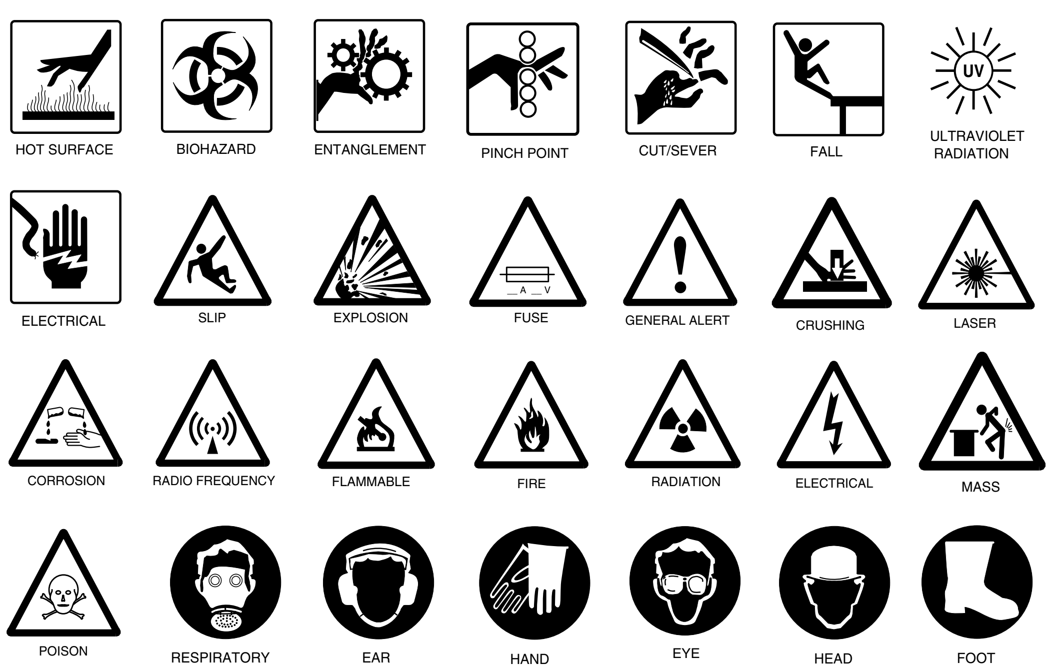

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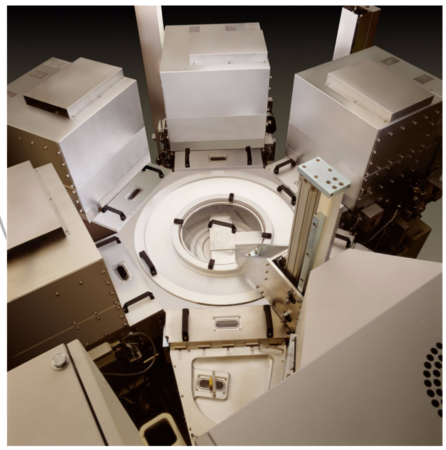
2300™ Etch Series



Lam's new 2300 etch series is the low-risk solution for sub-100 nm volume production on 300 mm substrates. The 2300 suite of products brings Lam's tradition of excellence in etch processing to 300 mm wafers with the 2300 Exelan®, the 2300 Versys™ Silicon and the 2300 Versys™ Metal. The Versys conductor chambers have 200 and 300 mm capability, and all systems for conductor and dielectric films are available in a four chamber configuration. The compact 2300 series design reduces the floorspace for high-volume production while still providing full service access.

The 2300 etch systems also enable wafer fabs to have one platform independent of their technology roadmap. Lam's 2300 etch series of products lowers the risk of transitioning from 200 to 300 mm wafers, of changing from metal etch to dual damascene, and of moving 300 mm volume production from 150 nm to sub-100 nm technology nodes.

Extensive use of modeling during system design has ensured that the best technology has been incorporated into all of the systems, optimizing chamber conductance, thermal characteristics, and plasma uniformity. The 2300 etch series also builds on the production experience of Lam's 200-mm Alliance® etch systems, preserving the production benefits of repeatability, damage-free processing, and process flexibility.

The 2300 Exelan leverages Lam's successful Dual Frequency Confined™ (DFC™) plasma technology currently used on Exelan, Lam's fastest ramping product, to 300 mm processes and next-generation applications. Developed processes include both critical and noncritical etch. DFC technology has become the most successful production-proven technology for oxide copper-damascene applications, and customers are evaluating it for leading-edge, low k, dual damascene. 2300 Exelan provides leading edge solutions, with the industry's best damage performance and the lowest CoO.

Versys conductor etch systems rely on Lam's production-proven Transformer Coupled Plasma™ source to support in situ process solutions for leading edge device structures. Both systems deliver superior performance, have large process windows, and process complex film stacks in situ with a single chamber configuration. Versys Silicon processes metal gate and STI with top corner rounding in situ. Versys Metal provides excellent process results with serial etch and strip on a single platform to control corrosion. Both Versys etch systems drive CoO down, to compete with the lowest cost systems in the industry.

Lam's 2300 etch systems offer the lowest risk path to 300-mm production. The systems allow processes to be fully matured in 200 mm volume production before they are transferred in the same chamber to 300 mm substrates. With a production-proven technology, advanced process capability, low capital investment, and the flexibility that delivers high volume throughput, Lam's 2300 Etch Series is the low risk solution for all 200 and 300 mm production lines at sub-100 nm technology nodes.

Contents

Figures

Tables

1
Overview

This manual provides installation information for the Versys™ Metal/ Silicon 2300™ process module (PM) on the Versys platform.

Changes Since Last Revision

Revision B contains the following changes:

- Corrections to Chapter 1, "Overview," including updates to plasma clean recipes.
- Updates to Chapter 4, "Checking the System," including:
    - Changes to pinlifter checks to include direct-drive pinlifters,
    - Improvements to solenoid test tables,
    - Includes additional Leakback tests and corrections to "Performing a Leakback Check Using a Helium Leak Detector,"
    - Corrections to tables and text in "Checking the Generator RF Linearity,"
    - Corrections to TCP RF parameters and Bias RF parameters in "Checking the Plasma."
- Updates to all text and illustrations in Chapter 5, "Optical Endpoint and Plasma Test."

Reference Documentation

Table 1–1 lists the manuals referenced in this manual.

Table 1–1. Reference Documentation

Part number	Manual
405-240340-001	*2300 Versys Metal/Silicon Process Module Facility*
406-240340-201	*2300 Versys Metal/Silicon Process Module Installation Guide*
406-240340-202	*2300 Versys Metal/Silicon Process Module Operation*
406-240311-002	*2300 Transport Module Operation*
406-240311-003	*2300 Transport Module Maintenance*
406-004558-002	*Enhanced Universal Gas Box User Guide*
406-240390-002	*2300 Etch Systems Safety*

Note The part numbers for cleanroom versions of the listed manuals (except facility manuals) start with the prefix 409. Facility manuals are not available in cleanroom version.

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Standard Configuration for the Versys Metal System

The standard configuration for the 2300 Versys Metal Etch System, which is also referred to as Versys metal process module (PM), includes:

- Wafer type: Semiconductor Equipment and Materials International (SEMI) notch
- Metal process kit that includes monopolar electrostatic chuck (ESC), focus ring, gas feed, and Transformer Couple Plasma™ (TCP®) coil.
- TCP 1500 watt kit
- Bias 1250 watt kit
- Fixed gap electrode
- Three pin wafer lift mechanism
- Heated foreline
- Seiko Seiki® 2200 liter per second (l/s) kit with VAT™ DN 250 valve
- Temperature control unit (TCU): Edwards 40/80 Plus kit (with LonWorks®, 55 pounds Fluorinert™, and installation kit)
- Chamber gas feed with 10 roughness average (Ra) gas line surface finish
- 200 millimeter (mm) or 300 mm courtesy kits
- Interconnect cables: PM peripheral kit, 25 foot (gas box, TCU, mechanical pump, emergency off (EMO), LonWorks).
- 8 gas line gas box (heated BC13 gas line position 1)
- Courtesy kit

Optional Features for the Versys Metal System

- Wafer type: Japanese Electronics Industry Development Association (JEIDA) flat
- Chamber gas feed with five roughness average (Ra) gas line surface finish

- Spares: quick clean kits, chamber O-ring kits Viton®, chamber O-ring kits Chemraz™
- Interconnect cables: PM peripheral kit, 50 foot (gas box, TCU, mechanical pump, EMO, LonWorks)
- Interconnect cables: PM peripheral kit, 100 foot (gas box, TCU, mechanical pump, EMO, LonWorks).
- Optional emission spectrocopy
- 10 or 12 gas line configuration with various MFC manufacturers (Unit 1660 Metal, Unit 8161 Metal Digital, Area FC-D980C)
- Double containment, heated lines at position 1-3, regulated inlet gas panel, nickel or stainless filters
- Alcatel® 2200 liter per second with VAT™ DN 250 valve

Standard Configuration for the Versys Silicon System

The standard configuration for the 2300 Versys Silicon Etch System, which is also referred to as the Versys Silicon process module (PM), includes:

- Wafer type: Semiconductor Equipment and Materials International (SEMI) notch
- Poly process kit that includes monopolar electrostatic chuck (ESC), quartz focus ring, gas feed, and Transformer Coupled Plasma™ (TCP) coil.
- TCP 1.25 kilowatt (kW) kit for 200 mm
- TCP 1.5 kW kit for 300 mm
- Bias 1.5 kW kit
- Fixed gap electrode
- Three pin wafer lift mechanism
- Alcatel® 1600 liter per second (l/s) with VAT™ DN 200 valve
- Temperature control unit (TCU): Edwards 40/80 Plus kit (with LonWorks™, 55 pounds Flourinert™, and installation kit)

- Chamber gas feed with 10 roughness average (Ra) gas line surface finish
- 200 millimeter (mm) and 300 mm courtesy kits
- Interconnect cables: PM peripheral kit, 30 foot (gas box, TCU, mechanical pump, emergency off (EMO), LonWorks).

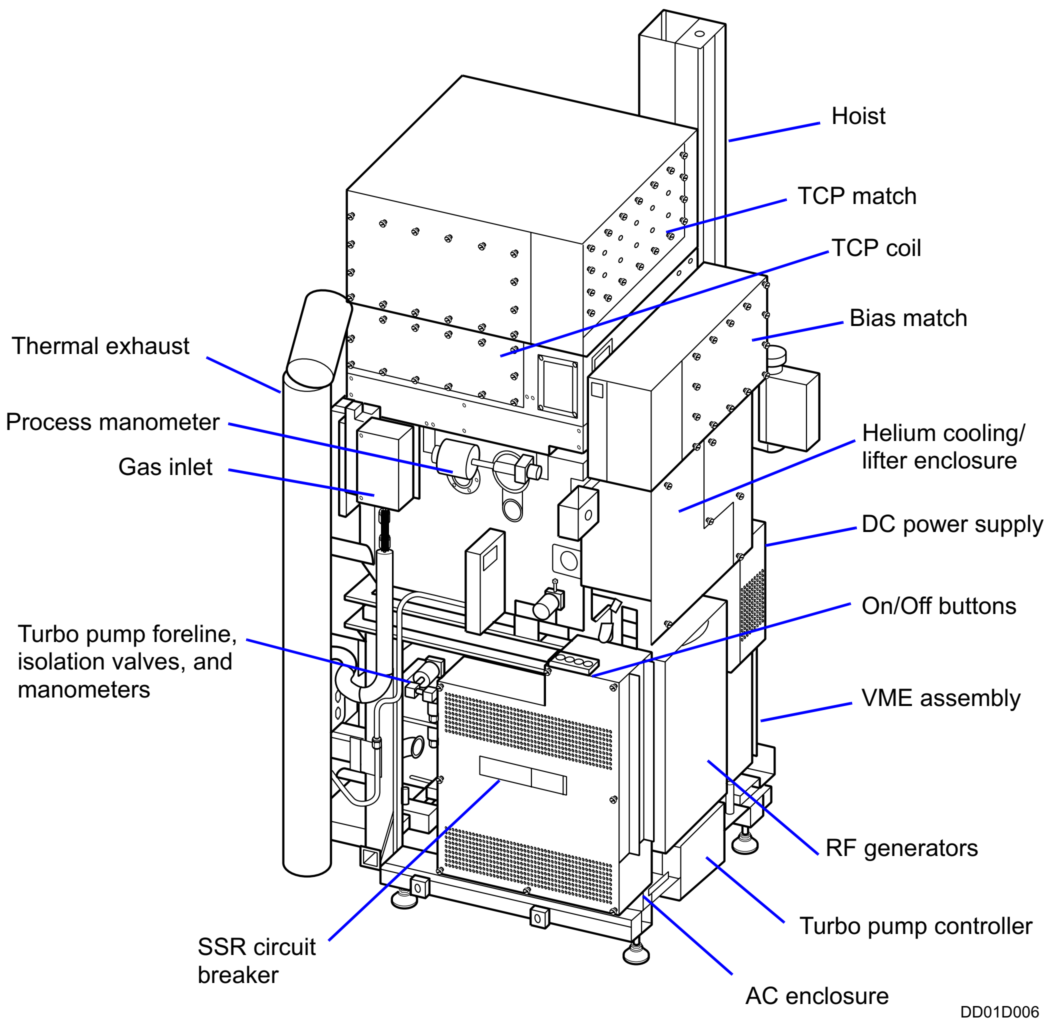
Optional Features for the Versys Silicon System

- Wafer type: Japanese Electronics Industry Development Association (JEIDA) flat
- Alcatel 2200 liter per second (l/s) with VAT DN 250 valve
- Seiko Seiki 2200 l/s kit with VAT DN 250 valve
- EndPoint Plus™ with interferometer and chamber fingerpoint software upgrade package
- Chamber gas feed with 5 roughness average gas line surface finish
- Spares: quick clean kits, chamber O-ring kits Viton, chamber O-ring kits Chemraz™, chamber O-ring kits Flourosilicone for low temperature processes.
- Interconnect cables: PM peripheral kit, 50 foot (gas box, TCU, mechanical pump, EMO, LonWorks)
- Interconnect cables: PM peripheral kit, 100 foot (gas box, TCU, mechanical pump, EMO, LonWorks).

Showing the Locations of the 2300 Versys Metal/Silicon PM Assemblies

Figure 1–1 shows the major assemblies for the Versys Metal/Silicon PM.

Figure 1–1. 2300 Versys Metal/Silicon PM Assemblies



Safety

This section provides safety information for the 2300 Versys Metal/ Silicon process module (PM).

Training

All operating personnel must have the appropriate safety training pertaining to the hazards of the system.

Emergency Off

All Lam systems include an emergency off (**EMO**) system to disconnect power when an emergency occurs.

On the 2300 system, large, red palm-sized buttons are positioned a maximum of 10 feet apart. **EMO** buttons are positioned on the UI, the front right side of the TM, and the PM 4 face if PM 4 is not installed. When you push any of these **EMO** buttons, the power to the system is turned off up to the load terminals of the main contactor.

When the **EMO** is activated for the uninterrupted power supply (UPS) option, power is shut off up to the load terminals of the main contactor and to the load terminals of the external (customer-provided) UPS main contactor.

The voltage for the EMO circuit is 24 VAC and limited to 1 ampere. The circuit is located in the power/control rack.

The global EMO distribution is located at the AC distribution rack. The remote power distribution box (RPDB) reports its EMO state to the global EMO distribution. The PM pump and TCU **EMO** buttons report to the RPDB. The EMO circuit in the AC distribution rack is 24 VAC and limited to 1 ampere. The EMO circuit transformer exclusively provides power to the EMO loop for all EMO contacts and all contactor pilot relays.

Power to the EMO transformer and associated circuitry remains on after the EMO system is activated.

All EMO events require manual recovery, which means that you must go to the module that generated the EMO event to verify that conditions are safe.

Remote Power Distribution Box

The remote power distribution box (RPDB) assembly is a standard component of each system. It includes the main circuit breaker and circuit breakers for the TCUs and PM dry pumps.

All electrical connections must comply with the requirements of the NEC and local standards.

Typically, certified journeymen electricians install the power distribution systems.

You are responsible for distributing power from the main power/control rack to the RPDB.

EMO Limitations

The following are the limitations of the EMO system when it is activated:

- When AC power to the turbo pump controller is disconnected, the controller will continue to operate for a few minutes while the pump spins down.
- Power to the system computer is not immediately disconnected. The internal uninterruptible power supply (UPS) supplies power for several seconds before turning off.
- Power to the pressure controller valve of the process module continues (with internal batteries) until the valve is fully closed. Then the power turns off.
- Power to the EMO transformer and associated circuitry remains on after an EMO event.

Figure 1–2 shows the interconnections between the TM and PM, and RPDB EMOs. Figure 1–3 shows the electrical connections of the TM and PM EMOs.

Figure 1–2. EMO Interconnect Diagram

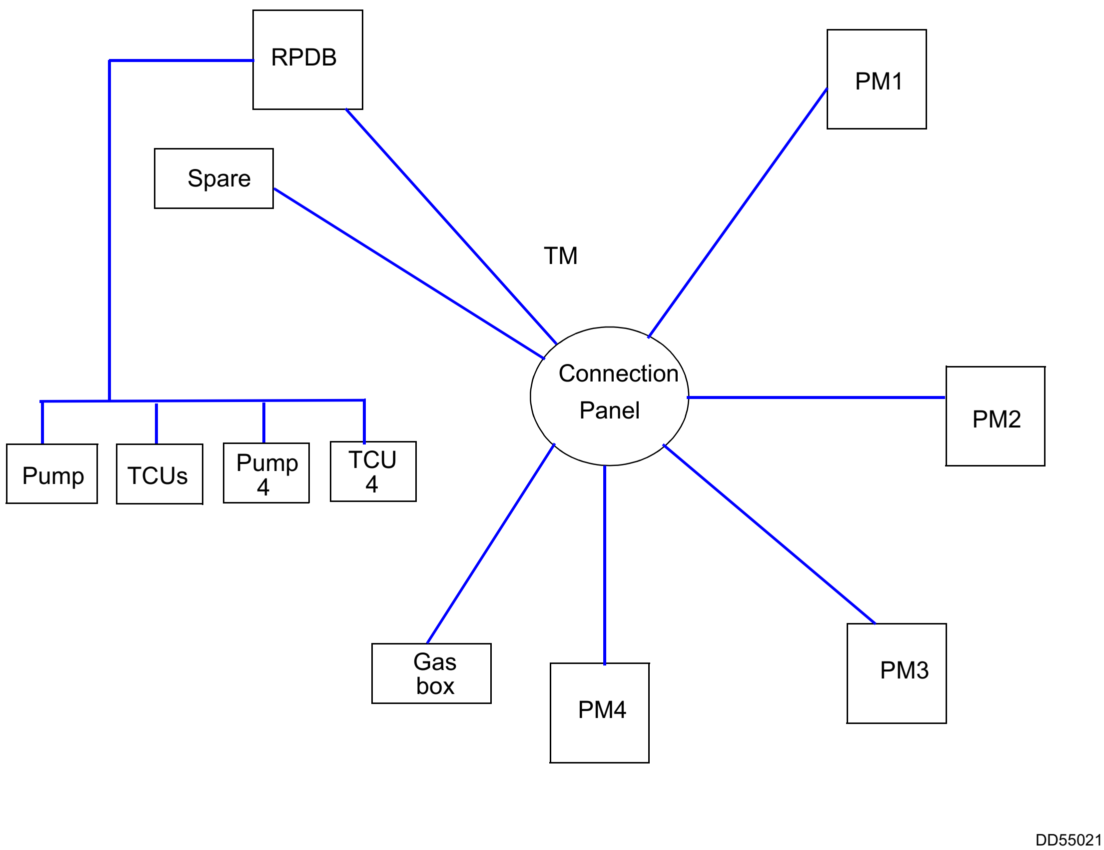
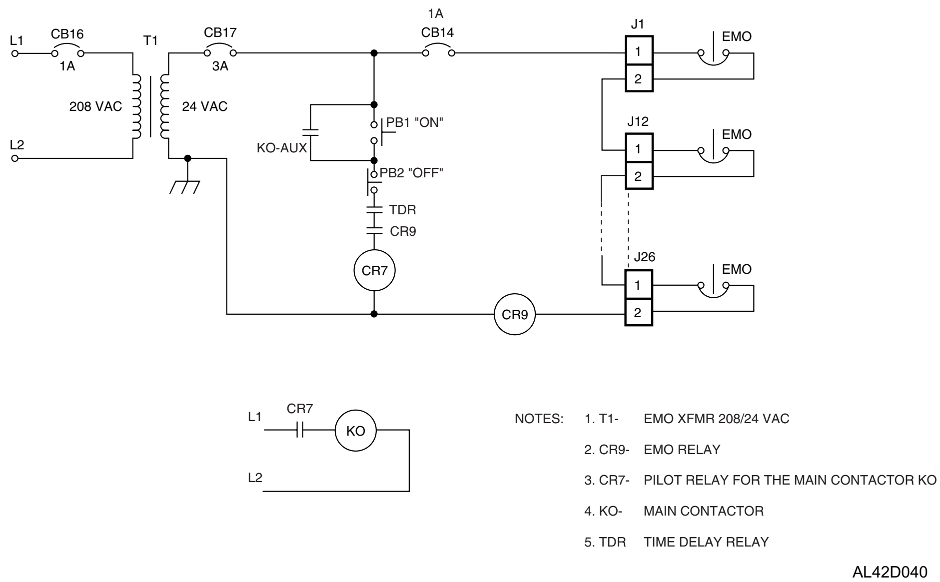


Figure 1–3. EMO Ladder Diagram



Lockout/Tagout for the Main Circuit Breaker Disconnect Handle

Use a lockout to prevent energizing the system and endangering workers.

