TRION TECHNOLOGY

MINILOCK-PHANTOM III
OPERATOR & MAINTENANCE MANUAL

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TABLE OF CONTENTS

WARRANTY

The TRION system is guaranteed to be free of defects in workmanship and components. This warranty covers labor and parts for a period of **one year**, unless an extended warranty has been purchased.

The exclusive remedy for any breach or violation of the warranty is as follows: TRION TECHNOLOGY F.O.B CLEARWATER, FL will furnish without charge repairs to or replacement of the parts or equipment that proved defective in material or workmanship. No claim may be made for any incidental or consequential damages.

All transportation and shipping charges must be prepaid by the customer.

TRION TECHNOLOGY will inspect the equipment and decide upon such repairs or replacement as necessary. The customer will be notified of any charges incurred that are not covered by this warranty prior to accomplishment of any such repairs.

Any customer modification of this equipment, or any repairs, undertaken without the prior consent of TRION TECHNOLOGY will render this warranty void.

This warranty is expressly in lieu of all other warranties, express or implied, including any implied warranty of merchantability or fitness for a particular purpose unless otherwise agreed in writing signed by TRION TECHNOLOGY.

SERVICE INFORMATION

NOTIFICATION OF EQUIPMENT PROBLEMS:

If the system has a failure or other equipment problems you must notify TRION TECHNOLOGY *immediately* in writing by either FAX to (727) 447-1581 or e-mail at service@triontech.com, addressed to the Service Coordinator. In addition please call the Service Department at (727) 447-1110 to schedule a service trip. Phone help is always provided free of charge. However, if the system is out of warranty a purchase order number will be required before a service trip is scheduled.

RETURN OF EQUIPMENT:

If an instrument is to be returned to TRION for service or for any reason, the following procedure should be followed:

Call the TRION TECHNOLOGY Service Department at (727) 447-1110 for a return authorization number (RMA). You may also e-mail TRION at "service@triontech.com" with any service related questions. If the unit is received without this number on the outside of the box it will be rejected by the Service Department.

Repack the instrument in the original shipping container. If this is no longer available, take special precautions to avoid damage to any fragile components. TRION will not be responsible for any damages incurred during shipment from customer to TRION. A shipping container may be purchased from TRION TECHNOLOGY for a nominal charge.

If the instrument is still under warranty, the only charges will be shipping costs. If the instrument is out of warranty, a purchase order will be required and you will be billed for all parts and service.

If you have any questions, do not hesitate to contact TRION Customer Service Department.

SYSTEM WARNING

SAFE OPERATING PROCEDURES AND PROPER USE OF THE EQUIPMENT ARE THE RESPONSIBILITY OF THE USER OF THIS SYSTEM.

TRION TECHNOLOGY provides information on its products and its associated hazards, but assumes no responsibility for the after sale operation and safety practices.

ALL PERSONNEL WHO WORK WITH OR ARE EXPOSED TO THIS EQUIPMENT MUST TAKE PRECAUTIONS TO PROTECT THEMSELVES AGAINST POSSIBLE SERIOUS AND/OR FATAL BODILY INJURY.

DO NOT BE CARELESS AROUND THIS EQUIPMENT.

The following hazards are present on this system. Warning labels are affixed to the appropriate locations on the system to notify the user of potential danger.

	HAZARD	LOCATION
	**HAZARDOUS VOLTAGE** Contact may cause electric shock or burn. Turn off and lock out system before servicing.	AC distribution module. Pump Contactor NEMA box. Inside RF generator. Inside chamber, at chuck.
	**FLAMMABLE MATERIAL** Contents may burn if exposed to flame source. Keep spark or flame sources from container.	Gas Cabinet.
	**NON-IONIZING RADITION** Contact may cause electric shock or burn. Turn off and lock out system before servicing.	Inside chamber with RF on. Inside RF generator with RF on.
	**CHEMICAL HAZARD** May cause skin/eye irritation. Wear gloves and eye protection while servicing.	Inside the chamber. Inside the gas cabinet.