Use standard lockout devices to lockout and tagout the main circuit breaker handle. You must place the main circuit breaker handle in the safe position (OFF). Attach a lock to the handle (special openings are dedicated for that) so that you cannot energize the equipment.

In a tagout, attach a written warning to the lockout device.

Lam recommends that you carefully follow the lockout and tagout procedures described in this manual before servicing the TM. Perform these procedures only if you are an authorized technician.

The 2300 system provides signal *EMO circuit closed* to the remote control unit. This signal is generated by normal opened dry contacts of a relay which are connected to pins 1 and 2 of the AC rack connector J28.

The 2300 system can connect your EMO device into the system's EMO daisy-chained circuit using the AC rack connector J34.

Note Based on the industry standard, you must bottom facilitize the 2300 system. Mount the main disconnect device with line terminals down and load terminals up.

If necessary, you should obtain a *code variance* from local jurisdictions in advance.

Environmental Regulations

Environmental regulations and requirements vary by the geographic location or governmental jurisdiction. Various local, regional, and national standards either exist, or are emerging, for the environmental performance of semiconductor process equipment.

Existing environmental requirements, as they pertain to process equipment, include the following categories: air emissions such as hazardous air pollutants (HAPs), perfluorocarbons (PFCs), volatile organic compounds (VOCs), water effluent, and solid or liquid hazardous wastes. In addition, performance requirements developed by the semiconductor industry are emerging in the areas of water and energy use efficiency. Lam participates in these discussions and tracks all important developments, some of which will be included in future facility manuals as industry or company standards are developed.

Material Safety Data Sheets

Always be sure to keep on hand and review the material safety data sheets (MSDS) provided by the chemical supplier. These sheets contain pertinent information and a profile of hazardous substances or mixtures.

Point-of-Use Abatement

Point-of-Use (POU) emission abatement systems are designed for treating air emissions from the outlet of a specific semiconductor process to remove compounds of interest before they enter the facility's main exhaust ductwork. This distinction separates POU systems from facility-level abatement systems, which treat the collected exhausts of an entire facility, or large portion thereof. A typical POU system may serve from one to four similar process modules.

Several types of POU systems currently exist in the marketplace for specific classes of effluents such as HAPs (wet-scrub with chemical, wet-scrub without chemical, oxidation, and so forth). Specific equipment is typically neither provided by, nor recommended by, system suppliers as standard peripheral equipment. As development of such equipment continues to evolve, this may change. Currently Lam is engaged in several research and development efforts for such equipment.

The SEMATECH Transfer Document *Point-of-Use Control Systems for Semiconductor Process Emissions* provides guidance in the identification and selection of POU systems for particular process applications. In all cases where such equipment is used with Lam products, it is essential that the end-user investigate and comply with any location-specific environmental regulations.

HAPs Regulation Management

Some qualitative and quantitative hazardous air pollutants (HAPs) emissions data for the 2300 Versys Metal/Silicon process modules exists.

Safety Precautions for Chemicals Used on the Versys Metal Process Module

The Versys Metal system is capable of two types of plasma etch processes, aluminum and tungsten. Both produce different exhaust effluents.

Aluminum Etch

Etching aluminum is based upon the following chemical reaction:

$2\ Al + 3\ Cl_2 \rightarrow Al_2Cl_6$

Actual plasma etch processes involve other chemicals. For example, other gases such as boron trichloride (BCl_3) are routinely added to the process and wafers contain other compounds including copper (Cu), titanium (Ti), nitrogen (N), silicon (Si), oxygen (O), and photoresist. You can readily predict the major effluent products from a calculation of the thermodynamically most stable products. The results shown in Table

1–2 indicate that unreacted BCl_3 and chlorine (Cl_2), and the product Aluminum Hexachloride (Al_2Cl_6) are the major components of the effluent.

Table 1–2. Aluminum Etch Effluent Components

Products	Per wafer units	Per year units
BCl_3	1.022 g	154 Kg
Cl_2	0.600 g	85.9 Kg
Al_2Cl_6	0.125 g	18.8 Kg
HCi	0.020 g	3.0 Kg
$TiCl_4$	0.020 g	3.0 Kg
N_2	0.014 g	2.1 Kg
CCl_4	0.016 g	2.4 Kg
$SiCl_4$	0.005 g	0.7 Kg
CO_2	0.001 g	0.1 Kg
Cu_3Cl_3	0.001 g	0.1 Kg

Note This calculation is for a baseline aluminum etch process of a 200-millimeter diameter wafer, and assumes a two-step etch, with a main etch step at 8 mtorr using 250 standard cubic centimeter per minute (sccm) Cl_2 and 150 sccm BCl_3 for 33 seconds, and an overetch step at 8 mtorr using 150 sccm Cl_2, 150 sccm boron trichloride (BCl_3), and 20 sccm nitrogen (N_2) for 45 seconds. The wafer is assumed to consist of 8000 angstrom (Å) SiO_2, 500 Å Ti, 6000 Å aluminum (Al) (with 0.5 percent Cu), 250 Å TiN, and 1.1 micron of photoresist and has 50 percent open area. The estimated effluent per year assumes 150,000 wafers are processed in a year.

Tungsten Etch

Etching of tungsten is based upon the formation of volatile tungsten hexafluoride (WF_6) from fluorine atoms generated in a plasma from a feed gas with sulfur hexafluoride (SF_6). Actual plasma etch processes, however, are more complex than this. You can readily predict the major products from a calculation of the thermodynamically most stable products. The results shown in Table 1–3 indicate that unreacted sulfur hexafluoride (SF_6), Chlorine (Cl_2), boron trichloride (BCl_3), and the product tungsten hexafluoride (WF_6) are the major components of the effluent.

Table 1–3. Tungsten Etch Effluent Components

Products	Per wafer units	Per year units
SF_6	0.623 g	93.5 Kg
WF_6	0.246 g	36.8 Kg
Cl_2	0.176 g	26.4 Kg
BCl_3	0.349 g	52.6 Kg
S	0.035 g	5.2 Kg
N_2	0.030 g	4.6 Kg
CF_4	0.025 g	3.8 Kg
$TiCl_4$	0.013 g	2.0 Kg
HF	0.009 g	1.3 Kg
CO_2	0.001 g	0.1 Kg

This calculation is for a baseline tungsten etch process of a 200-millimeter diameter wafer, and assumes a three-step etch, with a main etch step at 12 mtorr using 100 sccm SF_6 and 20 sccm N_2 for 60 seconds, an overetch step with the same recipe for 12 seconds, and a TiN barrier layer etch of 6 mtorr using 100 sccm Cl_2 and 115 sccm BCl_3 for 35 seconds. The wafer is assumed to consist of 8000 Å SiO2, 250 Å Ti, 250 Å TiN, 5000 Å Tungsten, and 1.2 micron of photoresist and has 50 percent open area. The estimated effluent per year assumes 150,000 wafers are processed in a year.

Safety Precautions for Chemicals Used on the Versys Silicon Process Module

The Versys Silicon process module is capable of three types of plasma etch processes: polysilicon, tungsten silicide, and nitride. All produce different exhaust effluents.

Polysilicon Etch

Etching polysilicon is based upon the following chemical reaction:

$$Si + 2\ Cl_2 \rightarrow SiCl_4$$

Actual plasma etch processes, however, are more complex than this, because there are more chemical species involved in the etch. For example, other gases such as hydrogen bromide (HBr) are routinely added to the process and wafers contain other compounds including N, Si, O, and photoresist. It is difficult to exactly calculate or even measure the effluent of a plasma reactor, but you can readily predict the major products from a calculation of the thermodynamically most stable products.

For polysilicon etch using a baseline Cl_2 and HBr, the most common effluent component is hydrochloric acid (HCl). Cl_2 utilization is complete, and not detected in the effluent. HBr and Br_2 were also detected in the effluent in smaller concentrations.

For the baseline tetrafluoromethane (Freon-14) (CF_4) oxide breakthrough step on polysilicon, CF_4 utilization is very low, at about 10 percent. Emissions are primarily PFCs, with small quantities of silicon hexafluoride (SiF_4) and carbon difluoride (COF_2). For the baseline process, the utilization efficiency of the CF_4 was 13.6 percent, while the production efficiency of trifluoromethane (CFH_3) and hexafluoroethane (C_2F_6) were 16.3 percent and 5.4 percent respectively.

For the baseline nitride bulk etch step using CF_4 and HBr chemistry, the utilization efficiency of the CF_4 is 34.2 percent, while the production efficiency of the CFH_3 is 12.7 percent and the C_2F_6 is 1.6 percent.

For the baseline nitride endpoint and overetch steps using SF_6 and HBr chemistry, the utilization efficiency of the SF_6 is 83.6 percent.

For the baseline Cl_2/SF_6 plasma clean, Cl_2 utilization is low, and is thus detected in the effluent. SF_6 utilization is 53.0 percent. There is evidence of sulfuryl fluoride (SO_2F_2) and thionyl fluoride (SOF_2) detected in the effluent as well.

For the baseline SF_6/O_2 plasma clean, there is low fluorine consumption, and thus high emission levels of SOF_2 and SO_2F_2, and possibly SOF_2. SF_6 utilization efficiency is 68.3 percent.

The baseline process for Polysilicon, Oxide Breakthrough Step Main, and Overetch Steps is,

BT step: 15 mtorr, 100 sccm CF_4 for 10 seconds

ME step: 10 mtorr, 50 sccm CL_2 150 sccm HBr

OE step: 60 mtorr, 200 sccm He, 100 sccm HBr, 2 sccm O_2

Baseline process for Tungsten Silicide Main and Overetch Steps is,

4 mtorr, 90 sccm CL_2, 2 sccm O_2

Baseline process for Nitride Bulk, Endpoint and Overetch Steps is,

BE step: 20 mtorr, 75 sccm CF_4 25 sccm HBr

EP step: 15 mtorr, 25 sccm SF_6 50 sccm HBr

OE step: 30 mtorr, 25 sccm SF_6 50 sccm HBr

Abatement

From these results, it is clear that the gaseous effluent from the Versys Metal/Silicon process modules contain hazardous species.

Of primary concern are the higher concentration and most stable species, such as elemental chlorine, unreacted BCl_3, and various chlorides and fluorides which readily hydrolyze to form HCL and HF.

Clean air requirements, in addition to prudent environmental practices, necessitate that you treat the gaseous effluent to remove these compounds before release of the effluent to the atmosphere.

Scrubber technology itself is complex and continues to evolve, but here is a brief description of the process:

Common practice is now to use a wet scrubber to react and absorb the species mentioned previously from the effluent. These species are acidic and will react to lower the pH of the water. You must neutralize the pH of the water from the scrubber before release.

Although the plasma generates a wide variety of other hazardous species, they are of less concern from an abatement viewpoint. These other species are at low concentration, and are unstable and short-lived.Thus, they tend to react or combine within the lines to the pump. As mentioned previously, this tends to create a hazardous deposit in the exhaust ductwork. Repair and replace this ductwork with due regard for safety and use of appropriate disposal technology.

Hazardous Waste

When you perform some of the maintenance procedures for the 2300 Versys Metal/Silicon system, waste products may be produced. Treat all waste as toxic. If disposal is required, please observe the proper Occupational and Safety Health Administration (OSHA)-approved or facility-approved disposal practices.

Table 1–4 shows the chemical by-products accumulated during regular maintenance of the Versys Metal process module:

Table 1–4. Hazardous Materials Used for Maintenance—Versys Metal

Material	Quantity per wet clean
DI H2O on 9 x 9 lint-polyester free wipes	40 each
Isopropyl alcohol on 9 x 9 lint-free polyester wipes	40 each
Dry wipes (9 x 9 lint-free polyester)	20 each
Latex gloves	12 pairs
Nitrogen and inline gas filters (796-091775-001)	1 each

Table 1–5 shows the chemical by-products accumulated during regular maintenance of the Versys Silicon process module:

Table 1–5. Hazardous Materials Used for Maintenance—Versys Silicon

Material	Quantity per wet clean
6 percent H_2O_2 with DI H_2O on 40 each 9 x 9 lint-free polyster wipes	
Isopropyl alcohol on 20 each 9 x 9 lint-free polyester wipes	
Dry wipes (9 x 9 lint-free polyester)	20 each

Table 1–5. Hazardous Materials Used for Maintenance—Versys Silicon

Material	Quantity per wet clean
Latex gloves	12 pairs
Nitrogen and inline gas filters (796-091775-001)	1 each

Recycling, Refurbishment, and Reuse of Equipment

In accordance with SEMI S2-0200 Paragraph 9.65, which references also SEMI S-12, in the event of system reuse, recycling, or refurbishment, use the following guidelines:

- Treat any part of the etch system that comes in contact with hazardous gases the same way as you treat the hazardous gases and by-products generated by your process. Follow the same regional environmental and worker protection laws regarding the contact and disposal of hazardous materials.
- The major structural components for the 2300 system, including the frames, are 1020 cold rolled steel. Most parts of process modules have areas contact with hazardous gases. Consider these parts as hazardous materials, unless they are determined to be otherwise or decontaminated. Exercise caution when you contact these parts.

The hazardous materials in a Lam etch system are primarily caused by the following two factors:

- Providing high pressure hazardous gas, typically from 5 to 50 per square inch (psi), to the gas box for the reaction chamber and delivering low pressure hazardous gas to the reaction chamber from the gas box: The predominant material used to contain the gas is 316L stainless steel tubing. The hazardous gases at worst case may corrode the steel after a period of years, depending on the consistency of gas purity supplied to the gas box. No residual personnel hazards should remain after the hazardous gases are removed. Evaluate residual contamination consistent with gas used and facility steel re-use and recycling plan.
- Removing low pressure hazardous gas from the reaction chamber, typically at pressure under 10 torr: Process by-products will adhere to the materials in the vacuum flow from the reaction chamber to the facility backing pump. The typical materials of construction in the

vacuum flow path are high purity ceramics (alumina), anodized 6061 aluminium, and 304 stainless steel. Process by-products are discussed elsewhere in this manual in more detail. At worst case, these process by-products may result in an airborne toxicity in the event of system reuse, recycling, or refurbishment. Use suitable personal protective equipment (PPE) consistent with the process by-products and regional environmental and worker protection laws.

Ergonomics

Use proper lifting and handling techniques when working on the system. Improper ergonomic handling may result in injury. Some tasks outlined in this manual may require excess reach by personnel of shorter height. Lam recommends the use of a suitable foot stool, stepladder, or appropriate means when performing these tasks.

Protective Gear

Wear protective, cleanroom-approved clothing and gloves, safety glasses and a full breathing apparatus whenever appropriate.

See the *2300 Etch Systems Safety* manual for additional safety information.

Energized Electrical Work Types

The *Environmental, Health, and Safety Guidelines for Semiconductor Manufacturing Equipment* (SEMI S2-0200) defines four types of electrical work. The four types are as follows:

Type 1	Equipment is fully de-energized.
Type 2	Equipment is energized. Energized circuits are covered or insulated. Type 2 work includes tasks where the energized circuits are or can be measured by placing probes through suitable openings in the covers or insulators.
Type 3	Equipment is energized. Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposures are no greater than 30 volts alternating current (VAC) root mean square (RMS), 42.4 VAC peak, 60 volts direct current (VDC), or 240 volt-amperes in dry locations.
Type 4	Equipment is energized. Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposures are greater than 30 VAC RMS, 42.4 VAC peak, 60 VDC, 240 volt-amperes in dry locations. Potential exposures to radio-frequency currents, whether induced or via contact, exceed the limits in Table A5-1 of Appendix 5, SEMI S2-0200.

The applicable electrical work types are indicated in the Safety section at the beginning of each procedure.

Lockout/Tagout

Use a lockout to prevent energizing the equipment and endangering workers. When using lockouts, the following conditions may exist.

- A disconnect switch, circuit breaker, valve, or other energy-isolating mechanism is put into the safe or off position.
- A device is often placed over the energy-isolating mechanism to hold it in the safe position.
- A lock is attached so that the equipment cannot be energized.

In a tagout, place the energy-isolating device into the safe position and attach a written warning to the device.

Lam recommends that you carefully perform the following lockout and tagout procedures before servicing the unit. Only qualified and authorized technicians should perform these tasks.

Note Use standard lockout devices for pneumatic and liquid lockout/tagout.

Electrical Isolation

Shutting Down the System for Electrical Isolation

► **To shut down the system for electrical isolation,**

1. Before servicing, inform all affected personnel that you will shut down the unit for servicing, and that all electrical power sources will be locked out.
2. Shut down the unit using normal shutdown procedures. See the *2300 Versys Metal/Silicon Process Module Operation* manual.
3. Lock all the electrical power sources in the disconnect position with a padlock that you can only open with a key.

Note Power to the EMO transformer and associated circuitry remains on after an EMO event. Always lockout/tagout the main circuit breaker in the AC rack when working inside the AC or DC box.

Note CB0 (main power) must be open when you are working inside the AC enclosure. If the system has the UPS option, some power may be present inside the AC enclosure. CB0 (main power) and the UPS main CB must be open when you are working inside the AC enclosure.

4. Attach written warnings to the locking devices.
5. Verify that you have disconnected all electrical power by attempting to restart the unit at the control panel and then observing that the *power on* light is off. In addition, measure the voltage to verify that the light is not burnt out.

Starting Up After Servicing

▶ **To start up after servicing,**

1. Make sure that you remove all hand tools and other foreign objects from the unit.
2. Restore all guards and enclosure panels to their normal operating positions.
3. Check the area around the unit to ensure that all personnel are at a safe distance.
4. Verify that all controls are in the off or neutral positions.
5. Remove the locks and tags that were placed on the electrical power sources.
6. Notify all area personnel that unit will be energized.
7. Energize the unit.

Process Gas Isolation

Generally, you need to isolate the process gas when performing maintenance on a gas panel or when opening the gas delivery system.

Be sure to purge hazardous gases from the gas panel (gas box) prior to servicing.

Be sure to purge the moisture from the gas panel prior to returning the gas line to service.

Shutting Down the Process Gas

▶ **To shutdown the process gas,**

1. Close the manual gas supply valve(s) on the inlet side of the gas panel.
2. Apply a locking device over each gas supply valve handle and lock with a padlock that you can only open with a key.
3. Attach written warnings to the locking devices.

Starting Up After Servicing

▶ **To start-up after servicing,**

1. Perform pump-and-purge cycles on the affected gas line to remove moisture.
2. Unlock and remove the locks and tags on each gas supply valve handle.
3. Open the manual gas supply valve(s) on the inlet side of the gas panel.

Liquid Lockout/Tagout

The fab's facilities directly supplies water to the system. There are manual shutoff valves for both the inlet and outlet water lines. These are located between the PM and the TM. Completely close the water valves, and place a standard, readily available lockout device over the valve and lock to lockout house water to the process module. Follow all other lockout/tagout procedures as recommended by Lam.

Pneumatic Air Lockout/Tagout

Air is supplied to the process module from the TM by way of a quick disconnect connection. This connection is located between the PM and the TM. Completely uncouple the pneumatic air quick disconnect fitting, and place a standard, readily available lockout device over the end of the fitting and lock it, to lockout pneumatic air to the process module. Follow all other lockout/tagout procedures as recommended by Lam.

Chemicals Used During Maintenance

The following chemicals are used in the maintenance of the Versys Metal process module:

- Isopropyl alcohol (IPA)
- Deionized (DI) water
- Hydrogen peroxide solution (for tungsten only)

- Fomblin® grease
- Krytox® grease

The following chemicals are used in the maintenance of the Versys Silicon process module:

- Isopropyl alcohol (IPA)
- Deionized (DI) water
- Hydrogen peroxide solution (for tungsten only)
- Fomblin® grease
- Hydrogen fluoride

Lam Recommendations

Use the following guidelines when performing routine maintenance on the reaction chamber:

- Wear appropriate protective gear, including arm guards, apron, goggles, and solvent-compatible gloves. This protective gear is essential to protect against human contact with toxic materials and vapors.
- Clear the surrounding area of all personnel not wearing appropriate protective gear.
- Prepare the chamber for pump-and-purge cycles by running the plasma clean recipes.These plasma clean recipes help to neutralize chlorine-based by-products in the chamber prior to opening it. See the metal and silicon wet clean procedures in the *2300 Versys Metal/ Silicon Maintenance* manual.
- Perform a nitrogen purge before beginning work on the reaction chamber or any chemistry-carrying parts. Perform a minimum of 60 pump-and-purge cycles prior to opening a chamber configured for non-toxic gases and 240 cycles for systems using HBr. If you run a plasma clean just before opening the chamber, then 60 cycles is sufficient. Because fab operation procedures vary, industrial hygiene air sampling tests are advised and/or required when qualifying specific procedures to ensure compliance with threshold limit value (TLV) and permissible exposure limit (PEL) specifications. Consult

the maintenance procedures for details. The pump-and-purge process is vital to reducing toxic chemical concentrations.

- Perform maintenance activities in a well-ventilated area. Air circulation will help prevent excessive build-up of vapors due to the residual chemistry that may remain after you perform the pump-and-purge cycles.

Ultrapure Water

The preventive maintenance and cleaning activities on the Versys Metal/ Silicon process module produce approximately 2 liters per year of ultrapure water (UPW).

Potentially Hazardous Operations

Some procedures required for system maintenance involve potentially hazardous operations. Specific hazards are indicated by warning labels on the system and by prominent warnings and cautions in the system maintenance and operation manuals. Safety information, including the electrical state of the system during a given procedure, if applicable, is provided at the beginning of each procedure in the system maintenance manual. You need to be aware of potential hazards and applicable safety information, and you need to take appropriate precautions.

Only qualified personnel should operate and maintain the systems. Failure to observe this important restriction could result in death or injury to persons or damage to the equipment. Lam offers extensive training courses to ensure that you have the training to perform your functions skillfully and safely. Lam strongly advises that you only perform tasks that are consistent with your levels of training and experience when you are working on a particular system.

Table 1–6 lists potentially hazardous operations and recommended procedures for minimizing dangers.

Table 1–6. Hazardous Operations

Operation	Danger	Recommended procedure(s)	Hazard alert
Chemical			
Opening the reaction chamber.	Residual gases may be present from recent processing of wafers and/or recent maintenance activities (such as gas calibrations). Reaction by-products could react with air to release hazardous gases.	Run chamber clean process, then perform the recommended number pump/purge cycles required. Ensure the plasma clean recipe is run.	Failure to observe this precaution could result in exposure to toxic chemicals which could cause injury.
Inspecting or performing maintenance inside the chamber.	Residual gases may be present from recent processing of wafers and/or recent maintenance activities (such as gas calibrations). Reaction by-products could react with air to release hazardous gases.	Do not insert head into the reaction chamber.	Failure to observe this precaution could result in exposure to toxic chemicals which could cause injury.
Inspecting or performing maintenance inside the chamber.	Anodized surfaces could be scratched.	Take care to avoid scratching any anodized aluminum surfaces.	Failure to observe this precaution can result in premature wear of parts and/or shift in process results. It can also cause arching and burns, depending on the location of the scratches.
Handling of ceramic and quartz chamber parts.	All ceramic and quartz chamber parts are brittle and could break if dropped or bumped.	Take care when handling any ceramic or quartz parts not to drop or bump them.	Failure to observe this precaution could result in breakage of parts and the possible creation of sharp edges.
Cleaning ceramic chamber parts.	If the ceramic chamber parts are exposed to excessive moisture, a potential outgassing problem may exist.	Ensure the ceramic chamber parts have been thoroughly baked out.	Failure to observe this precaution could result in excessively high leakback rates.

Table 1–6. Hazardous Operations (continued)

Operation	Danger	Recommended procedure(s)	Hazard alert
Electrical			
Troubleshooting in AC/DC power distribution box.	Live terminals inside cover. Extreme hazard of electric shock if cover is removed with doors open and power on.	No regular maintenance is required. Troubleshoot only after lockout/tagout has been performed.	Failure to observe this precaution could result in serious injury or death.
Troubleshooting roughing pumps after performing an EMO.	Electrical shock from hazardous voltage.	Lockout and tagout of power to the roughing pumps before servicing.	Failure to observe this precaution could result in serious injury or death.
Troubleshooting ESC power supply with the cover off and the interlock bypassed.	Electrical shock from hazardous voltage.	Performed by only qualified technicians informed of this precaution to work on ESC power supply with the cover removed.	Failure to observe this precaution could result in serious injury.
Calibration of components in RF system.	Exposure to non-ionizing radiation. Risk of electric shock and/or burn.	Turn off all generators from both the control screen and the circuit breakers prior to disconnecting any RF cables. Always securely connect RF cables prior to turning on power to the module and/or generators.	Failure to observe this precaution could result in serious injury or death.
Thermal			
Cleaning a hot reaction chamber.	Burns to personnel, potential fire if wrong cleaning chemicals are used.	Turn down chamber wall temperature prior to opening the chamber. Use cleaning chemicals recommended by Lam only.	Failure to observe this precaution could result in burns caused by contact with hot chamber elements. Potential flash fire if acetone or other similar high pressure solvent is used.

Table 1–6. Hazardous Operations (continued)

Operation	Danger	Recommended procedure(s)	Hazard alert
Removing hot ESC cap with TCU running or lines not drained.	Burns to personnel, contamination to reaction chamber caused by TCU fluid.	Turn down electrode temperature. Turn off TCU and drain lines.	Failure to observe this precaution could result in burns caused by high pressure, high temperature TCU fluid spray. Chamber contamination caused by TCU fluid spraying around the chamber.
Removing gate valve when it is still hot.	Burns to personnel.	Turn down the reactor temperature. Allow to cool prior to removal.	Failure to observe this precaution could result in burns to hands and fingers unless unit is allowed to cool prior to removal.
Service/cleaning the gate valve while hot.	Burns to personnel.	Follow the pressure control procedures in this manual. Turn down temperature to ambient and allow to cool.	Failure to observe this precaution could result in burns to hands and fingers unless unit is allowed to cool prior to removal.
Servicing reactor cartridge heaters.	Burns to personnel.	Turn down all reactor temperature channels to ambient and allow to cool. Prior to removal, unplug heater(s) from power source. Lockout/tagout power to the heater.	Failure to comply could result in severe burns and a potential fire if the hot heater contacts a flammable surface.
Exposing the TCP coil.	The TCP coil and TCP window may be at a very high temperature.	Wait one half hour after operation of the upper RF. Lockout/tagout TCP generator.	Failure to observe this precaution could result in exposure to very hot parts.

Table 1–6. Hazardous Operations (continued)

Operation	Danger	Recommended procedure(s)	Hazard alert
Water Spill			
Replacing RF generators or turbo pump.	Water spill.	Turn off main power to the module and turn off water source to the process module. Disconnect the lowest line in the system and drain water into a catch pot. When disconnecting other lines, have wipes handy to soak up spills.	Failure to turn off water or drain lines could result in a water spill.
Mechanical			
Manually opening the gate valve.	The turbo pump could be running and the chamber at atmosphere. The gate valve should never open if the 3 torr switch is not mated.	Ensure that both the pump and chamber are at vacuum or that they are both at atmosphere.	Failure to observe this precaution could result in catastrophic failure of the turbo pump and damage to the pumping system.
Manually opening the gate valve.	The valve may close. A potential pinch point may exist during certain maintenance situations.	Do not insert your hands in the valve while it is closing.	Failure to observe this precaution could result in a pinched hand by the valve while it closes.
Many maintenance operations require reaches which may be excessive for smaller operators.	The operator may sustain injury (such as a strained muscle), or lose their balance and fall.	Provide suitable step stools and ladders for the task at hand. Do not use the process module as a ladder or step stool.	Failure to observe this precaution could result in injury.

System Checks

Use of potentially hazardous process chemistries requires a daily leak check of the 2300 PM gas distribution and chamber assemblies in order to ensure the absence of potentially dangerous leaks. Give special attention to parts that are susceptible to leaks, such as:

- Ultra-torr fittings
- VCR connections
- Flex lines

- Conflat gaskets
- O-ring materials

When disassembling system assemblies, inspect the O-rings and air lines for cracks, nicks, or other deformations. Replace the O-rings and air lines as needed. Replace the VCR gaskets or nickel gaskets whenever the vacuum seal is broken.

General Interlocks

The 2300 system is interlocked to protect against single fault hazards. These interlocks protect against human error or equipment failures that could allow exposure of personnel, facilities, or community to hazards or directly result in injury, death, or equipment loss. They are implemented in circuitry that is independent of the system controls. All of these interlocks will report alarms to the user interface if activated. They are also copied in the system control software.

Human Safety Interlocks

Human safety interlocks used to protect against injury of personnel rely only on electro-mechanical devices that are dual compliant. Microprocessors and integrated circuits are not used. Safety interlocks of the 2300 transport module and the Versys Metal/Silicon PM are described in the following sections.

Process Module Interlocks

The hazardous functions of the process module are interlocked as shown in Table 1–7.

Table 1–7. Process Module Interlocks

Table functions	Top RF power on	Lower RF power on	ESC power on	Chamber gas delivery valve on	Pendulum valve open	TMP not inhibited	Turbo exhaust valve on
Chamber pressure sw true		H	H	H	F		
Foreline pressure sw true		H			F	F	F
Chamber vacuum sw true	H		H	H			
Chamber sw closed	H			H			
HE/RF enclosure cover sw closed		H					
Helium maximum flow sw true		F					
Station X slot valve closed				H			
Coil enclosure down sw closed	H	H		H			
TCP RF connector sw closed	H						
TCP match scrubber sw closed	H			H			
TCP Match cover sw closed	H			H			
Lower match cover sw closed		H	H				
Lower match connector sw closed		H					

Table 1–7. Process Module Interlocks (continued)

Table functions	Top RF power on	Lower RF power on	ESC power on	Chamber gas delivery valve on	Pendulum valve open	TMP not inhibited	Turbo exhaust valve on
Roughing pump on				H			
Precharge manifold at vacuum				H			
No customer gas detect				H			
No customer interlock				H			

H = hardware human safety interlock, F = firmware equipment safety interlock

Describing the Interlocks

Enclosure Hardware Interlocks

The following enclosures are equipped with interlocks that disconnect AC power to the PM if they are activated. These interlocks are all in series in the 24 VAC interlock circuit.

- AC power distribution enclosure cover for the process module
- DC power distribution enclosure cover for the process module

Process Module Hardware and Firmware Interlocks

All hardware and firmware interlocks on the PM have redundant software interlocks also. The following table lists the various PM interlocks implemented in hardware and firmware (as well as software) and the process that they interlock.

Table 1–8. PM Hardware Interlocks

	Interlock switches/ DI ID no./ conditions																
	Chamber pressure sw true	**Foreline pressure sw true**	**Chamber vacuum sw true**	**Chamber switch closed true**	**Water leak sensor true**	**He/RF enclosure cover sw closed**	**Station X slot valve closed**	**Coil enclosure down sw closed**	**TCP RF connector sw closed**	**Chamber scrubber sw closed**	**TCP match cover sw closed**	**Bias match cover sw close**	**Bias match RF connector sw closed**	**Precharge manifold at vacuum**	**No Customer gas detect**	**No Customer Interlock**	**Hardware itlk bypass DO activated**
P&ID designation	CM2S1	CM3S1	PS1	SW1					PS4								
	node1	node1	node1	node1	node1	node2	node2	VIOP	VIOP	VIOP	VIOP	VIOP	VIOP	node3	node3	node3	
	DI0	DI2	DI3	DI6	DIC	DI2	DIA	DI3	DI4	DI5	DI2	DI17	DI18	DI2	DI6	D17	
Enable the following functions when the PM is in process mode																	
TCP RF power on			H	H				H	H	H	H						
Bias RF power on			H	H		H		H				H					
ESC power on			H		H									H	H	H	
Chamber gas delivery valve on			H	H			H	H		H	H			H	H	H	

Table 1–8. PM Hardware Interlocks (continued)

Interlock switches/ DI ID no./ conditions	Chamber pressure sw true	Foreline pressure sw true	Chamber vacuum sw true	Chamber switch closed true	Water leak sensor true	He/RF enclosure cover sw closed	Station X slot valve closed	Coil enclosure down sw closed	TCP RF connector sw closed	Chamber scrubber sw closed	TCP match cover sw closed	Bias match cover sw close	Bias match RF connector sw closed	Precharge manifold at vacuum	No Customer gas detect	No Customer Interlock	Hardware itlk bypass DO activated
Pendulum valve open	F	F															
Turbo exhaust valve on		F															
Main water control valve					H												
Enable the following functions when the PM is in maintenance mode																	
Pendulum valve open																	F
Turbo exhaust valve on																	F

Note: H =Hardware interlock, relay used on the board. F=Firmware interlock, opto-couples used on the board

LEDs Location (top of the board):

TM Slot Valve CR2-D	He Max Flow Switch CR2-C	He/RF Enclosure Cover Switch CR2-B	Chamber ATM switch CR2-A	Gas Ring Down Switch CR1-D	Chamber Vacuum Switch CR1-C	Foreline Vacuum Switch CR1-B	Chamber Pressure Switch CR1-A
TMP Exh Valve Open CR4-D	HardwareBypass ON CR4-C	Bias RF Connector Switch CR4-B	Bias Match Covers Switches CR4-A	TCP Match Covers Switches CR3-D	TCP Match Scrubber Switch CR3-C	TCP RF Connector Switch CR3-B	Coil Enclosure Down Switch CR3-A
Not used	Not used	Not used	Pendulum Valve Open CR6-A	Bias RF Interlocks OK CR5-D	TCP RF Interlocks OK CR5-C	Chamber Gas Delivery OK CR5-B	ESC High Voltage On CR5-A

DI Lights

Green=Switch is true

No light=Switch is not true

Node 3 (Gas Box) DS3	Node 1 (Chamber) DS1
Node 5 (VME) DS4	Node 2 (Lower Electrode) DS2

Node Connection Lights

Green=connected correctly

Red=not connected or connected wrong

Processes Which Are Interlocked

TCP RF Power On

Table 1–9 shows the hardware interlocks that disable TCP RF power unless they are satisfied.

Table 1–9. TCP RF Power

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
Coil Enclosure Down sw closed	VIOP_DI03
TCP RF connector sw closed	VIOP_DI04
TCP Match scrubber sw closed	VIOP_DI05
TCP Match cover sw closed	VIOP_DI02
Chamber switch closed	node1_DI6

Ensure that the PM chamber is at vacuum (less than 75 torr). Ensure that the coil enclosure is in the down position so that RF cannot be generated and expose personnel to dangerous RF.

Ensure that the TCP RF generator is connected to the TCP Matching Network. Ensure that the house supplied scrubber is operational so that the pressure differential between inside the coil enclosure and ambient pressure is met. You must have all of the covers in place on the TCP enclosure.

Additionally, check to be sure that excessive heat has not tripped the RF generator's internal temperature interlock.

Bias RF Power On

Table 1–10 shows the hardware interlocks that disable bias RF power unless they are satisfied.

Table 1–10. Bias RF Power On

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
He/RF enclosure cover sw closed	node2_DI2
Coil Enclosure Down sw closed	VIOP_DI03
Bias Match cover sw closed	VIOP_DI17
Bias Match RF Connector sw closed	VIOP_DI18
Chamber switch closed	node1_DI6

Additionally, check to be sure that excessive heat has not tripped the RF generator's internal temperature interlock.

ESC Power On

Table 1–11 shows the hardware interlocks that disable ESC power unless they are satisfied:

Table 1–11. ESC Power On

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
He/RF enclosure cover sw closed	node2_DI2
Bias Match cover sw closed	VIOP_DI17

The vacuum switch prevents the you from operating the ESC when the chamber is at atmosphere, thus opening and exposing personnel to dangerous voltages. The covers on the He/RF enclosure and the bias match prevent exposure to RF radiation.

Chamber Gas Delivery

Table 1–12 shows the hardware interlocks that disable delivery of process gas from the gas box to the reaction chamber unless they are satisfied:

Table 1–12. Chamber Gas Delivery

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
Chamber sw closed	node1_DI6
Station X slot valve closed	node2_DIA
Coil Enclosure Down sw closed	VIOP_DI03
TCP Match scrubber sw closed	VIOP_DI05
TCP Match cover sw closed	VIOP_DI02
Precharge manifold at vacuum	node3_DI2
No Customer gas detect	node3_DI6
No Customer interlock	node3_DI7

The precharge manifold vacuum switch is located inside of the gas box. The two customer specific I/Os are available to connect external switches to the process modules to act as interlocks.

Pendulum Valve Open

Table 1–13 shows the firmware interlocks that do not allow the pendulum valve to open unless they are satisfied:

Table 1–13. Pendulum Valve Open

Interlock state	Hardware
Chamber pressure sw true	node1_DI0
Foreline pressure sw true	node1_DI2

The chamber pressure switch prevents the pendulum valve from opening if the chamber pressure is greater than 500 mtorr. This prevents damage to the turbo pump. The pendulum valve is additionally interlocked to the foreline pressure switch which monitors pressure in the foreline and is a measure of how well the roughing pump is pumping.

Turbo Exhaust Valve Open

Table 1–14 shows the firmware interlock that does not allow the turbo exhaust valve to open unless it is satisfied:

Table 1–14. Turbo Exhaust Open

Interlock State	Hardware
Foreline pressure sw true	node1_DI2

Opening the foreline exhaust valve at a pressure above 750 mtorr could damage the turbo pump. The foreline pressure switch measures pressure in the foreline and prevents this from happening.

PM Heater Power Interlock

The enclosure for the AC/DC power distribution provides contactor K1 to interrupt AC power to the system heaters. This contactor is enabled by a combination RTD over-temperature sensors, the temperature monitor board (TMB) of the Anafaze™ temperature controller, and ground fault interrupter (GFI) T1. All over-temperature sensors for all controlled heaters, and GFI sensor must be safe to enable AC power to heaters.

Thermal Interlock

The foreline manifold heaters are temperature regulated 208 VAC heaters, which employ bi-metallic over-temperature switches set at 100 degrees Celsius to disconnect heater power in the event of a thermal runaway.

Wafer Transfer Slot Valve Interlock

The wafer transfer slot valve is interlocked. This interlock helps to isolate gases in the reaction chamber. Signals are sent from the PM to the TM, so that the TM does not open the slot valve when the PM is at atmosphere and the TM is at vacuum, nor when the PM is at vacuum and the TM is at atmosphere.

Gas Box Hardware Interlocks

The interlock circuitry must rely only on the dual compliant electro-mechanical devices to protect personnel from exposure to toxic gases.

Table 1–15 shows the gas panel functional interlocks.

Table 1–15. Gas Box Hardware Interlocks

		Inputs							
		Chamber delivery valve ok contact closure from PM interlock board	Roughing Pump ok contact Closure from PM interlock board	Precharge Manifold at VAC	Chamber Delivery at VAC	Differential pressure SW ok	N2 Purge Supply	Customer Gas Detect	Customer Interlock SW ok
				PSH2	PSH3	PSH8	PSH9	IS20	IS21
				DI2	DI3	DI4	DI5	DI6	DI7
SOV No.	*Enable following function*								
SOV1	N2 Primary valve on						X	X	X
SOV2	Vacuum Primary valve on		X	X				X	X
SOV3	Gas Manifold Purge valve on						X	X	X
SOV4	Gas Manifold Precharge valve on		X	X				X	X
SOV5	Chamber gas delivery valve on	X	X	X				X	X
SOV7	Chamber slow vent						X	X	X
SOV8	Chamber wafer transfer						X	X	X
SOV9	Chamber N2 valve on						X	X	X
SOV10-80	All gas primary valve on				X	X		X	X
SOV12-82	All gas secondary valve on				X	X		X	X

SOVx refers to the shutoff valve in the gas box.

Table 1–16. PM Interlock Board

Interlock	Hardware	Switch
Precharge Manifold @ VAC	DI2	PSH2
Chamber Delivery @ VAC	DI3	PSH3
Differential pressure SW ok	DI3	PSH8
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV1 Nitrogen Primary Valve On

Table 1–17 shows the following interlocks that prevent the opening of the nitrogen primary valve unless they are true.

Table 1–17. SOV1

Interlock	Number	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	S20
Customer Interlock SW ok	DI7	IS21

Interlocked unless opening by the nitrogen purge supply pressure switch, PSH9. Additionally, the you have the option of adding up to two external interlocks of your choice. The system ships with these two I/Os jumpered short.

SOV2 Vacuum Primary Valve On

Table 1–18 shows the following interlocks that prevent the opening of the vacuum primary valve unless they are true.

Table 1–18. SOV2

Interlock	Hardware	Switch
Roughing Pump ok contact Closure from PM interlock board	-	-
Precharge Manifold @ VAC	DI2	PSH2
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV3 Gas Manifold Purge Valve On

Table 1–19 shows the following interlocks that prevent the opening of the gas manifold purge valve unless they are true.