SYSTEM DESCRIPTION

GENERAL DESCRIPTION (OBJECTIVE)

The Minilock-Phantom III RIE is a plasma system designed to supply laboratories and pilot line production environments with state-of-the-art etch capability using single wafers or mounted parts. It also has multiple size batch capability.

The RIE (reactive ion etch) system has up to seven process gases used to etch films such as silicon oxide, silicon nitride, polysilicon, aluminum, GaAs and many others. This reactor can also be used to strip photoresist and other organic materials. An electrostatic chuck (E-chuck) is offered as an option to more effectively keep the wafer cool during the etch process. This E-chuck uses a helium pressure controller to build up a cooling layer of helium on the backside of the wafer.

An inductively coupled plasma (ICP) source is offered as an option for this tool. The ICP allows the user to create a higher density plasma and thereby increases etch rates and anisotropy.

Typical process recipes and results can be found in the processing section of this manual.

Samples are loaded into the process chamber via the vacuum load lock. This feature increases user safety by preventing contact with the process chamber and any residual etch by-products. The load lock also allows the chamber to remain permanently under vacuum thereby keeping out moisture and keeping the reaction chamber free of possible corrosion.

SYSTEM SPECIFICATIONS:

SIZE:	18 in (.5 m) Wide 51 in (1.3 m) Deep 53 in (1.4 m) Tall – with ICP
MAX RF POWER:	1000 Watts – ICP 600 Watts – RIE
SYSTEM POWER REQ	15A, 208Vac (phase-to-phase) 3-phase for the system. 20A, 208Vac (phase-to-phase) 3-phase for the remote pump box. (Remote pumps may need more amperage depending on pump size and quantity)
GAS CHANNELS	7 Maximum
MAX WAFER SIZE - SINGLE:	3 in - 12 in (300 mm)
MAX WAFER SIZE - BATCH:	4 x 3 in 3 x 4 in 7 x 2 in

EQUIPMENT

The Trion Technology Minilock-Phantom III includes the following components:

EMERGENCY SHUT-OFF

To start the system, make sure the EMO button has been twisted to release and then press in the “MAIN” button. This will supply power to the computer, RF generators and turbo controller. Next, press in the “PUMP” button to turn on the chamber-roughing pump. The computer will start and automatically load the system operation software.

To turn off the system, first exit the software. Then press in the “OFF” button. This will turn off the power to the computer (and thereby closing all gas and vacuum valves), the RF generators and the turbo pump. You must press in the “EMO” button to shut off the pump.

At any time the user may quickly shut down the system by pressing the “EMO” button. This will automatically shut off all AC power to the system including the computer, RF generators, turbo controller and the pump. This palm-activated button must be twisted to release. The system will NOT turn on until the user presses the “MAIN” button.

A full description and schematics for the EMO circuit are presented in the “SAFETY SPECIFICATIONS” section below.

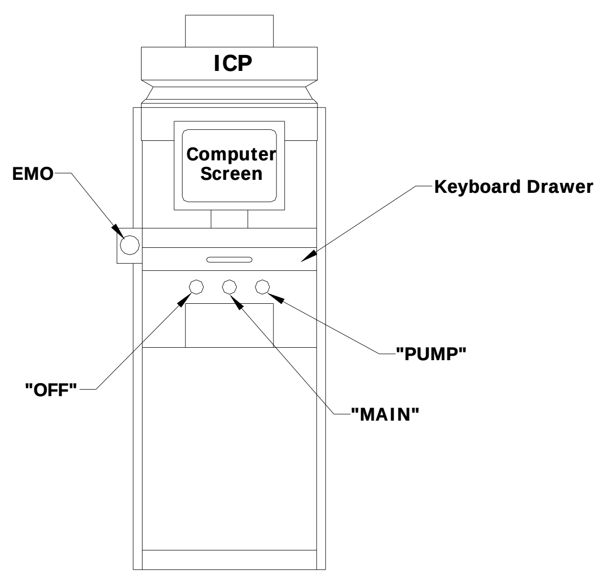


Figure 1. - System Frontal View

PROCESS CHAMBER

The process chamber is defined by the vacuum enclosure shown in Figure 2. below and made up of the ICP, the chamber block and the RIE matching network. The chuck (where samples are placed) is an integral part of the RIE matching network. During a process, the process gases (such as O_2 and CF_4) enter at the rear of the ICP, flow through the center of the ICP lid and exit into the chamber volume at the top center. The gas flow rates are controlled by mass flow controllers (MFC).