Table 1–19. SOV3

Interlocks	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

Interlocked unless opening by the nitrogen purge supply pressure switch (PSH9). Additionally, you have the option of adding up to two external interlocks of your choice. The system ships with the two I/Os jumpered "short."

SOV4 Gas Manifold Precharge Valve On

Table 1–20 shows the following interlocks that prevent the opening of the manifold precharge valve unless they are true.

Table 1–20. SOV4

Interlock	Hardware	Switch
Roughing Pump ok contact Closure from PM interlock board	-	-
Precharge Manifold @ VAC	DI2	PSH2
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV5 Chamber Gas Delivery Valve On X

Table 1–21 shows the following interlocks that prevent the opening of the chamber gas delivery valve unless they are true.

Table 1–21. SOV5

Interlock	Hardware	Switch
Chamber delivery valve ok contact closure from PM interlock board.	-	-
Roughing Pump ok contact Closure from PM interlock board	-	-
Precharge Manifold @ VAC	DI2	PSH2
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV7 Chamber Slow Vent

Table 1–22 shows the following interlocks that prevent the opening of the chamber slow vent valve unless they are true.

Table 1–22. SOV7

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV8 Chamber Wafer Transfer

Table 1–23 shows the following interlocks that prevent the opening of the chamber wafer valve unless they are true.

Table 1–23. SOV8

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV9 Chamber N2 Valve On

Table 1–24 shows the following interlocks that prevent the opening of the chamber nitrogen valve unless they are true.

Table 1–24. SOV9

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV10-80 All Gas Primary Valve On

Table 1–25 shows the following interlocks that prevent the opening of the all gas primary valve unless they are true.

Table 1–25. SOV12-82

Interlock	Hardware	Switch
Chamber Delivery @ VAC	DI3	PSH3
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

Gas is prevented from going to the PM from the gas box if the chamber is not vacuum as read through vacuum switch (PSH3) and if the differential pressure switch (PSH8) in the coil enclosure is not true.

SOV12-82 All Gas Secondary Valve On

Table 1–26 shows the following interlocks that prevent the opening of the all gas primary valve unless they are true.

Table 1–26. SOV12-82

Interlock	Hardware	Switch
Chamber Delivery @ VAC	DI3	PSH3
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

Gas Safety


GENERAL ALERT

> **Warning**
> ***Chemical Hazard:*** Consult the material safety data sheets or equivalent material safety information for chemical hazards. Hazardous gases may be used on the 2300 system.

The plasma clean recipes help to neutralize chlorine-based by-products in the chamber prior to opening.

If you run the plasma clean recipes on the system, perform a minimum of 60 pump-and-purge cycles prior to opening the chamber. The number of cycles may vary depending on the process recipes and number of wafers between cleans. Because fab operation procedures and chemistry vary, industrial hygiene air sampling tests are advised and/or required when qualifying specific procedures to ensure compliance with threshold limit value (TLV) and permissible exposure limit (PEL) specifications. Lam recommends that you run 240 pump/purge cycles for systems using hydrogen bromide and 60 pump/purge cycles for non-toxic gases.

Gas Leak Detection Strategy

Containment of hazardous gases and detection of leaks are provided by a combination of on-board features and facilities infrastructure. The first priority is leak prevention, which is provided by physical containment, including back-up or double containment. The next priority is that you insure proper evacuation of gases in case containment systems fail or internal subatmospheric pressures are not maintained.

On-board safety systems continuously monitor chamber vacuum. Should chamber vacuum fall out of specification, a red alarm is generated, the system returns to a safe, standby state, and you are notified by the user interface.

Additional gas containment features include:

- A differential-pressure switch interlock in the gas box that shuts off all gas being supplied by that gas box if the exhaust is lost.

- Vacuum interlocks on the reaction chamber that cut off the flow of process gases and any RF power being supplied whenever vacuum integrity is lost.
- Provisions for a customer-supplied, double-contained gas line that runs between the gas panel and the reaction chamber.
- Upper chamber/upper match housing provided with scrubbed exhaust connection.
- Gas panel flanged for scrubber protection.
- Enclosure volume above the chamber is provided with a differential pressure switch interlock which shuts off all gas being supplied to the chamber if the exhaust is lost. Exhaust requirements are defined in the 2300 Versys Metal/Silicon PM facility specification drawing.

Lam advises you to provide an additional level of protection by augmenting the containment features, described earlier, with leak detectors located in the breathing zone in work areas adjacent to the main chamber and in the scrubbed exhaust from the on-board gas panel.

In the event that the detection of hazardous production materials is required by regulations in place at your site, Lam recommends that you locate the sample point one foot downstream of the exhaust port.

Lam also recommends the following:

- That you use exhaust duct material that is compatible with the exhaust gases and not subject to degradation with exposure to hazardous and/or corrosive materials.
- That you supply overpressure protection for each vacuum pump in compliance with SEMI S2-0200 safety guidelines.
- That you measure exhaust performance close to the system end of the exhaust line (approximately 10 duct diameters optimum) using an anemometer to estimate volume flow based on linear flow measurements.
- That you provide an audible and visual alarm on the chase side of the equipment to alert personnel of inadequate exhaust flow.

Gas Panel Safety

The Versys Metal/Silicon PM gas panel is designed for fail-safe operation under all reasonably foreseeable failure conditions. During failures, the gas panel prohibits gas flow and contains gases in a scrubbed enclosure to prevent the contamination of the environment and exposure to operating personnel.

POISON

Warning

Chemical Hazard: Consult the material safety data sheets (MSDS) or equivalent material safety information for chemical hazards. Hazardous gases may be used on the Versys Metal/Silicon PM.

Greenhouse Gases

At this printing, Lam is involved in a perfluorocarbon (PFC) leadership group with some of the leading semiconductor companies in an ongoing effort to meet future environmental regulations for wafer fabrication. This includes efforts to reduce and/or eliminate the use of global warming gases (PFCs) and ozone-depleting chemicals (CFCs). The technology today requires you to use some PFCs and CFCs for processing semiconductor devices. Whenever possible less hazardous process chemicals are replacing the more hazardous substances used in wafer fabrication.

The primary concern for the 2300 system is the use of sulfur hexafluoride (SF_6) in the baseline process for tungsten etch. Trifluoromethane (CHF_3) is another PFC sometimes used in both aluminum and tungsten etch. If a fluorine-containing process gas is used in an etch reactor, there is the possibility of the production of PFCs by the plasma process. Future restrictions of PFCs are possible and may require that you optimize the process or treat the effluent to reduce the emission of PFCs.

Exhaust Duct Material Recommendations

See the 2300 Versys Metal/Silicon PM facility drawing for the exhaust duct material that Lam recommends for use.

Seismic Protection

The transport module complies to SEMI S2-0200, section 19, Seismic Protection when secured at the eight TM locations (as shown on 253-810068-001) and installed on the ground level of a building secured with ductile anchors with a length to diameter ratio greater than eight, in any seismic condition or region. When the TM is populated with the process modules, you need to secure each PM at the seismic locations specified on the PM's facility drawing.

When the TM is installed on building levels other than at ground level, you must provide a seismic analysis of the installation site to determine if the TM standard configuration will meet S2-0200. In cases where seismic loading is more severe, you may have to provide additional seismic bracing. Contact Lam for availability of severe seismic bracing kits.

Servicing the MFCs

When performing the pump-and-purge cycles on the mass flow controllers (MFCs) prior to servicing, verify that there is no trapped gas between the MFC primary and secondary valves. Use this procedure to ensure that the gas is purged and that the proper nitrogen pump/purge procedure is performed on the MFCs. The key to this procedure is to observe the pump/purge action on the operator or maintenance interface screen.

▶ **To service the MFCs,**

1. Turn off the hand valves on the gas inlet line and lock them out.
2. Flow the gas on the **Maintain\Chamber** window by giving the maximum setpoint value for each gas.
3. Check the monitored flow value for each gas and make sure the gas flows go to zero.
4. Make sure the chamber manometer goes to base pressure.
5. Change the setpoints of the MFCs to zero on the **Maintain\Chamber** windows.
6. From the **Maintain\Gas/Vac** window, activate the pump/purge cycle on the gas panel.

7. Check the MFC flow on the **Maintain\Chamber** window. The MFC should cycle from maximum flow to zero with every pump/purge cycle.
8. See the maintenance service manual to determine how many pump/purges cycles you need to perform for the gas or gases that require servicing.
9. When the MFC service is complete, leak check the fittings that were opened.
10. Perform a pump/purge cycle on the MFC with nitrogen, using the number recommended in the maintenance manual.
11. Perform a purge cycle of the MFCs of the nitrogen gas by setting the MFC setpoints to the maximum flow.
12. When the MFC monitored flow goes to zero, set the MFC setpoints to zero.
13. Unlock and open the hand valves on the gas inlet line and charge the gas lines.

Lifting Safety

Many of the components of the 2300 systems are heavy. When performing maintenance operations, use proper lifting techniques, lifting aids and multiple personnel. Most heavy objects are identified with labels.

RF Shields

The 2300 Versys Metal/Silicon process module is designed with several RF shields. Install the RF shields properly onto the system prior to engaging RF power. Do not activate the generator(s) if the covers on the upper or lower match are removed. The cover ensures safety, shielding operating personnel from the effects of RF Power. Use caution when working in the vicinity of RF power.

RF Energy

RF energy is produced by the 2300 Versys Metal/Silicon process modules. Table 1–27 shows the RF frequencies and power requirements for various applications of the 2300 Versys Metal/Silicon process modules.

RFG – Conventional regulated power
RFDS – Regulates on delivered power (forward power – reflected power).

Table 1–27. RF Frequencies and Power

Process	Process gas	Generator type (upper/lower)	Generator frequency (upper/lower)	Generator power (max.)	Generator power (typical)
Plasma Clean Step 1	SF_6, Cl_2, O_2	RFG RFDS	13.56 MHz 13.56 MHz	1.50 kW 1.25 kW	600-800W 0W
Plasma Clean Step 2	SF_6, O_2	RFG RFDS	13.56 MHz 13.56 MHz	1.50 kW 1.25 kW	600-800W 0W

Corrosive Gases

Etch processes often use gases that are susceptible to atmospheric contamination. While Lam systems are designed to minimize the chance of such contamination, proper preventive procedures are necessary to maintain contamination-free equipment and to ensure continued operator safety.

Several system subassemblies can be affected by the improper handling of corrosive gases:

- The gas panel, during a mass flow controller (MFC) and source bottle changes.
- The reaction chamber, during pumping-and-purging cycles, before venting, and after chamber cleaning.
- The transfer chamber, during pump-and-purge steps when cycling wafers.
- The system pumps.

Gas Contamination

Table 1–28 lists the four most common causes of contamination in order of their frequency of occurrence, and preventive measures that address each cause.

Table 1–28. Preventing Gas Contamination

Contamination cause	Preventive measure
Improper purging before and after gas system maintenance	Use nitrogen purging procedures
Contaminated nitrogen purge gas	Monitoring and filtering nitrogen purge gas
Leaks in the gas delivery system	Leak-testing the gas delivery
Impurities in process gases	System Analyzing source gases

Improper Purging Before and After Gas System Maintenance

Purging It is critically important to use a purging procedure whenever any part of the gas delivery system is exposed to air. Such exposure typically occurs during gas bottle changes or when the gas system is dismantled for maintenance purposes, such as an MFC change or reaction chamber cleaning.

Gas Absorption While a system processes wafers, process gases absorb into the internal surfaces of the system. When a system is opened for maintenance, gas lines all the way back to the manifold or isolation valve may be exposed to air, thus creating possible contamination conditions.

Exposure When exposure to air occurs, the internal surfaces of the system absorb both moisture and oxygen. The amounts absorbed depend primarily on the length of time exposed, the surface characteristics of the lines, and the environmental conditions. Particle filters are particularly sensitive to exposure to atmosphere because of their large surface areas.

Residual Gas Removal Removing residual process gases or moisture and oxygen is very difficult and time-consuming. The most effective approach is to use vacuum and nitrogen purging in repetitive cycles. The vacuum increases the outgassing while the nitrogen purging scrubs the surfaces clean of adhered foreign molecules. 2300 software provides automatic routines to pump/purge cycles for the gas panel and main chamber portions of the gas system.

Exercise judgment when determining how long to purge the gas system before exposing it to atmosphere. Consider the probable time of system exposure, the surface area to be exposed, and the corrosive properties of the process gases used. For example, changing an MFC, which exposes four to five inches of gas line for several minutes or more, typically requires only 30 minutes to 1 hour of purging before and after exposure. Main chamber maintenance requiring 1 to 2 hours of exposure to atmosphere requires 2 to 4 hours of purging before and after exposure.

Lam Recommendations For Pump/Purge Procedures

Use the following guidelines when developing maintenance purge procedures and production recipes,

- Before and after maintenance procedures that expose the gas system to atmosphere, perform a pump-and-purge operation on the gas system for at least two to four hours with a reasonably low vacuum and adequately high flow rate for a minimum of 5 to 10 cycles. Use nitrogen or another inert gas, such as argon.
- Lam recommends including production recipe steps to perform a pump-and-purge operation on the main chamber after wafer processing. For most applications, five seconds of flowing helium or argon followed by five seconds of pumping is adequate to purge most of the residual gas and process by-products from the chamber during wafer cycling.

Contaminated Nitrogen Purge Gas

Most semiconductor facilities use house nitrogen for purging gas lines. House nitrogen often is provided from a liquid source tank located remotely and piped throughout the facility to supply nitrogen for wet and dry process equipment, maintenance shops, and a wide variety of other uses. It is primarily within this maze of piping that small air leaks occur. These small leaks can contaminate the main piping, eventually affecting the system. You must maintain nitrogen purity at levels below one part per million of moisture and oxygen, to prevent significant contamination.

It is important to note that the specifications for moisture and oxygen content are separate from the standard 99.999 percent or 99.99999 percent gas purities often referred to by suppliers.

Monitoring Gas Supplies

Many commercial units are available to monitor moisture and oxygen content in gas supplies, most of which use the dewpoint method to determine impurity levels. While many semiconductor facilities monitor moisture and oxygen content in their house nitrogen supplies, these levels are typically monitored at the source instead of the point of use. Therefore process and purge nitrogen supplies which are considered clean and dry are often contaminated with high levels of moisture and oxygen.

One of the major causes of contamination of reactive process systems is purging with contaminated nitrogen supplies. You must test at the point-of-use of equipment to verify this contamination source.

Lam Recommendations for Nitrogen Purges

Use the following guidelines for nitrogen purge supplies:

- Specify and verify the nitrogen purge gas at or below one part per million (ppm) of moisture and oxygen.
- Use special filters for moisture and oxygen, installed at the point of use. These filters are available from a number of commercial gas suppliers. Typically these filters can reduce moisture and oxygen content to less than 10 parts per billion (ppb).
- Provide separate dedicated nitrogen lines for reactive process gas purging.
- Use separate dedicated nitrogen bottle sources for reactive process gas purging.

Leaks in the Gas Delivery System

Any small leak in the gas delivery system creates a continuous source of contamination. Such a leak causes particulates at the location of the leak and generates them continuously through to the process. This occurs because the air that has leaked into the line is still reacting with the process gas as it flows into the reaction chamber. Because of this, particle filters have a limited effect in preventing a continuous flow of particles even though the leak may be upstream of the filter.

Leaks as small as 10^{-5} cubic centimeters/helium/second (cc/He/sec) can cause contamination with highly reactive gases. Using a leakback rate for the reaction chamber typically is not sensitive enough to measure these leak rates.

Lam Recommendations

Use the following guidelines to prevent any small leaks that could cause contamination:

- Whenever fittings are unsealed for any purpose in the delivery system, you must leak test each fitting with a helium leak detector to 10^{-8} cc/He/sec.
- Test all fittings regularly to monitor for leaks, especially where lines are subject to vibration or when equipment has been moved.

Impurities in Process Gases

Another source of contamination is the process gas itself. The purity specification for all gases used on a 2300 Versys Metal/Silicon PM system should be less than one ppm of moisture and oxygen.

A typical gas cabinet in a semiconductor facility consists of the following elements:

- High-pressure regulation, from gas bottle pressure to delivery pressure
- Nitrogen purge source for the gas delivery line
- Venturi vacuum source for the gas delivery line

Often, leaks in the shutoff valves of the source bottles are a cause of contamination. A visual inspection of the valve outlet on the bottle for signs of contamination will detect a seriously contaminated source bottle.

Lam Recommendations for Process Gas

Follow these recommendations for impurities in the process gas:

- Any gas cabinet used with Lam equipment should have the ability to perform nitrogen purge/pump cycles on the gas line from the cabinet during bottle changes. The cabinet purge nitrogen specifications for moisture and oxygen should be the same as for the system purge nitrogen.
- Filters similar to those recommended for purge nitrogen should be installed at the point of use. These filters can typically reduce moisture, oxygen, and other contaminants to less than 10 ppb in the more commonly used process gases.
- Contact the gas cabinet manufacturers or gas suppliers for more information on recommended procedures and specifications relating to their products.

Pumping Considerations

Corrosive gases have a detrimental effect on pump performance over time. Acids and particulates from process by-products build up in the pump and pump oil. By its very nature, metal etching is very hard on pumps. Metal processing using chlorine-based chemistries degrades pump function.

Lam Recommendations for Pumping Considerations

Follow these recommendations for pumping considerations:

- Because of their proven performance, safety, and maintainability in corrosive applications, Lam recommends using dry pumps on any system that will use corrosive gases. Dry pumps are available from Lam for all systems. If oil-based pumps are used in applications where corrosives are present, proper filtering and a preventive maintenance schedule to clean and change the oil is imperative.
- You should equip any system used in a corrosive application to purge nitrogen through the pump when it is not in use for processing. This purging helps flush residual corrosives and process by-products out of

the pump to the exhaust. All systems are programmed to purge the pump line automatically when idle.

Water Leak Detection

The leak detector resides in the water drip pan which houses the water manifolds. The pan sits beneath the turbo pump above the turbo molecular pump (TMP) controller. If water is detected in the pan, an alarm will appear indicating that there is a leak.

Supplemental Monitoring Ports

The 2300 Versys Metal PM contains two supplemental monitoring ports for you to connect an external monitoring device. These ports are:

- *Leak check port*: KF25 port in the foreline below the TMP isolation valve.
- *Spare chamber port:* Chamber is provided with spare port compatible with KF40 hardware for mounting leak check or sensing hardware.

Industrial Hygiene Report for the 2300 Versys Metal/Silicon PM

To be supplied.

Locations of the Safety Labels on the PM

Figures 1–4 through 1–8 show the location of the safety labels. Table 1–29 describes the part numbers for the safety labels.

Figure 1–4. Label Locations on the Front of the PM

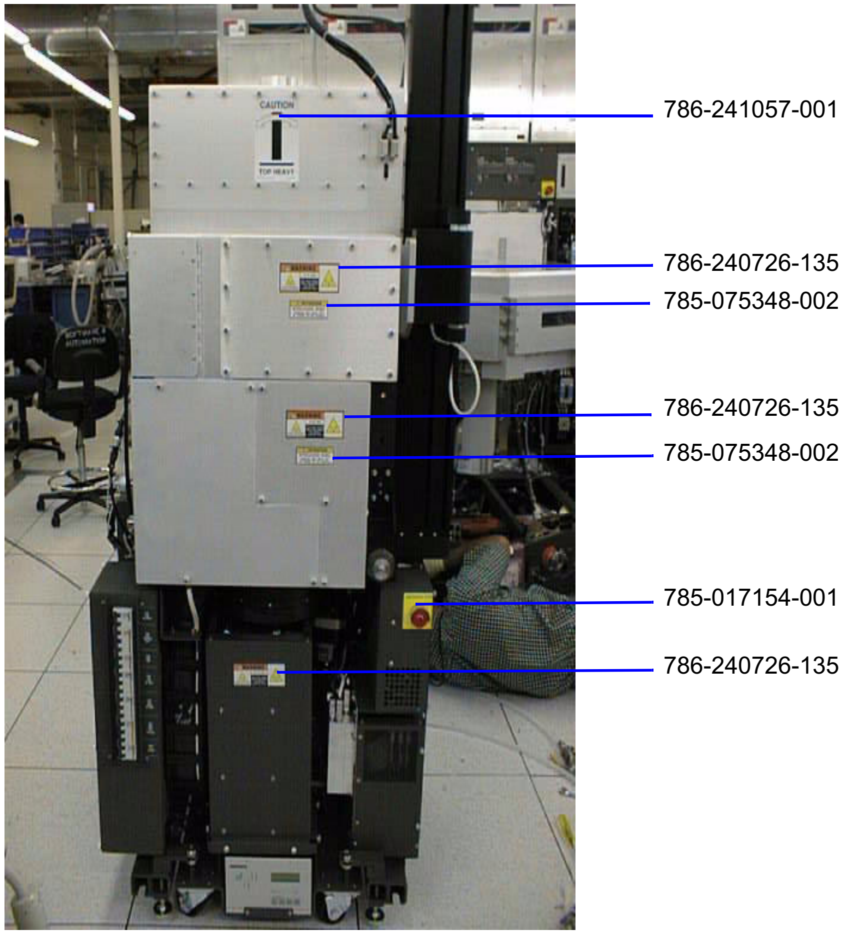


Figure 1–5. Label Locations on the Right of the PM

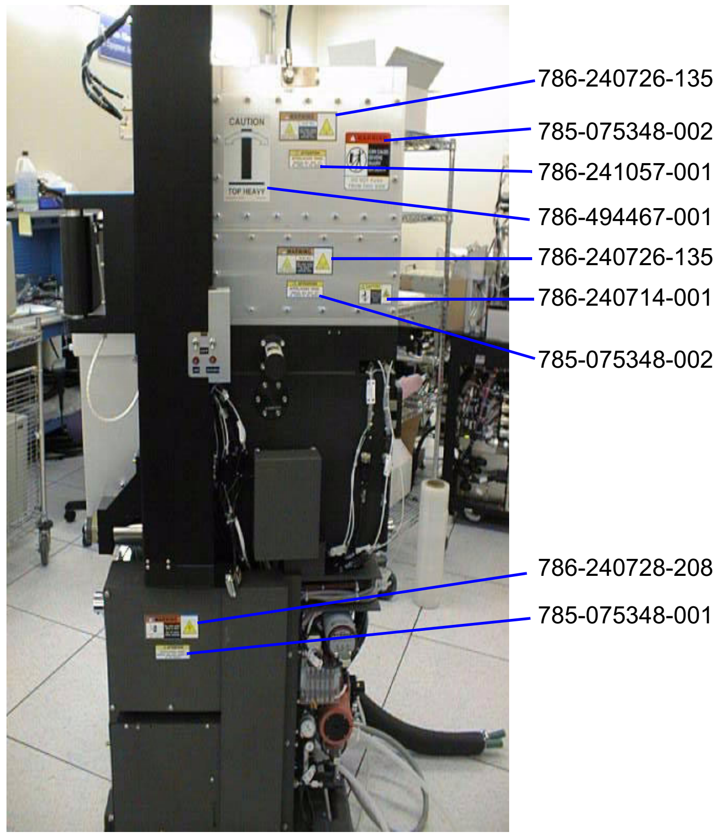


Figure 1–6. Label Locations on the Top Left of the PM

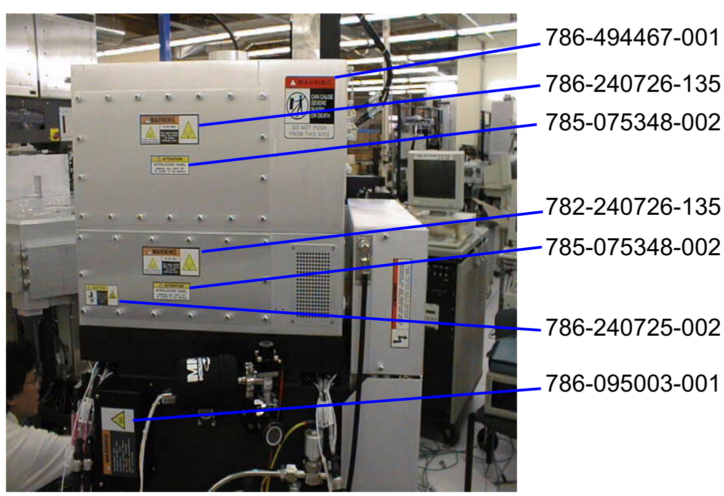


Figure 1–7. Label Locations on the Lower Left of the PM

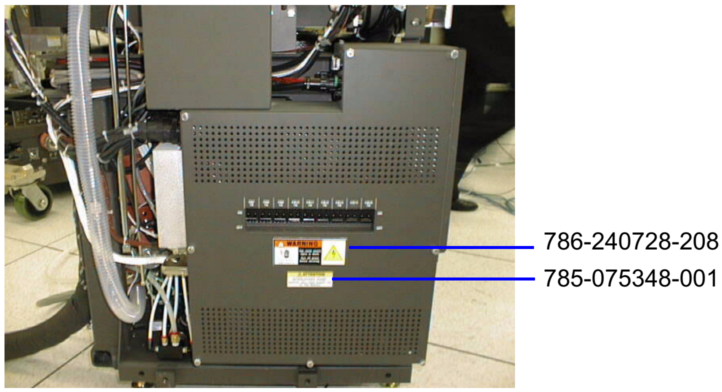


Figure 1–8. Label Locations on the Top of the PM

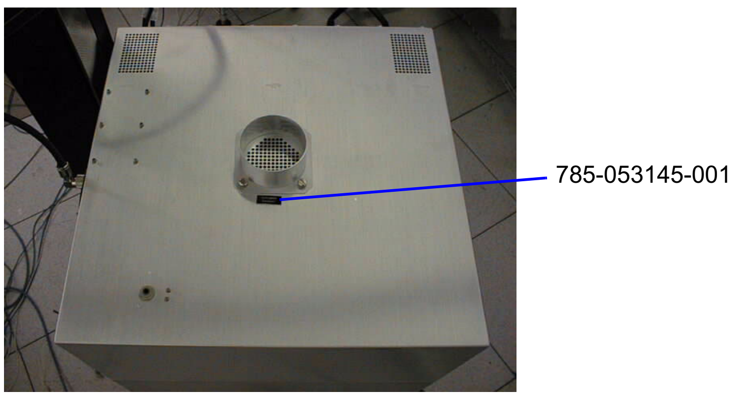


Table 1–29. Safety Label Descriptions

Part number	Title	Quantity
786-240728-208	Label, ANSI-CIS, Hi Volt, 208 VAC	2
786-494467-001	Label, Don't Push	2
786-241057-001	Label, Top Heavy	2
786-095003-001	Label, Warning, Toxic, Gas	1
785-017154-001	Label, Emergency Stop	1
786-240714-001	Label, ANSI-CIS UV	1
786-240726-135	Label, ANSI-CIS, RF	7
785-075348-002	Label, Attn, Intlk, Pnl, RF Pwr	6

Table 1–29. Safety Label Descriptions (continued)

Part number	Title	Quantity
785-075350-001	Label, Warning, Wtr & Elec Cmpnt	1
785-053145-001	Label, Scrubber Exhaust	1
786-240725-002	Label, ANSI-CIS, Pinch	2
785-075348-001	Label, Warning, Interlocked Pnl	2

2300 System Software

The 2300 system software has a graphical user interface with menu buttons and icons that allow you to quickly access software signals and change data.

After system start-up, each screen that appears on the flat panel display is called a window. Each window is identified by a window name, and the windows are organized into window groups. Icons for all the window groups appear along the bottom of every screen.

The primary window groups used during maintenance are **Maintain, Diagnose**, and **Setup**. These window group icons and their window names are shown in the following section.

Using Custom I/O Windows

As a convenience for accessing the most frequently-used software signals, the 2300 system control software allows you to create multiple **Custom I/O** windows in the **Operate, Process and Diagnose** window groups. **Custom I/O** windows can save time when performing maintenance procedures and you should take advantage of them whenever possible.

For more details about **Custom I/O** windows and how to create them, see the *2300 Versys Metal/Silicon Process Module Operation* manual.

Chamber

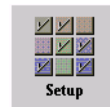
Calibration
One Point
Ten Point
Ten Point View All
One Point View All

Gas/Vac
Gas Box
Conductance
Partial Pressure
Partial Pressure View All
Leak Back

RF
TCP
Bias
VProbe

I/O (- TM)
SlotValvePGCWaferSensor
TraceDataEnable

I/O (- PM)
Vacuum IO
Pressure Control (VIOP Stepper)
Manometer Raw Reading
Vacuum-Hardware Interlock Bypass
Bias Match
Bias RF/Match & Pressure Control
TCP Match
TCP RF/Match & Pressure Control
RF & Match Interlock Signals
RF Generator Cooling Water
Wafer Lifter, Helium ESC,RF
ESC/He, Lifter, & Pressure Control
PCC
Chiller ESC Temperature
Anafaze
HeaterChannels
V gas
Gas 1-4
Gas 5-8
Gas Switches
System Information
OES Signals



Config IO
Vacuum
Pressure Control
Pressure Control Algorithm
Bias RF & Match
Bias RF Voltage Control
TCP RF & Match
Helium ESC Config
Temperature
Chiller ESC Config
Gas Name
MFC Types
Gas MaxFlow
GasCal/Maintenance
Gas Tolerances (Gas 1 to Gas 4)
Gas Tolerances (Gas 5 to Gas 8)
Gas Tolerances (Gas 9 to Gas 12)
OES CCD Config
Miscellaneous Configuration

Maintenance Recipes

Plasma Cleaning the Chamber

The recipes in tables 1–30, 1–31, and 1–32 help remove by-products in the chamber prior to opening the chamber.

Plasma Cleaning the 2300 Versys Metal PM Chamber

▶ **To plasma clean the 2300 Versys Metal PM chamber,**

1. Run the Cl_2/O_2 plasma clean recipe in Table 1–30 one time for every 100 RF minutes of process. Set up the recipe as a waferless auto clean, and run the recipe with no wafers in the chamber. Run the recipe a maximum of three times. You must set all tolerances in step 2 to 99 percent.

Note When you run a waferless auto clean, remove the backside helium flow.

Note If you are using the plasma clean recipe at regular intervals, calculate the amount of Cl_2/O_2 plasma clean you need based on the number of RF minutes from the last plasma clean run.

Table 1–30. 2300 Versys Metal Cl_2/O_2 Waferless Auto Clean Recipe

Parameter	Step 1	Step 2	Step 3	Step 4
Pressure (mtorr)	15	15	0	0
TCP RF power (watt)	0	800	0	0
Bias RF power (watt)	0	0	0	0
Cl_2 (sccm)	50	50	0	0
O_2 (sccm)	200	200	0	0
He (torr)	0	0	0	0
Step type	Stability	Time	Time	End
Process time (sec)	15	120	10	

2 Run the O_2 plasma clean recipe one time. (See Table 1–31.) Run the recipe with no wafers in the chamber. You must set all tolerances in step 2 to 99 percent.

Table 1–31. O_2 Plasma Clean Recipe

Parameter	Step 1	Step 2	Step 3	Step 4
Pressure (mtorr)	15	15	0	0
TCP RF power (watt)	0	800	0	0
Bias RF power (watt)	0	8	0	0
O_2 (sccm)	200	200	0	0
He (torr)	0	0	0	0
Step type	Stability	Time	Time	End
Process time (sec)	30	300	10	

3 When the plasma clean is done, perform the pump-and-purge process on the reaction chamber. See the *2300 Versys Metal/ Silicon Maintenance* manual for the procedure for performing a pump-and-purge process.

Plasma Cleaning the 2300 Versys Silicon PM Chamber

▶ **To plasma clean the 2300 Versys Silicon PM chamber,**

1 Run the waferless auto clean recipe with endpoint functionality. (See Table 1–32.) Contact your Lam representative to obtain CEE reports 18014 and 22002 for background information on endpoint functionality and waferless auto clean theory.

Note When you run a waferless auto clean, remove the backside helium flow.

Table 1–32. 2300 Versys Silicon Waferless Auto Clean Recipe

Step	1	2	3	4	5	6	7
Step Description	Pressurize	Ignition	SiO Clean	Transi-tion	CFx Clean	End	End
Pressure (mtorr)	65	65	65	65	15	0	0
TCP RF Power (W)	0	1000	1000	1000	1000	0	0
Bias Power (W)	0	0	0	0	0	0	0
SF_6 (sccm)	200	200	200	0	0	0	0
Cl_2 (sccm)	0	0	0	0	0	0	0
O_2 (sccm)	20	20	20	200	200	0	0
He (torr)	0	0	0	0	0	0	0
Step type	Stability	Time	Time	Time	Time	End	End
Process time (sec)	30	3	EP + 180 sec	2	EP + 180 sec	0	0
Wavelenght (OES)			703 um Rising signal. Manually endpoint if rising signal gradually plateaus, but there is no clear endpoint.		516 um Dropping signal.		

2 After you complete the plasma clean, perform a pump-and-purge process on the reaction chamber. See Section 3.6, "Performing a Pump-and-Purge Process on the Chamber."

2
Uncrating, Inspecting, and Docking the Process Module

Use this procedure to uncrate and inspect the 2300 Versys Metal/Silicon PM and to dock it to the transport module.

The following sections are found in this chapter:

- "Reference Documentation."
- "Docking the Process Module to the Transport Module."

Reference Documentation

- 405-240340-001, *2300 Versys Metal/Silicon Process Module Facility* manual

Equipment Required

- Set of Allen wrenches
- Set of open-end wrenches

Safety

Type 2 task involved.

Preparation

▶ **To prepare to uncrate the system,**

1 Verify the system location, floor layout and facility template.

2 Inspect all the module and ancillary equipment crates for damage. Document any damage and tripped tilt switches.

3 Verify that all the totes were shipped.

- Make sure a ship list is attached to all the totes and that they are double wrapped.
- Document any damage and tripped tilt switches.

Procedure

Uncrating and Inspecting the Process Module

▶ **To uncrate and inspect the process module,**

1 Move the totes and module into the fab.

2 Remove the bagging and visually inspect the system and tote content for any damage.

- Document all damaged items found.

Take an inventory of the tote contents and compare it with the shipping list.

- Document any missing parts.

Docking the Process Module to the Transport Module

Use this section to dock the process module (PM) to the transport module (TM).

Note Prior to docking the PM to the slot valve mounting surface, be sure to remove the corresponding slot valve controller board. This board directly blocks the four mounting bolts for one side of the PM.

- Remove the cover plate and inspect the face seal and O-ring.

▶ **To dock the PM to the TM,**

1 Move the specific PM into position directly behind its corresponding slot valve opening.

2 Align, dock and level the PM to the TM.

- Use casters to raise or lower the PM so its mounting face plate is aligned to the face plate of the TM slot valve. Be sure you have an equidistant gap on top and bottom.
- Make sure the guide pin path is aligned and clear between PM and TM.
- Push the PM into the slot valve opening. Once the PM is docked, use the four screws on each side to attach it permanently.
- Lower the feet to take the pressure off of casters.
- Install the soft valve controller board that you previously removed.

3 Ensure the PM is level.

- Visually inspect the PM and verify it is properly attached to TM. See the *2300 Versys Metal/Silicon Process Module Facility* manual for instructions.
- Place a level on the electrostatic chuck (ESC) and adjust the feet on the PM until they are level. At the same time, place a level inside the TM to make sure the feet adjustments you make to the PM do not affect the TM.

Note Plastic bubble levels tend to give unreliable readings.

4 Attach the seismic connections.

3
Facilitizing the System

Use this procedure to facilitize the 2300 Versys Metal process module (PM).

The following sections are found in this chapter:

- "Checking System Components."
- "Connecting the Generator Rack."
- "Verifying the Emergency Off."
- "Completing Initial Checks."
- "Checking the Power Supply."
- "Powering Up the System."

Checking System Components

Use these procedures to check the following components:

- Checking the Input Power Circuit Breakers
- Checking the PM to TM Connections
- Checking the Vacuum Plumbing and Lines
- Verifying the N_2 Connections
- Checking the TCU and Cooling Lines
- Checking the Gas Box Connections
- Verifying the Scrubber Connections

Reference Documentation

- *2300 Versys Metal/Silicon Process Module Maintenance* manual

- *2300 Transport Module Maintenance* manual

Equipment Required

- Digital voltmeter
- Set of Allen wrenches
- Set of open end wrenches

Safety

Type 2 task involved.

Preparation

None

Procedure

Checking the Input Power Circuit Breakers

▶ **To check the input power circuit breakers,**

1. Verify that all circuit breakers on the PM are off.
   - Be sure the TM circuit breaker that feeds power to the PM AC box is off (the TM circuit breaker from the TM AC box).
2. Verify that all the printed circuit boards (PCB) on the PM are properly seated.

Checking the PM to TM Connections

▶ **To check the PM to TM connections,**

1. Verify that the EMO cable on the PM is securely connected to J3 on the TM facility panel.

2 Verify that the communication cable (usually blue) on the PM is connected from 1B2P22A (on the back of the VME) to J7 on TM facility panel.

3 Verify that the clean dry air (CDA) has been routed from the CDA switch (behind the AC box on the PM) to the facility panel CDA fitting on the TM.

- Adjust to 80-90 pounds per square inch (psi).

4 Verify that the helium (He) connection from the He weldment (behind AC box on the PM) to the facility panel He fitting on the TM is secure.

- Adjust the helium connection to 10 psi.

5 Verify that the N_2 connection from the N_2 weldment (behind the VME on the PM) to the facility panel N_2 fitting is secure.

- Adjust the nitrogen connection to approximately 25 ± 5 psi.

Checking the Vacuum Plumbing and Lines

▶ **To check the vacuum plumbing and vacuum lines,**

1 Verify that all the plumbing is present for the vacuum and the vacuum line. Hook up the plumbing between the corresponding pump on the PM and the pump manifold on the PM.

- Check all the heater jacket connections on the plumbing.

2 Verify that the vacuum pump exhaust is connected to a scrubber.

3 Connect the cooling water supply and return lines to the vacuum pump.

4 Connect the N_2 ballast to the vacuum pump.

5 Verify that power is routed to the pump.

6 Verify that all the pump power phases are present and in correct phasing.

7 Verify that the N_2 ballast is set to the customer's pump requirements.

8 Verify there are no leaks at the pump. Check for:

- N_2 leaks
- Water leaks
- Vacuum

Verifying the N_2 Connections

- Verify that the N_2 connection for the turbo N_2 purge is secure.

Checking the TCU and Cooling Lines

▶ **To check the TCU and cooling lines,**

1 Make sure you have good connections at the cooling water supply and the return quick disconnects located behind VME.

2 Make sure you have a good connection from the TCU supply to the supply fitting located behind AC box.

- Verify that the return line from the TCU comes from the OUT fitting of the flow switch.

3 Verify that the TCU lines going to the PM are routed and insulated.

4 Verify that the house cooling lines are connected to the TCU supply and return cooling fittings.

5 Set the water pressure to 80 psi ± 10 psi with an approximate flow rate of 3-6 gallons per minute (GPM).

6 Verify that the reservoir is filled with the coolant the customer recommends.

- Label the TCU to reflect the type of coolant used.

Checking the Gas Box Connections

▶ **To check the gas box connections,**

1 Turn off all the process gases at the facility bottles.

2 Verify that all the facility requirements are routed and connected.

- Leak check all the gas lines to the gas box connection specified for the PM:
- Gases 1-12
- CDA
- N_2 pump ballast (foreline)
- N_2 purge gas
- Mixed gas
- Delivery line

3 Verify that all the valves are OFF or closed inside the gas panel.

4 Make sure that gas delivery line from the gas box to the PM chamber is connected. Check that all of the customer's safety requirements are incorporated into the connection.

5 Make sure that the mass flow controller (MFC) pre-charge line from the gas box to the PM pump foreline is connected.

6 Verify that the LonWorks® cable connects 41J1 on the PM and the J2B on the gas panel.

7 Verify that the LonWorks cable connects 41J6 on the PM and the TCU.

8 Verify that the LonWorks cable connects the TCU and J2A on the gas panel.

9 Verify that the DC cable connects 41J4 on the PM and J1 on the gas panel.

10 Verify that the interlock cable connects 41J10 on the PM to J3 on the gas panel.

11 Verify that the connection between the N_2 purge fitting on the gas panel and the process N_2 regulator on the wall is secure.

- Adjust the pressure to 35-40 psi.

12 Verify that the correct gases are routed to the corresponding fittings on the gas panel.

- Set the process gas regulators to 15-20 psi.

13 Verify that J11 on the gas panel is either jumped-out or is being used as an interlock.

14 Verify that the scrubbed exhaust line to the PM gas box is routed and on.

- Make sure the pressure switch line from the gas box to the scrubber exhaust is routed.

Verifying the Scrubber Connection

- Verify that the scrubber is hooked up to the TCP match enclosure scrubber.

For silicon,

- The flow specification equals 530 cubic feet per minute.

For metal,

- The facility scrubber must accommodate up to 150 standard cubic feet per meter (SCFM) while providing at least 0.5 H_2O at the scrubber duct.