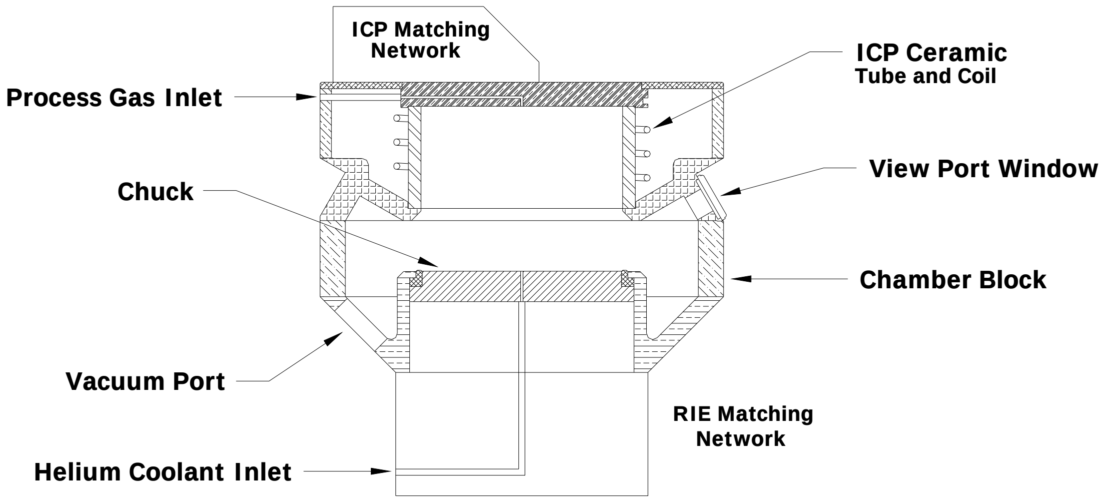


Figure 2. - Overall Process Chamber w/ICP

In addition to the process gases, helium gas can be introduced into the chamber via the chuck as shown. The helium pressure on the backside of the wafer is controlled by an analog pressure controller and is set as a process variable in the recipe file on the computer. The purpose of the helium is to help cool the sample. Since the chuck has RF power flowing through it, samples can heat up over time and the helium helps maintain the sample at a reasonably cool temperature.

All of the gases entering the chamber are sucked out of the chamber through the vacuum port at the rear of the system. When the RF generators for both the RIE and ICP are turned on, then a plasma is created in the chamber. The glow discharge can be seen from the front view port window.

The chamber block has internal dimensions of 14" diameter x 2.50" high and will hold a 200 mm wafer on the RIE chuck. The chamber, plenum and ICP base are constructed of hard anodized aluminum. The ICP has an 8” inner ceramic diameter x 4.00” tall.

The chuck, or bottom electrode, produces a negative DC bias, which increases ion bombardment and anisotropy while etching. The ICP is used as the primary plasma source and creates this plasma by inductively coupling the RF power through the ceramic and into the vacuum via the copper coil. The idea is to use the ICP to generator a high-density plasma in the ceramic tube above the chuck. Then smaller amounts of RF power are supplied to the chuck to generate the DC bias. This DC voltage is the driving factor in accelerating the ions to the sample and thereby increases etch rate and anisotropy.

Samples are loaded into the chamber by using tweezers to set them down onto the chuck. The ICP assembly also serves as the main lid. This assembly automatically lifts open using twin pneumatic cylinders, which are controlled by the computer.

An E-chuck is available as an option to better cool the wafer during the process.

<u>LOAD LOCK AND TRANSPORT ROBOT</u>

The load lock chamber is connected to the process chamber via a gate valve. When the user loads a sample, he places the sample onto the robot and effector. The system then pumps down the load lock to approximately 100 mTorr and then opens the gate valve. The arm moves into the process chamber where 3 pins lift the sample up off of the arm. The end effector retracts back into the load lock and the gate valve closes. The lift pins then lower the sample onto the chuck and the system is reading to process the part.