Connecting the Generator Rack

▶ **To connect the generator rack,**

1 Check the water detection circuit. Make sure the P1 connector goes to the J1 socket.

2 Make sure all the flow switches are plugged into their corresponding component.

- FS1 is bias generator
- FS2 is TCP generator
- FS3 is bias match

3 Verify the TCP RF generator connections.

- 7J2 is output
- 47P1 is input

- 47P2 is control (common exiter [CEX] coaxial connector goes to the IN coaxial connection)

4 Verify the bias RF generator connections.
   - 8J2 is output
   - 48P1 is input
   - 48P2 is control (CEX coaxial connector goes to the OUT coaxial connection)

5 Verify the turbo water supply and return lines are plugged in using quick disconnects.

6 Verify the bias match water supply and return lines are plugged in using quick disconnects.

7 Make sure the turbo controller is plugged into all the necessary hardware.
   - Verify that the power cable is plugged into 2J3 on the inner side of AC box.
   - Verify the signal cable is plugged into the daisy-chained cable labeled Dry Contacts, TMP water valve, and so forth.
   - Verify that the control cable is plugged into the TMP (cannon plug).

8 Make sure all the water connections are present. Physically check each water connection to make sure it is secure and does not pull out of the fittings.

Verifying the Emergency Off

▶ **To verify the emergency off (EMO),**

1 Verify that all the PM-to-TM cable connections are secure.

2 Verify that the PM main and EMO breaker switches are in working order.

3 Verify that the auxiliary rack EMO switch is in working order (if applicable).

Completing Initial Checks

▶ **To complete the initial checks,**

1. Remove the cover to the DC power supply enclosure and locate the distribution printed circuit board (PCB).
   - Use a digital voltmeter (DVM), and place the negative lead to the ground test point (PTA) in the DC box and the positive lead to each of the designations listed in Table 3–1. Record the resistance values in the table provided.


ELECTRICAL

Caution
Electrical Hazard: Ensure that the power is off to the system before checking the PCB valves.

Table 3–1. Distribution PCB

Distribution PCB	Actual value (ohms)	Specification (ohms)
PT1		
PT2 (RTN)		
PT3 (-15 VDC)		
PT4 (+24 VDC)		
PT5 (RTN)		
PT5 (GND)		
PT4 (Jumper PT1A)		
PT2 (RTN)		
PT1 (+24 VDC)		

2. Install the process module AC power cable from the transport module AC box (the PM's corresponding CB and earthground) to the process module AC box (L1, L2, L3, and earthground).
3. Turn on the system, the TM and the remote power distribution box (RPDB).
4. Turn on the user interface (UI) and log onto Windows NT™ on the TM.

5 Turn on the main power circuit breaker for the PM located on the AC panel of the TM.

- Measure the voltages inside process module AC box on the LI, L2, L3 contacts to earthground.
- Check for 110 VAC. Confirm that each line (LI, L2, L3) is out of phase with the others.
- Measure the voltage across each phase pair and verify that 208 VAC is present.

Table 3–2. Phase to Ground

Phase to ground	X (L1)	Y (L2)	Z (L3)
Measured Voltage			

Table 3–3. Phase to Phase

Phase to phase	X - Y (L1 - L2)	Y - Z (L2 - L3)	X - Z (L1 - L3)
Measured Voltage			

Checking the Power Supply

► **To check the power supply**

1 Apply power to the PM by switching CB1 to the ON position.

2 Check the powers supply voltages listed in Table 3–4.

- Use a DVM, and place the negative lead to PTA and the positive lead to each of the following designations. Record the voltage values in the table provided.

Table 3–4. Distribution PCB for Power Supply

Distribution PCB	Actual value (voltage)	Specification (voltage)
PT1		
PT2 (RTN)		
PT3 (-15 VDC)		

Table 3–4. Distribution PCB for Power Supply (continued)

Distribution PCB	Actual value (voltage)	Specification (voltage)
PT4 (+24 VDC)		
PT5 (RTN)		
PT5A (GND)		
PT4A (+24 VDC)		
PT2A (GND)		
PT1A (+24 VDC)		

3. Verify that all eight voltage light-emitting diodes (LEDs) are illuminated on the VME enclosure. 5 volts direct current (vdc) may be a little dim.
4. Verify that the VME enclosure fan and the DC enclosure fan are on.
5. Verify that all necessary hardware is installed in the PM (containment ring, injector, injector weldment, and so forth).

GENERAL ALERT

Warning

Warning: Due to the hardware design and the software configuration, it is important to equalize the pressure inside the slot valve to that of the PM if you are opening the door between the two. Damage to the quartz components and the pump stack components (including the turbo) is possible if you do not track the equal pressure carefully.

Powering Up the System

▶ **To power up the system,**

1. Apply power to the process module by pressing the **AC/on** button on top of the AC box.
2. Press the **reset** button (labeled **RST**) on the computer, inside the VME.
3. Power up the auxiliary generator rack by turning on the following:
   - CB3 (TMP)

- CB4 (TCP generator)
- CB5 (bias generator) on the AC box of the PM

4. Verify the EMO operation for the PM and TM. See the *2300 Versys Metal/Silicon Process Module Maintenance* manual and the *2300 Transport Module Maintenance* manual for more information.
5. Verify that the robot has been taught entry positions into the PM and that the Z-height of the robot is correctly set to clear the slot valve port, the chamber liner and the focus-ring insert.

The PM should be completely facilitized at this point. If no problems arise, continue with the PM functionality tests. Be sure to check off every test and initial/date at the end of each completed section.

4
Checking the System

Use this procedure to check the 2300 Versys Metal/Silicon process module (PM) after the facilitation is complete.

The following sections are found in this chapter:

Reference Documentation

- *2300 Versys Metal/Silicon Process Module Maintenance* manual

Equipment Required

None

Safety

Type 2 task involved.

Preparation

None

Checking the Node Communications

▶ **To check the node communications,**

1. Enter the Lam supplied **User Name** and **Password** in the spaces provided in order to gain access to the 2300 software.
2. Verify that the PM is in focus on the UI. Look in the lower left corner of the UI and verify that the PM2 position is gray.
3. Go to the **Alarm** window and verify that none of the following communication alarms are listed:
   - Node 1
   - Node 2
   - Node 3 (gas panel)
   - Node 4 (gas panel)
   - Anafaze controller

Note Communication alarms are usually caused when the RJ 45 connector is not plugged in completely. You must power up the TCU to clear any communication alarms.

Initials ____________________ Date ____________________

Checking the External Interlocks

▶ **To check the external interlocks,**

1. Trip all the safety cover switches and verify that they post an alarm in the **Alarm** window.
2. Install and clear the alarms.

Initials ____________________ Date ____________________

Checking Cable-drive Wafer Pinlifters

▶ **To check cable-drive wafer pinlifters,**

1. Verify that the depth of the pins when they are in the down position is 0.017 inches ± 0.002 below the surface of the electrode.
   - If the pins are not at the correct depth, adjust them using the "Adjusting the Wafer Pinlifter" procedure in the *2300 Versys Metal/Silicon Process Module Maintenance* manual.
2. Set the tension of each pin lifter to approximately one (1) pound of force. (See the "Adjusting the Wafer Pinlifter" procedure in the *2300 Versys Metal/Silicon Process Module Maintenance* manual for more information.)
3. Verify that the height of the pins in the up position is 0.440 inches (metal) or 0.375 inches (silicon) ± 0.005 above the surface of the electrode.
   - If the pins are not at the correct depth, adjust them using the "Adjusting the Wafer Pinlifter" procedure in the *2300 Versys Metal/Silicon Process Module Maintenance* manual.
4. Verify that the Pinlift UP and DOWN sensors read the correct position of the lifter.
   - If the sensors do not read the correct position use the "Adjusting the Cable Pinlifter" procedure in the *2300 Versys Metal/Silicon Process Module Maintenance* manual and adjust the sensors.

5. Cycle the atmospheric transfer module (ATM) and volts alternating current (VAC) actuator in and out and verify that the sensors read the correct position on the UI. Adjust the sensors as necessary.
   - VAC Mode = actuator is extended toward the front of the PM.
   - ATM Mode = actuator is retracted.

Initials ____________________ Date __________________

Checking Direct-drive Pinlifters

▶ **To check direct-drive wafer pinlifters,**

1. Verify that the depth of the pins when they are in the *down* position is 0.020 inches ± 0.005 (for metal or silicon process modules) below the surface of the electrode.
   - If the pins are not at the correct depth, adjust them using the "Adjusting the Wafer Pinlifter" procedure in the *2300 Versys Metal/Silicon Process Module Maintenance* manual.
2. Verify that the height of the pins in the *up* position is 0.520 ± 0.005 inches (for metal process modules) or 0.375 ± 0.005 inches (for silicon modules) above the surface of the electrode.
   - If the pins are not at the correct depth, adjust them using the "Adjusting the Wafer Pinlifter" procedure in the *2300 Versys Metal/Silicon Process Module Maintenance* manual.
3. Verify that the Pinlift UP and DOWN sensors read the correct position of the lifter.
   - If the sensors do not read the correct position use the "Adjusting the Wafer Pinlifter" procedure in the *2300 Versys Metal/Silicon Process Module Maintenance* manual and adjust the sensors.

Initials ____________________ Date __________________

Performing the Facility Checks

▶ **To perform the facility checks,**

1. Verify the trip setting for Channel A on the foreline manometer is 1.00 VDC.
2. Verify the following trip settings for Channel A and B on the 10 torr chamber manometer:
   - Channel A: 0.500 VDC
   - Channel B: 0.100 VDC
3. Adjust the CDA regulator at the wall for 90 psi.
4. Set the helium regulator on the PM to 10 psi.
5. Adjust the turbo N_2 pressure regulator to 7 psi.
6. Open the bias match panels for the leak test.
7. Charge the water cooling lines to the RF generator cart and verify that there are no leaks at the following areas:
   - Bias match
   - Turbo pump
   - RF generator
   - Manifold blocks (RF cart)
8. Verify that none of the following water flow alarms are shown on the **Alarm** window:
   - Bias match
   - TCP RF generator
   - Bias RF generator
9. Disconnect the electrical plug at each of the following water flow sensors (one at a time) and verify that the correct alarm is posted:
   - Bias match
   - TCP RF generator
   - Bias RF generator

10 Connect all the plugs for the water flow sensors listed previously and verify that the alarms cleared.

11 Put the chamber under vacuum by using the *Pump Down* function on the **Maintain\Chamber** window. The turbo should spin up at this time.

Initials ____________________ Date ________________

Performing the Solenoid Test

► **To perform the solenoid test,**

1 Activate each solenoid listed in Table 4–1and Table 4–2. Verify the corresponding valve receives CDA pressure.

Table 4–1. Metal Solenoid Test

Check	Solenoid Name	Solenoid bank location
❑	Chamber lifter up	1-1A
❑	Chamber lifter down	1-1B
❑	Chamber isolation valve	1-2A
❑	Gasline shutoff	1-2B
❑	Gasline bypass	1-3A
❑	Manometer isolation valve	1-3B
❑	VODM water fill valve	1-4A
❑	Pin lifter at Vac	1-6A
❑	Pin lifter at ATM	1-6B

Initials ____________________ Date ________________

Table 4–2. Silicon Solenoid Test

Check	Solenoid Name	Solenoid bank location
❑	TMP N_2 Purge Valve	1-1B
❑	Gasline Shutoff Valve	1-4B
❑	TMP Exhaust Valve	1-4A
❑	Chamber Lifter Up	2-1A
❑	Pin Lift at ATM	2-3B
❑	Chamber Rough Valve	1-2B
❑	Chamber Mano. Iso Valve	1-1A
❑	He Supply Valve	1-5A
❑	He Isolation Valve	2-2B
❑	Soft Rough Valve	1-3B
❑	He Foreline Valve	1-2A
❑	Chamber Lifter Down	2-1B
❑	Pin Lift at VAC	2-3A

Initials ______________________ Date ___________________

2 Check all the solenoid valves in the gas box for the PM. Activate each solenoid to verify the corresponding valve receives CDA pressure.

- This includes the MFC primary and secondary valves as well as the mixed gas valves.

Initials ______________________ Date ___________________

Performing the Chamber and Gas Panel Pump-and-Purge Test

▶ **To perform the chamber and gas panel pump-and-purge test,**

1. Select the pump-and-purge function on the **Maintain\Chamber** window. Verify that the chamber pressure rises and falls during each cycle. See "Performing a Pump-and-Purge Process on the Chamber" in the *2300 Versys Metal/Silicon Process Module Maintenance* manual for more information.
2. Select the gas panel pump-and-purge function on the **Maintain\Gas/Vac** window. Verify that there is positive and negative maximum gas flow observed in each MFC during each cycle.

Initials ____________________ Date ________________

Checking the Module Heater Current

▶ **To check the module heater current,**

1. Verify that the upper match gas ring is completely down and resting securely on the lower chamber.
2. Flip the heater distribution circuit breaker CB2 to the **ON** position.
3. Verify there are no overtemp or ground fault isolation (GFI) conditions present.
4. Go to the **Setup\Config IO\Temperature** window and set the following Anafaze channels to 60 degrees Celsius:
   - Chamber temperature setpoint
   - Gas ring temperature setpoint
   - Bias electrode housing temperature setpoint
   - Throttle valve temperature setpoint

Initials ____________________ Date ________________

Testing the Chamber Temperature Control

▶ **To test the chamber temperature control,**

1. Verify that all the upper chamber hardware is installed and that the upper match is in the lowered position.
2. Verify that the heaters ramp up and stabilize at 60 degrees Celsius.
   - Chamber
   - Gas ring
   - Electrode housing
   - Throttle valve
3. Enter the readings in Table 4–3.

Table 4–3. Chamber Temperature Test

Location	Setpoint	Monitored	Measured
Chamber rear left	60 degrees Celsius		
Chamber front left	60 degrees Celsius		
Chamber front right	60 degrees Celsius		
Chamber rear right	60 degrees Celsius		
Gas ring	60 degrees Celsius		
Throttle valve	60 degrees Celsius		
Electrode housing	60 degrees Celsius		

Initials ______________________ Date ___________________

Performing the System Leak Check

Use the following procedures to perform an *automatic* leakback check, a *manual* leakback check, and to perform a leakback check using a helium leak detector.

Performing an Automatic Leakback Check

► **To perform an automatic leakback check,**

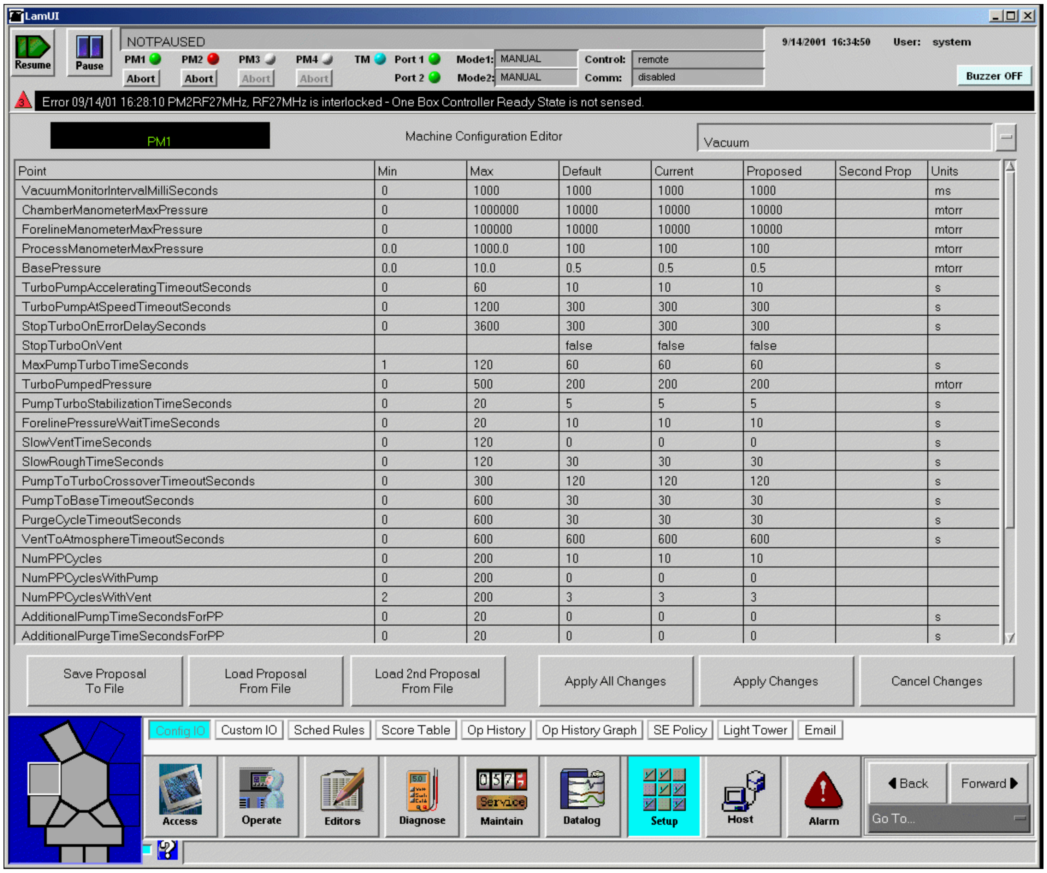
1 Set the UI to display the windows for the Versys Metal or Silicon process module. Select the applicable PM on the station locator in the lower left window.

2 In the **Setup\Config IO\Vacuum** window, verify that the applicable variables are set to the proper values. See Figure 4–1.

The chamber leakback check is terminated after the time specified by *LeakbackTestTimeSeconds* (default value is 60 seconds) or when the chamber pressure rises above the value specified by *LeakbackMaxChamberPressure*.

An alarm posts if the leak rate is greater than the value specified by *LeakbackAlarmRate*.

Figure 4–1. Setup\Config IO\Vacuum Window



3 Initiate the leakback-rate test for the chamber. In the **Maintain\Chamber** window, click **LeakBack**.

4 Wait five minutes and observe the Leak Rate variable in the upper middle area of the **Maintain\Chamber** window. The leakback rate appears when the leakback-rate test sequence ends.

During the chamber leakback check, the chamber is pumped down to base pressure and isolated, and the chamber pressure is then sampled at fixed intervals. The leak rate is calculated based on the initial and final pressure readings and the total elapsed time.

Before the leakback-rate test sequence has ended, full pumping of the reaction chamber is restored.

Performing a Manual Leakback Check

▶ **To perform a manual leakback check,**

1. Verify that the TMP controller is plugged in to all the applicable connections. Turn the TMP on by flipping the circuit breaker in the back of it to the **UP** position.
2. Complete an automatic pump-down of the PM by pressing the pump down feature on the **Maintain\Chamber** window. Be sure the corresponding PM is highlighted in the bottom left corner of the screen.
3. Verify that the turbo spins up by observing the RPM number rise above 27,000 for process modules with a 1.6 liters/second pump, or above 32,000 for process modules with a 2.2 liters/second pump. Be sure the **Start** button is highlighted.
   - The isolation valve is green in the open position and red in the closed. Verify that the valve is green.
4. Go to the **Maintain\Chamber** window and open the turbo exhaust valve and the pendulum valve.
5. Open the He isolation valve and enter a setpoint of 20 torr for the universal pressure control (UPC).
6. Allow the module to pump-down at least eight (8) hours before continuing with the leakback checks.
7. Close the manometer isolation valve for the reaction chamber and perform a five-minute leakback. Record the results in Table 4–4.

Note The leakback is to determine if the manometer itself is leaktight.

Table 4–4. Main Chamber Manometer Leakback Rate - Five Minutes

Name	Start	Stop	Difference
Pressure (mtorr)			
Time (minute)			
Calculated leak rate (mtorr/minute)			

Note Maximum leak specification is less than one (1) mtorr/minute.

8 Open the reaction chamber manometer isolation valve on the **Maintain\Chamber** window.

9 Close the pendulum valve. Perform a five-minute leakback rate. Record the results in Table 4–5.

Table 4–5. Main Chamber Leakback Rate - Five Minutes

Name	Start	Stop	Difference
Pressure (mtorr)			
Time (minute)			
Calculated leak rate (mtorr/minute)			

Note Maximum leak specification is less than one (1) mtorr/minute.

10 Check the gas box leak rate by closing all hand valves at facility input. Open all valves inside gas box that are pertinent to gas flow. Pump down the chamber, close the pendulum valve, and perform a five-minute leakback rate. Record the results in Table 4–6.

Note The delta between the gas box and the chamber is the gas box leak rate.

Table 4–6. Main Chamber and Gas Box Leakback Rate - Five Minutes

Name	Start	Stop	Difference
Pressure (mtorr)			
Time (minute)			
Calculated leak rate (mtorr/minute)			

Note Maximum leak specification is less than one (1) mtorr/minute

Initials ____________________ Date __________________

Performing a Leakback Check Using a Helium Leak Detector

▶ **To perform a leak check using a helium leak detector,**

1. Go to the **Maintain\Chamber** window and stop the turbo. Allow time for it to spin down.
2. Connect the helium leak detector to the leak check port.
3. Turn on the helium leak detector and allow it to perform its start up checks.
4. Go to the **Maintain\Chamber** window and perform the following:
    - Select the **PumpDown** button.
    - Open the helium isolation valve.
    - Set the UPC to 50 torr.
    - Open the helium supply valve.
5. Close the helium manual valve at the wall.
6. Open the gas shutoff valve on the side of the PM.
7. Verify that the temperatures are stabilized at 60 degrees Celsius, and leak check the following areas:
    - Upper chamber
    - Lower chamber
    - Helium cooling enclosure
    - Turbo
    - Lower electrode
    - Exhaust manifold
    - Pendulum valve
8. Disconnect the helium leak detector after you locate and fix all of the leaks.
9. Go to the **Maintain\Chamber** window and select **PumpDown**. Allow time for the turbo to spin up.