RF GENERATOR

There are two RF generators on the Minilock-Phantom III model; #1 is for the ICP source of plasma and #2 is for the RIE source. Depending on process demands, TRION TECHNOLOGY supplies various RF generators and power ranges. Our standard generators are:

Advanced Energy 3000 Watt, 13.56 Mhz.
Advanced Energy 600 Watt, 13.56Mhz
(ICP is currently limited to 1000-Watts maximum power)

The power level and on/off functions are controlled from the process control computer. For further information see the RF generator manuals in the appendices.

AUTOMATIC RF TUNING

The RF generators supply a predetermined amount of power to the ICP and RIE matching networks. The amount of power is set by the user via the process control computer and is called the FORWARD POWER. The electrical schematics for each are shown below.

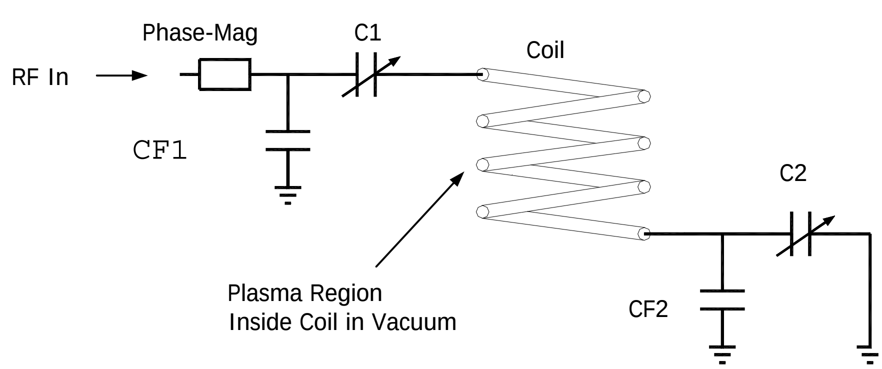


Figure 3. - ICP Electrical Schematic

For the ICP, the RF power first enters the matching network at the Phase-Mag detector. Then is goes through CF1 (fixed capacitance) to ground while also going through C1 (variable capacitance). After C1, the power goes through the coil and then out through C2 (variable capacitance) and CF2 (fixed capacitance).

The RIE matching network is shown in Figure 4 below and is similar to that of the ICP. The RF power first goes through the phase-mag detector and then through the rest of the network and into the plasma inside the vacuum chamber.

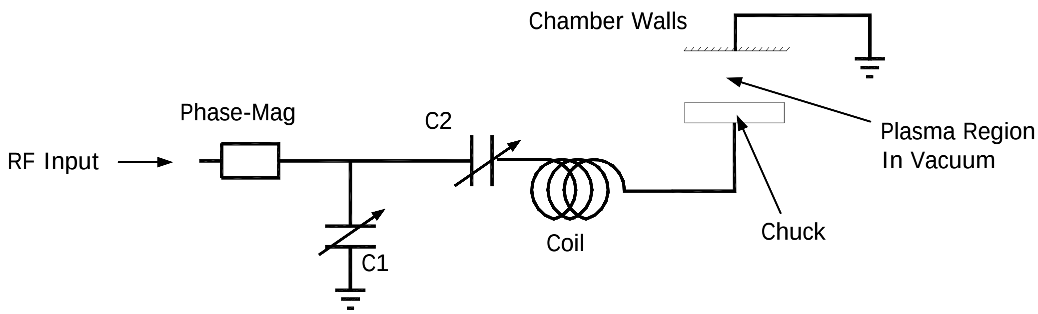


Figure 4. - RIE Electrical Schematic

The overall impedance of each network must be 50 ohms. The network for both the ICP and RIE include the electrical impedance of the plasma. Plasma impedance is determined by a process pressure, RF power input, and the species of gases flowing into the chamber. If the overall impedance of the system is not 50 ohms, then a certain amount of RF power essentially bounces off the network and gets reflected back to the generator itself. This is called the REFLECTED POWER. The actual RF power delivered to the chuck or the ICP plasma is given by:

RF Delivered = FORWARD POWER – REFLECTED POWER

In order to consistently deliver the proper power to the chamber, it is important to properly “match” the network impedance so that the REFLECTED POWER is near zero. We use the variable capacitors to tune the impedance of the networks to keep the reflected power to near zero.