Initials ____________________ Date ________________

Calibrating and Zeroing the Manometer

▶ **To calibrate and zero the manometer,**

1. Install a calibrated pressure-monitoring device on the chamber, preferably on the same manometer weldment the reaction chamber manometer sits.
2. Verify that the turbo is completely spun up and the exhaust valve is open.
3. Open the pendulum valve and shut off the turbo ballast.
4. Measure the signal output and verify the voltage reading matches the pressure reading on the pressure-monitoring device. Use the nine-pin extension board or disassemble the DB9 backshell on the process manometer to verify that the readings match.
   - Example: 4 mtorr = 0.4 VDC. If this is not the case, adjust the zero potentiometer on the process manometer.
5. Switch the **Auto Zero** toggle button on the **Maintain\Chamber** window.
6. Adjust the 10 torr chamber manometer and the foreline manometer to match the Penning gauge pressure reading.
7. Open the helium isolation valve and adjust the zero potentiometer on the UPC so the pressure reads zero.
8. Record all the values in Table 4–7.

Table 4–7. Calibrating the Manometer

Name	Value
Chamber process manometer (mtorr)	
Inlet 10 torr manometer (mtorr)	
Reference manometer (mtorr)	
He cooling manometer (torr)	

Initials ____________________ Date ____________________

Checking the Pressure Transducer Settings

► **To check the pressure transducer setting,**

1. Close all the hand valves at the gas box facility inlets and open all other pertinent valves for gas flow.
2. Each transducer should pump down to negative 17 psi.
   - If not, adjust the transducer to reflect the vacuum inside it to negative 17 psi.

Initials ____________________ Date __________________

Performing Chamber Pressure Stability and Conductance Learn Procedures

► **To complete a chamber pressure stability and conductance learn procedure,**

1. Go to the **Setup\Config IO\GasCal Maintenance** window and verify that *VolumeSize* is set to 80500 milliliter (ml).
2. Go to the **Maintain\Gas/Vac** window and perform a conductance learn using 150 standard cubic centimeter per minute (sccm) O_2.
   - See Table 4–8 and Table 4–9 to ensure that you enter the correct set of valve position setpoints for the measurement.
   - After measuring and verifying the curves (see Table 4–2), select the **Accept** and **Save** buttons in the conductance window.

Conductance learn valve positions for a 1600 l/sec pump and a DN200 throttle valve:

Table 4–8. Conductance Learn Values for 1600 l/sec Pump and DN200 Valve

Measurement number	Valve positions (counts)	Flowrate/pressure sccm/m/Torr
1	1000	50.0
2	800	49.9
3	700	47.1
4	600	44.4
5	500	41.7
6	400	35.7
7	350	31.3
8	300	27.0
9	250	20.6
10	220	16.7
11	200	14.1
12	180	10.9
13	160	7.75
14	150	6.31
15	140	4.88
16	130	3.71
17	120	2.54
18	110	1.69
19	100	1.07
Explicitly defined	0	0

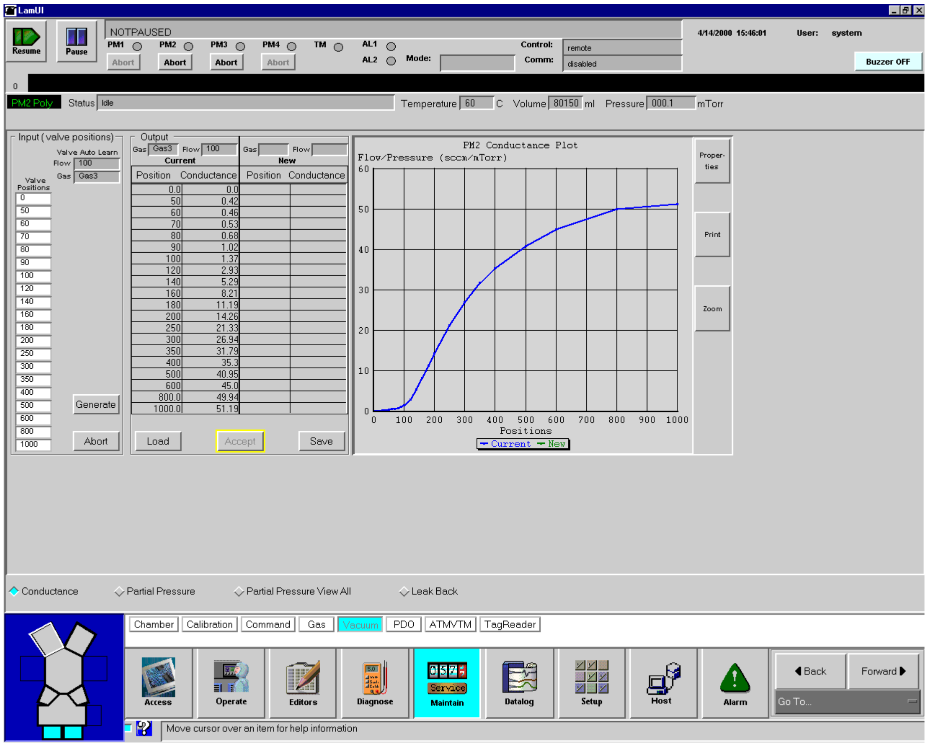
Conductance learn valve positions for a 2200 l/sec pump and a DN250 throttle valve:

Table 4–9. Conductance Learn Values for 2200 l/sec Pump and DN250 Valve

Measurement number	Valve positions (counts)	Flowrate/pressure sccm/m/Torr
1	1000	64.8
2	800	61.2
3	600	56.9
4	500	52.5
5	400	47.6
6	350	43.6
7	300	38.9
8	250	33.0
9	200	26.2
10	180	22.8
11	160	19.3
12	140	15.4
13	120	11.2
14	100	7.3
15	90	5.5
16	80	4.0
17	70	2.8
18	60	1.9
19	50	1.3
Explicitly defined	0	0

Figure 4–2 shows a typical conductance curves for a 1600 l/sec pump.

Figure 4–2. Typical Conductance Curves for a 1600 l/sec Pump



3 Verify the following parameters on the **Setup\Config IO\Pressure Control Algorithm** window:

Table 4–10. Setup\Config IO\Pressure Control Algorithm Parameters

Point	Minimum	Maximum	Default	Current	Proposed	Units
PressControlAlgorithim	0	2	1	0	0	
ThrottleValveProportionalGain	0	10	1.0	5.0	4.0	
ThrottleValveIntegralGain	0	10	1.0	1.0	0.8	
ThrottleValveDerivativeGain	0	1.0	0.1	0.0	0.0	
ThrottleValveAutoPositionalHoldDelay	0	10	0.5	1	1	S
ThrottleValveMaxPIDDelay	0	10	3	3	3	S
ThrottleValveMoveTimeout	0	30	5	5	5	S
ThrottleValvePrepositionMoveTime	0	2.0	0.8	0.8	0.8	S
ThrottleValvePositionLoopProportionalGain	0	10.0	1.0	2.0	2.0	
ThrottleValvePositionLoopDerivativeGain	0	10.0	0.1	0.2	0.2	
ThrottleValveHomeOnEachOpen	0	1	1	1	1	

4 Enter a 150 sccm flow of O_2.

5 Go to the **Maintain\Chamber** window and enter the chamber pressure setpoints listed in Table 4–11. Verify that the chamber pressure stabilizes within eight (8) seconds for each setpoint.

Table 4–11. Chamber Pressure Setpoints

Setpoint	Monitor
5	
10	
15	
20	
25	

Initials ____________________ Date ____________________

Checking the TCU Temperature

▶ **To check the TCU temperature,**

1. Go to the **Diagnose\IO\ChillerESCTemperature** window and set the *TCU Setpoint*_AO to **25** degrees Celsius.
2. Record the values in Table 4–12 and then do the same for **40** and **60** degrees Celsius (after allowing time for TCU to reach the setpoint).
3. Be sure these specifications are met:
   - The TCU setpoint reading should be within ± 0.2 degrees Celsius of the PM setpoint.
   - The TCU temperature monitor should be within ± 1 degree Celsius.
   - The measured value should be within ± 1 degree Celsius of the setpoint.
   - The PM monitor value should be within ± 2 degrees Celsius of the setpoint.

Table 4–12. TCU Temperature

PM setpoint	PM monitor	TCU setpoint monitor	TCU temperature monitor	Measured
25 degrees Celsius				
40 degrees Celsius				
60 degrees Celsius				

Initials ______________________ Date ________________________

Note Set the electrode heater to the same temperature as the TCU for the best results.

Checking the Generator RF Linearity

▶ **To check the generator RF linearity,**

1. Go to the **Setup\Config IO\TCP RF & Match** window and verify that the *TCPRFMaxPowerWithoutWafer* parameter is set to **1250** watts (RFDS) or **1500** (Apex).
2. Verify the RF linearity on both the TCP and bias generators. See the *2300 Versys Metal/Silicon Process Module Maintenance* manual section “Testing RF Linearity.” Use Table 4–13 and Table 4–14 to enter the appropriate data.
3. After you verify RF linearity, go to the **Setup\Config IO\TCP RF & Match** window and set the *TCPRFMaxPowerWithoutWafer* parameter to **1000** watts (applies to both RFDS and Apex).

Initials ______________________ Date ______________________

Table 4–13. RF Linearity - TCP - RFDS 1250 or APEX 1500

Information						
Name:			Date:			
Machine S/N			Generator S/N:			
Measurement unit S/N:						
Measurement unit cal date:						
Measurement unit next cal date:						
Frequency = 13.56 MHz						
Setpoint		**Forward power**			**Measured (meter) power**	
Power Spec	Gen Tol Setpoint Tol	2W 0.50%		Gen Tol Meter Tol	2W 3.00%	
100	97.5		102.5	95.1		105.1
200	197.0		203.0	192.1		208.1
300	296.5		303.5	289.1		311.1
400	396.0		404.0	386.1		414.1
500	495.5		504.5	483.1		517.1
600	595.0		605.0	580.1		620.1
700	694.5		705.5	677.1		723.1
800	794.0		806.0	774.1		826.1
900	893.5		906.5	871.1		929.1
1000	993.0		1007.5	968.1		1032.1
1100	1092.5		1107.5	1065.1		1135.1
1200	1192.0		1208.0	1162.1		1238.1
1300 (APEX only)	1291.5		1308.5	1259.1		1341.1
1400 (APEX only)	1391.0		1409.0	1356.1		1444.1
1500 (APEX only)	1490.5		1509.5	1453.1		1547.1

Table 4–14. RF Linearity - Bias - RFDS 1250

Information					
Name:			Date:		
Machine S/N			Generator S/N:		
Measurement unit S/N:					
Measurement unit cal date:					
Measurement unit next cal date:					
Frequency = 13.56 MHz					
Setpoint		**Forward power**			**Measured (meter) power**
Power Spec	Gen Tol Setpoint Tol	2W 0.50%		Gen Tol Meter Tol	2W 3.00%
100	97.5		102.5	95.1	105.1
200	197.0		203.0	192.1	208.1
300	296.5		303.5	289.1	311.1
400	396.0		404.0	386.1	414.1
500	495.5		504.5	483.1	517.1
600	595.0		605.0	580.1	620.1
700	694.5		705.5	677.1	723.1
800	794.0		806.0	774.1	826.1
900	893.5		906.5	871.1	929.1
1000	993.0		1007.5	968.1	1032.1
1100	1092.5		1107.5	1065.1	1135.1
1200	1192.0		1208.0	1162.1	1238.1

Checking the Plasma

▶ **To check the plasma,**

1 Verify that the parameters from the **Setup\Config IO\TCP RF & Match** and **Bias RF & Match** windows are correct:

Table 4–15. TCP RF and Match Parameters

Point	Minimum	Maximum	Default	Current	Proposed	Units
TCPAutoIgnitionSearchMode	0	1	Enable	0	1	
TCPRFGenPowerRegulationMode	0	1	Fwd Pwr	0	1	
TCPRFMaxPower	0	10000	2500	1250	1250	
TCPRFMaxReflectedPower	0	10000	500	250	250	
TCPRFMaxPowerWithoutWafer	0	10000	500	1000	1000	
TCPRFDefaultSoftTolerance	0	100	10	10	10	%
TCPRFDefaultHardTolerance	0	100	90	90	90	%
TCPRFToleranceCheckDelay	0	20	5	5	5	seconds
TCPRFSoftToleranceTimeout	0	20	2	3	3	seconds
TCPRFHardToleranceTimeout	0	20	2	3	3	seconds
TCPMatchDistanceToSenseBox	0	12	8	8	8	feet
TCPMatchMinPositionReading	-10000	10000	-250	-250	-250	count
TCPMatchMaxPositionReading	-10000	10000	1750	1750	1750	count
TCPIgnitionCheckDelay	0.0	20.0	5	5.0	5.0	seconds
TCPIgnitionFailedTimeout	0.0	20.0	3	3.0	3.0	seconds
TCPMatchC1CapDefaultPosition	0	1000	500	300	300	count
TCPMatchC3CapDefaultPosition	0	1000	500	600	600	count
TCPMatchC1CapMinimumPosition	0	300	100	0	0	count
TCPMatchC1CapMaximumPosition	700	1000	900	990	990	count
TCPMatchC1CapLearnedIgnition Offset	-1000	1000	0	0	0	
TCPMatchC1CapProportionalGain	- 10.0	10.0	1.0	0.5	0.5	
TCPMatchC1CapIntegralGain	- 10.0	10.0	0.0	0.0	0.0	

Table 4–15. TCP RF and Match Parameters (continued)

Point	Minimum	Maximum	Default	Current	Proposed	Units
TCPMatchC1CapDerivativeGain	- 10.0	10.0	0.0	0.0	0.0	
TCPMatchC3CapMinimumPosition	0	300	100	0	0	
TCPMatchC3CapMaximumPosition	700	1000	900	990	990	
TCPMatchC3CapLearningIgnition Offset	-1000	1000	0	0	0	
TCPMatchC3CapProportonalGain	- 10.0	10.0	1.0	0.5	0.5	
TCPMatchC3CapIntegralGain	- 10.0	10.0	0.0	0.0	0.0	
TCPMatchC3CapDerivativeGain	- 10.0	10.0	0.0	0.0	0.0	

Table 4–16. Bias RF and Match Parameters

Point	Minimum	Maximum	Default	Current	Proposed	Units
BiasRFGenRegulationMode	0	1	Fwd Pwr	0	1	
BiasRfMaxPower	0	10000	2500	1250	1250	watt
BiasRFMaxReflectedPower	0	10000	500	250	250	watt
BiasRFPowerWithoutWafer	0	10000	500	0	0.0	watt
BiasRFDefaultSoftTolerance	0	100	10	10	10	%
BiasRFDefaultHardTolerance	0	100	90	90	90	%
BiasRFToleranceCheckDelay	0	20	5	5	5	seconds
BiasRFSoftToleranceTimeout	0	20	2	3	3	seconds
BiasRFHardToleranceTimeout	0	20	2	3	3	seconds
BiasRFHeESCCheckDelay	0	20.0	0	0.0	0.0	seconds
BiasRFvoltageProbeFullScale	0	2000.0	447.0	447.0	447.0	volt
BiasRFCurrentProbeFullScale	0	10	10	10	10	amp
BiasMatchDistanceToSenseBox	0	12	8	8	8	feet
BiasMatchMinPositionReading	- 10000	10000	-250	- 88	- 88	count
BiasMatchMaxPositionReading	- 10000	10000	1750	1088	1088	count
BiasMatchSeriesCapDefaultPosition	0	1000	500	300	300	count
BiasMatchShuntCapDefaultPosition	0	1000	500	600	600	count

Table 4–16. Bias RF and Match Parameters (continued)

Point	Minimum	Maximum	Default	Current	Proposed	Units
BiasMatchSeriesCapMinimumPosition	0	300	100	0	0	count
BiasMatchSeriesCapMaximumPosition	700	1000	900	990	990	count
BiasMatchSeriesCapLearnedIgnition Offset	- 1000	1000	0	0	0	
BiasMatchSeriesCapProportionalGain	- 10.0	10.0	1.0	0.5	0.3	
BiasMatchSeriesCapIntegralGain	- 10.0	10.0	0.0	0.0	0.0	
BiasMatchSeriesCapDerivativeGain	- 10.0	10.0	0.0	0.0	0.0	
BiasMatchShuntCapMinimumPosition	0	300	100	0	0	
BiasMatchShuntCapMaximumPosition	700	1000	900	990	990	count
BiasMatchShuntCapLearnedIgnition Offset	- 1000	1000	0	0	0	
BiasMatchShuntCapProportionalGain	- 10.0	0.5	- 0.3	- 0.3	- 0.3	
BiasMatchShuntCapIntegralGain	- 10.0	10.0	0.0	0.0	0.0	
BiasMatchShuntCapDerivativeGain	- 10.0	10.0	0.0	0.0	0.0	

2. Ensure that all the covers are installed on the PM.
3. Place a wafer in the chamber and pump-down the system to base pressure.
4. Go to the **Maintain\Chamber** window and enter the parameters as they are listed in Table 4–17. Verify the following:
   - Both TCP and bias matches quickly tune and maintain reflected power to less than one (1) percent of the forward power setpoint.
   - Helium cooling promptly reaches setpoint and flow is stable.
   - Chamber pressure stabilizes within five (5) seconds.

Table 4–17. Maintain\Chamber Parameters

Parameter	Setpoint
Chamber pressure	10 mtorr
O2	200 sccm
TCP power	200 watts

Table 4–17. Maintain\Chamber Parameters (continued)

Parameter	Setpoint
He cooling	6 torr
Bias power	50 watts

Initials ____________________ Date _________________

Checking the Helium Cooling

Verifying the UPC

▶ **To verify the UPC,**

1. Pump-down the chamber.
2. Open the He isolation valve on the **Maintain\Chamber** window.
3. Input a setpoint of two (2) torr to the UPC.
4. Monitor the helium flow and the time required for the chamber to rise to a pressure of less than 10 torr. Compare this time to the time required for the He MFC to fill the chamber to 10 torr pressure at the same flow setpoint as observed on the helium flow controller.

Testing the Helium Flow

▶ **To test the helium flow,**

1. Place a wafer in the chamber.
2. Go to the **Maintain\Chamber** window and set the following parameters:

Table 4–18. Helium Flow Test Parameters

Parameter	Setpoint
O_2	200 sccm
Chamber Pressure	10 mtorr

Table 4–18. Helium Flow Test Parameters

Parameter	Setpoint
TCP RF	400 watts

3 Enter the helium-cooling setpoints in Table 4–19 and record the flows.

- For each setpoint, start with a zero (0) torr initial condition.
- Verify the UPC stabilizes pressure control.

Table 4–19. Helium-Cooling Setpoints

He-Cooling setpoint (Torr)	Helium flow (sccm)	Specification less than 2 for all setpoints
6		
8		
10		
12		
14		

Initials ________________ Date ________________

5
Optical Endpoint and Plasma Test

Use this procedure to complete an optical endpoint and a plasma test for the 2300 Versys Metal/Silicon process module (PM).

The optical endpoint test section is divided into the following sections:

- "Describing the Fibers."
- "Verifying the CCD Wavelength Calibration."
- "Aligning the Interferometer."
- "Troubleshooting the Endpoint Interferometer System."
- "Cleaning the Collimator Lens."
- "Performing the Plasma Test."

Reference Documentation

None

Equipment Required

None

Safety

Type 2 task involved.

Preparation

None

Optical Endpoint Test

Use the diagram in Figure 5–1 and Figure 5–2 to verify the fiber optics connection. This will ensure the correct connection of the optical system for the endpoint test (EPT).

Describing the Fibers

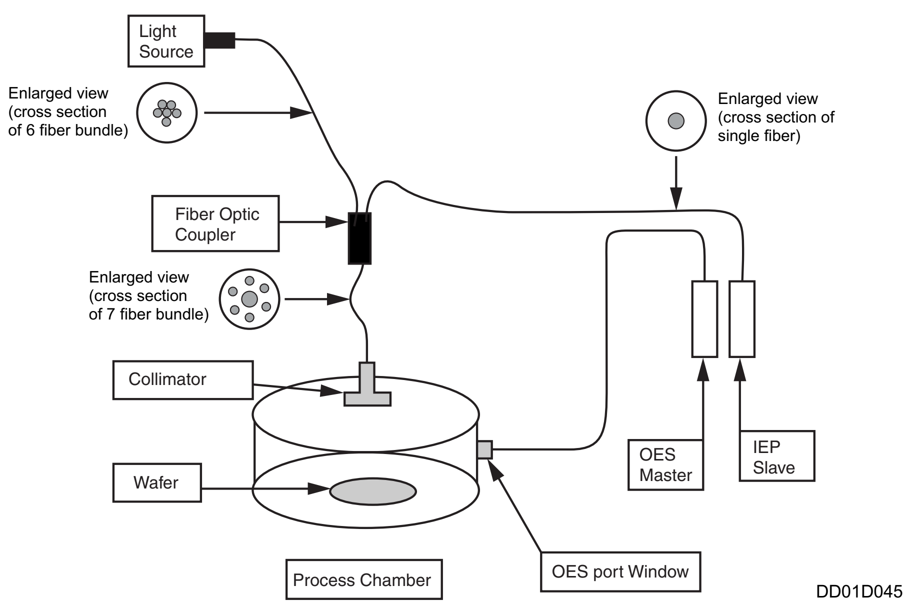
OES Fiber Connections

A single fiber is used for the OES signal. One end of the fiber is connected to the OES Window (reaction chamber, side wall) and the other end is connected to the OES Master CCD (camera).

IEP Fiber Connections

The interferometer system uses a branched (Y-shaped) fiber optic cable. It has one fiber bundle at one end, and two fiber bundles at the other end. See Figure 5–1.

Figure 5–1. Optical Fiber Interconnect Diagram



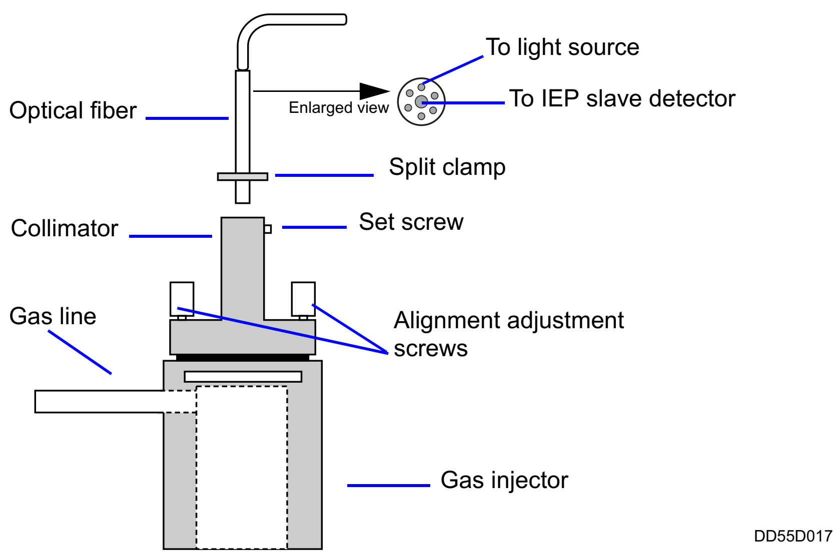
The light source and the detector are connected to the end of the optical fiber "Y" with the two bundles.

The fiber with large diameter (six individual fibers) is connected to the light source. This fiber delivers light from the source to the wafer through the collimator.

The fiber with small diameter (single fiber) is connected to the IEP Slave detector. This fiber is the delivery path for the reflected signal from the wafer (by means of the collimator) to the IEP Slave detector.

The bundle end (seven individual fibers) of the branched fiber optic cable is connected to the collimator. The collimator mounts on the gas injector (in the middle of the source window), and delivers the incident light from the source onto the wafer and then transmits light reflected from the wafer surface back to detector. (See Figure 5–1 and Figure 5–2.)

Figure 5–2. Optical Fiber Connection



Connecting the Fibers

▶ **To connect the optical fibers,**

1 Locate the split clamp (726-003734-010).

2 Slide the split clamp onto the seven fiber bundle end of the fiber optic cable until about 6 mm of the metal end of the fiber protrudes from the clamp (see Figure 5–2).

3 Tighten the clamp (1/16 hex key) just enough to stop the clamp from sliding.

4 Loosen the set screw in the top of the collimator.

5 Insert the metal end of the fiber optic cable into the collimator until the clamp is resting against the end of the collimator.

6 Tighten the set screw.

Verifying the CCD Wavelength Calibration

This calibration ensures the spectral wavelength recorded in the OES is close to the true wavelength.

Verifying the Parameters

▶ **To verify the parameters,**

1 Read the two serial numbers (one for the master and one for slave) from the back side of the spectrometers (two CCDs by Ocean Optics, Inc.™).

- The serial numbers are: anannn, a is an alphabetic letter, n is a numerical number. Obtain the calibration values (two co-efficients and one intercept constants) provided by Ocean Optics, Inc. for each serial number.

Note Ocean Optics, Inc. provides quadratic fitting (three value set) and cubic fitting (four value set) calibration constants. Use the three value set (quadratic fitting: two coefficients and one intercept). Do not use the cubic fitting set on the 2300 Versys Metal/Silicon PM.

2 Verify the two coefficients and one intercept constant in the system (CCD calibration coefficients in the **PM\Setup\OES CCD Config** window) are the right numbers corresponding to the serial number provided by Ocean Optics, Inc. Check both the OES master and the IEP slave.

- If the calibration coefficients and constant are not right, enter the correct numbers. Save the value to the PM cv. file.

Verifying the Spectral Wavelength Calibration

You can verify the spectral wavelength calibration by using a mercury-argon lamp.

► **To verify the spectral wavelength calibration,**

1. Connect a 50 mm diameter or smaller optical fiber to the HG-1 Mercury Argon™ (Ocean Optics, Inc.) calibration source and the CCD (OES master or IEP slave) which you are verifying.
2. Turn on the light source. The HG-1 Mercury Argon lamp is operated with a 12 VDC or 9 VDC battery.
3. Select the **Datalog** window for the PM you are testing.
   - Select the **OES** window.
   - Select **Spectra.**
   - Select **OES** or **IEP** (depending on which CCD you are verifying).
4. Adjust the gain to obtain sharp spectral lines and take a snap shot.
5. Verify the wavelength calibration.
   - Mercury emission lines are less than 600 nm, argon emission lines are greater than 600 nanometer (nm). The wavelength is labeled on the lamp source box.
6. Send the CCD back to Ocean Optics, Inc. for re-calibration if the calibration is off. There is no field calibration available for the CCD.

Aligning the Interferometer

Perform the following interferometer alignment procedure to ensure that the incident light from the collimator is normal (perpendicular) to the surface of the wafer. The collimator can then capture the light reflected from the wafer surface and transfers the light to the IEP slave detector by the fiber bundle. You will also adjust the signal level so that it does not saturate the IEP detector.

▶ **To align the interferometer,**

1. Transfer a clean, bare silicon wafer into the process module. Do not use a wafer that has been etched even if it looks clean.
2. Turn on the light source.
3. Check that the single fiber end of the optical fiber is inserted approximately 6 mm into the collimator (the split clamp is resting on the collimator) and the set screw is tight.
4. Hand tighten the three leveling screws at the base of the collimator. (Do not use a tool.)
5. Display the interferometer signal as follows.
   - Go to the **Datalog** window. Select the correct process module by clicking on the illustration at the bottom left of the user interface display.
   - Select the **OES** window.
   - Select **Spectra**.
   - Select **Show IEP Data**.
   - Set the *CCD gain* variable to 0.
   - Select **Continuous Snap Shot**.
6. Adjust (by hand) the three leveling screws to maximize the intensity. If the signal is very low to start with, increase the gain until you can clearly see the signal on the display.
7. When the intensity is a maximum, the collimator is aligned correctly to the wafer (the incident light from the collimator is perpendicular to the wafer).
8. Remove the wafer from the chamber to verify that the collimator is aligned correctly. The signal should drop almost to zero.
   - If the signal remains high, you have tilted the collimator so that it is collecting light that is reflected from the sapphire optical window.

- Look carefully at the collimator and adjust the leveling screws until the collimator is vertical. The signal should drop to zero.
- Reload the wafer and adjust the leveling screws by small amounts until the signal is a maximum.

9 Adjust the intensity to ensure that the detector will not saturate and the signal-to-noise ratio is as high as possible. The maximum intensity in the spectrum should be between 1000 and 1500 counts with the *CCD gain* variable set to 0. See Figure 5–3.

- If the system has been aligned previously (the position of the split clamp has already been adjusted as described in the next step) you should not need to adjust the intensity.

10 If the maximum intensity is above 1500 or below 1000 counts you must adjust the intensity as follows.

- Loosen the set screw in the collimator and the split clamp.
- Move the fiber optic down or up slightly (into or out of the collimator) until the maximum intensity is between 1000 and 1500 counts.
- Tighten the set screw and the split clamp.

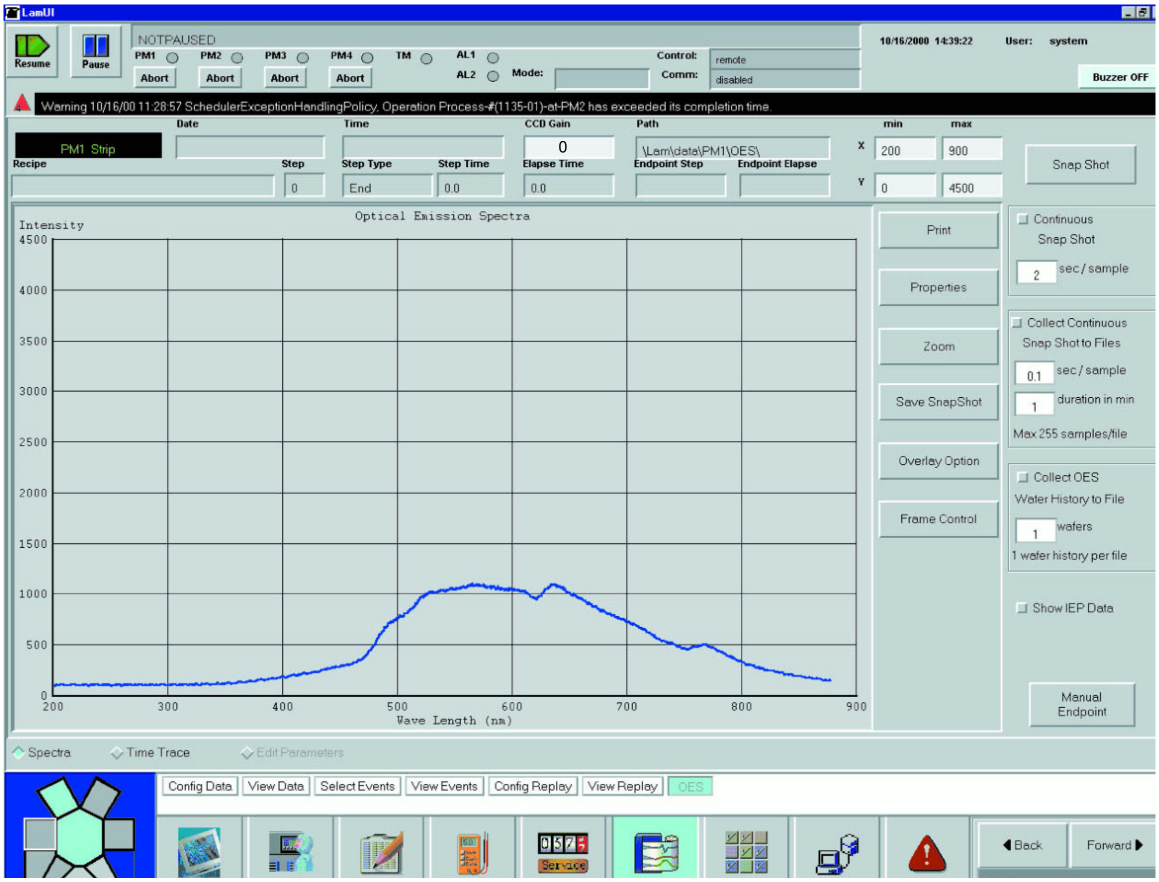
11 For small changes in the intensity it is possible to adjust the amount of light that couples from the light source into the optical fiber. Loosen the set screw where the optical fiber is attached to the light source and rotate the optical fiber slightly.

12 If you need to remove the optical fiber from the collimator:

- Loosen the set screw and pull the fiber out of the collimator.
- Do not loosen the split clamp.

13 If you replace a spectrometer on the system, you must enter new calibration parameters into the system software to preserve the accuracy of the wavelength calibration on the system. For more detailed information on how to set new calibration parameters, see Section 10.1, "Calibrating the Spectrometer."

Figure 5–3. Tungsten Lamp Spectrum



The maximum signal should be between 1000 and 1500 counts.

Initials ______________________ Date ___________________

Troubleshooting the Endpoint Interferometer System

Use the following table to troubleshoot the endpoint interferometer system.

Table 5–1. Interferometer Symptoms and Corrective Action

Symptom	Corrective action
No signal on the **Datalog** window.	Ensure that Datalog is in *IEP* mode. (Select **Show IEP Data**.)

Table 5–1. Interferometer Symptoms and Corrective Action (continued)

Symptom	Corrective action
	Ensure that Datalog is in *Continuous Snap Shot* mode. (Select **Continuous Snap Shot**.)
	Ensure that there is a clean, bare silicon wafer on the chuck.
	Check to see if the optical fiber is broken. *Remove fiber from system.* *Point the end of the fiber that is normally connected to the collimator at the lights in the ceiling of the fab. You should see light when you look into the small and big connectors at the other end of the fiber cable. If either of these is dark, the fiber is broken. Replace fiber.*
Light source is not functioning.	Ensure that the electrical cables to the light source are securely connected.
	Ensure that the light switch is on.
	Hold a piece of lint-free wipe or paper about 5cm away from the output of the light source. *Do not look directly into the light source.* You should see a bright spot of light on the paper coming from the light source.
Detector is not functioning.	Check that the electrical cables to the OES and IEP detectors are securely connected.
	Ensure that the Datalog is set to *IEP*.
	Connect one end of the short OES fiber to the IEP slave detector. Point the other end toward the lights in the ceiling of the fab. You should see the spectrum of the light on the **Datalog** window. If you do not see a signal, the detector is faulty.
Signal is weak (cannot reach 1000 counts when gain equals 0).	Ensure that there a clean bare silicon wafer on the chuck.
	Check to see if the fiber too far *out* or too far *in* to the collimator. Reset fiber so that it is approximately 6 mm into the collimator. Adjust three alignment screws to maximize intensity.

Table 5–1. Interferometer Symptoms and Corrective Action (continued)

Symptom	Corrective action
Alignment is too far off.	Starting with one of the alignment screws, turn it until the signal is a maximum. Adjust the next screw until the signal is a maximum. Adjust the last screw until the signal is a maximum. If the result is higher than when you started, continue with the first screw again. Proceed until the signal is as high as possible.
Optical pathway is dirty.	Ensure that the lens in the base of the collimator is clean. See "Cleaning the Collimator Lens."
	Check that the window at the top of the gas inject is clean. (Even thin films of grease can greatly reduce the transmission at short wavelength.)
Signal remains high even when the wafer is removed from the chamber.	This occurs when the collimator is so far out of alignment (off vertically) that the collimator is collecting light reflected from the sapphire optical window. *Look carefully at the collimator and adjust the leveling screws until the collimator is vertical. The signal should drop to zero.* *Reload the wafer and adjust the leveling screws by small amounts until the signal is a maximum.*

Cleaning the Collimator Lens

It is important not to touch the lens or let any vacuum or other grease come into contact with the lens since this will greatly reduce its transmission at short wavelengths.

- If the lens is dirty, wipe it gently with a clean, lint-free wipe moistened with IPA.

Performing the Plasma Test

▶ **To perform the plasma test,**

1. Verify that all the covers are installed on the PM.
2. Place a wafer in the chamber.

3 Go to the **Setup\Heaters** window and verify that all the temperature channels are set to 60 degrees Celsius.

4 Go to the **Editors\Recipe** window and open the file named *Module Checklist* and verify that the recipe matches the one in Table 5–2.

Table 5–2. Plasma Test Recipe

Step number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Step Description	**Stab**	**Ingition**	**Chuck**	**Brkthru**	**ME Stab**	**Main Etch**	**Stab**	**OE Stab**	**OE**	**De chuck**	**Pins Up**
Pressure (mtorr)	7	7	7	7	12	12	12	80	80	80	10
TCP RF Power (watts)	0	500	500	800	0	600	600	0	500	500	0
Bias RF Power (watts)	0	0	0	150	0	100	100	0	80	0	0
Bias RF Voltage (volts)	0	0	0	0	0	0	0	0	0	0	0
Bias RF Control Mode	Power	Power	Power	Power	Power	Power	Power	Power	Power	Power	Power
Argon Flow (sccm)	150	150	150	150	100	100	100	200	200	200	200
Oxygen Flow (sccm)	50	50	50	50	100	100	0	100	100	0	0
Helium (torr)	0	0	8	8	8	8	8	8	8	0	0
Lifter Pin Position	down	down	down	down	down	down	down	down	down	down	up
Step Type	Stab	Stab	Time	Time	Stab	Time	Stab	Stab	TIme	De chuck	Time
Process Time (sec)	15	6	5	10	15	30	10	15	15	15	4

5 Go to the **Setup\ConfigIO\Helium ESC Config** window and set the parameter *Allow TCP Off After Chucked* to **True**.

6 Set the endpoint parameters for step seven of the recipe to the following:

Table 5–3. Plasma Test Endpoint Parameters

Parameter	Setpoint
Wavelength	604
Basis Function 1	IBL
DelayTime	1
Ibl Width	10
Ibl Filter	Null
Algorithm	Percent Change
NormalizationTime	1
PercentToChange	20
CCDGain	2

7 Start the recipe and verify the following:

- The chamber pressure reaches the setpoint well within the time allowed in the recipe.
- Both TCP and bias matches quickly tune and maintain reflected power to less than one (1) percent of the forward power setpoint.
- Helium cooling promptly reaches setpoint and flow is stable.
- Temperatures are within ± five (5) degrees Celsius of the setpoint.

Initials ______________________ Date _______________________

This concludes the hardware portion of a PM startup and functionality check. If the system has passed all the required tests outlined in this section, notify the responsible process personnel that the system is ready for baseline process qualification testing.

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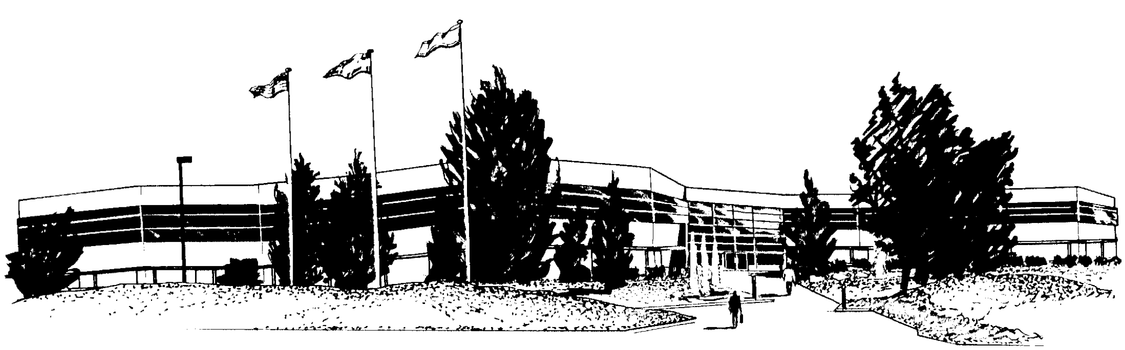

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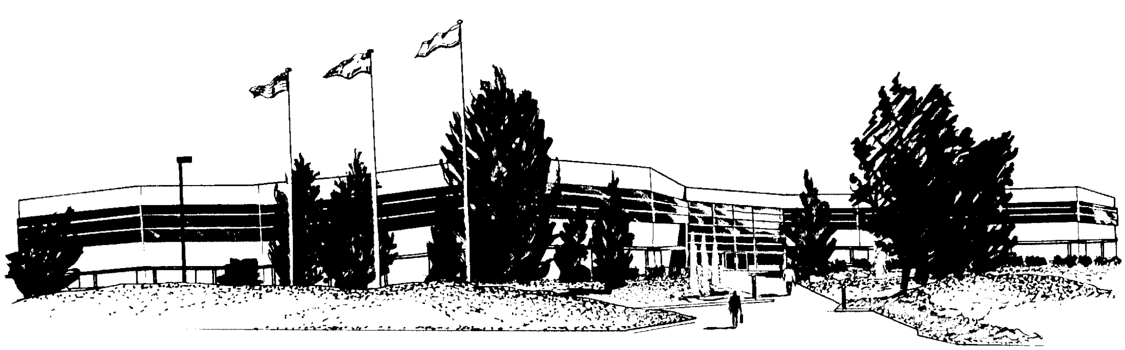

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