In order to have the system automatically keep the networks tuned, we employ a device that detects the phase and magnitude of the reflected wave. This is called the “PHASE-MAG” detector. The phase-mag picks of the level of reflected power and then sends two low voltage signals (-2 to +2 Vdc) to an op-amp, which in turn sends proportionally higher voltages (-15 to +15 Vdc) to two DC servomotor coupled to the shafts of the C1 and C2 capacitors.

For example, let’s say that the process pressure is changed so that the reflected power goes from 0 watts to 25 watts. The phase-mag will now generate voltage signals to the op-amp proportional to the amount of reflected power. The op-amp in turn sends higher voltages to the DC servomotors, thus turning the capacitors and decreasing the reflected power until it is near zero. Trion Technology calibrates the phase-mag so that the networks tune to within 5% of the set point RF power value.

<u>MANUAL RF TUNING</u>

If there is a problem with the phase-mag or op-amp circuit, there are switches that can be used to override the automatic tuning and allow the user to manually adjust the network impedance. The switches that control the override and manual tuning are located behind the flip-down door at the center console of the system just below the ON/OFF buttons. This is shown in Figure 5.

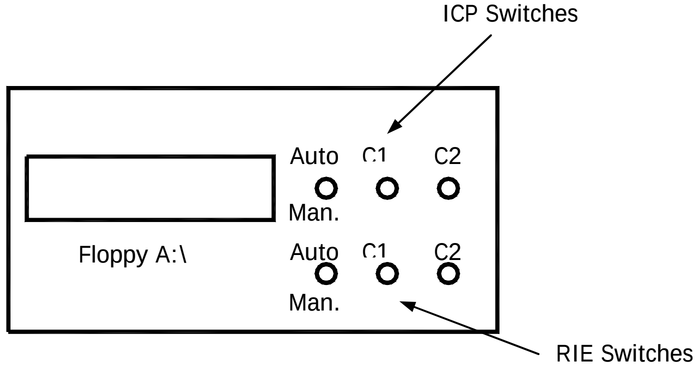


Figure 5. - Floppy Access And Network Tuning Controls

To manually tune a plasma, follow the steps below.

1. Open the flip door at the center console of the system.
2. Locate the group of three tuner controls that correspond to the plasma source that is not automatically tuning. For example, if the ICP is not tuning, then locate the upper three switches.
3. Flip the “AUTO/MAN” switch to the fully down position. This switch has 3 positions: up = automatic, middle = nothing, down = manual.
4. While looking at the computer screen while the process is running, notice the amount of reflected power for RF #1 (which is the ICP).
5. Adjust the “C1” switch so that the reflected power decreases. This switch is momentary so when you release it, it will return to the center, or neutral position. If the reflected power increases, then reverse the direction on the switch. Keep adjusting this switch until the reflected power is at a minimum.
6. Then adjust the “C2” switch in the same manner until the reflected power again goes to a minimum.
7. Repeat steps 5 and 6 iteratively until the reflected power gets to near zero.
8. Leave the “AUTO/MAN” switch in the manual (or down) position. Putting it back to the automatic position may increase the reflected power.

PROCESS CONTROLLER

The Minilock-Phantom III comes with a Pentium based process control computer with a touch screen user interface. The Trion designed data acquisition board has 12 analog output channels (8 bit resolution), which control the 6 gas channels, process pressure, chuck temperature, and the RF power. The system also comes with 16 channels of 12 bit analog input. The DAQ board and controller are run by LabView for Windows software. All processing parameters can be programmed by the user and stored into recipes files on the hard drive and/or on a floppy drive. Up to fifteen process steps per recipe can be stored. The system controller also has a manual override, which can be used to override the process endpoint and reprogram the process in-situ.

VACUUM SYSTEM

A schematic of the vacuum system is shown below in Figure 6. This consists of the chamber, load lock, gas distribution manifold, throttle valve, turbo pump and the two roughing pumps. A detailed gas cabinet schematic is shown later.

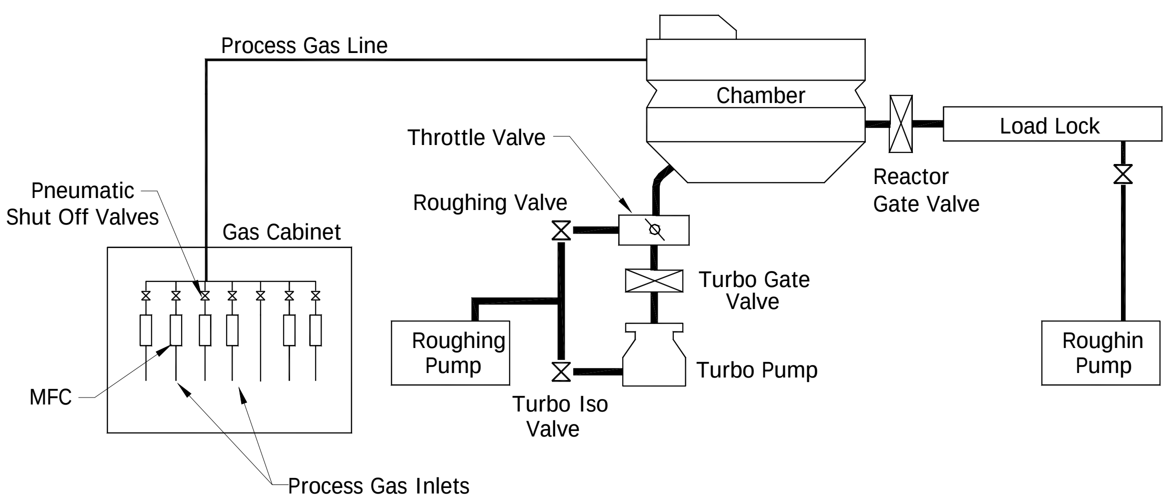


Figure 6. - Vacuum Schematic

Note: **Trion passes on the manufacturer's warranty on pumps to the end user and does not itself warrant them. It should be noted, that in any system using corrosive gases, that the roughing pump (Dry or oil lubricated) and the turbo pump must remain running *AT ALL TIMES*. Likewise, the N2 purge gas must remain on *AT ALL TIMES*. Pumps can seize if they are not kept rotating, purged and lubricated after being exposed to metal corroding gases. In the case of power failure, the end user must insure that the pumps are restarted, as soon as possible, after power is restored. The pump manufacturers, can, and will, void the warranty if this is not done.**

RECIRCULATING CHILLER

A recirculating chiller can be purchase from TRION as an option. For ICP systems, recommends the Neslab Merlin M75 unit, capable of removing ~8000 BTU/hr @ 20C. Units without ICP only require a Merlin M33 chiller capable of removing 3300 BTU/hr @ 20C. It is used to cool the RIE process chamber, the turbo pump and the ICP source. The temperature set point is controlled from the front panel on the unit and be can set anywhere from 5 to 25C. TRION TECHNOLOGY recommends the chiller be set to 80C for the Minilock-Phantom III system unless otherwise specified for certain processes. For further information refer to the manufacturer’s manual in the appendix of this manual.

SAFETY SPECIFICATIONS

SAFETY STANDARDS

The TRION Minilock-Phantom III was built with standard safety requirements in mind. Purchased electrical components meet national UL standards where applicable and materials used in the machine's construction meet National Electric and Fire Codes. This machine has been found to meet SEMI S2-93 product safety guidelines.

The machine has the proper ANSI Z535 high voltage warning labels where high voltage is present, and chemical warning labels where those chemicals are present.

LOCK OUT/TAG OUT

Electrical power is supplied from the house system to the Minilock-Phantom III at only two locations; the AC distribution and the process chamber Pump Control NEMA Box. Figure 7 shows a diagram of this electrical distribution system.

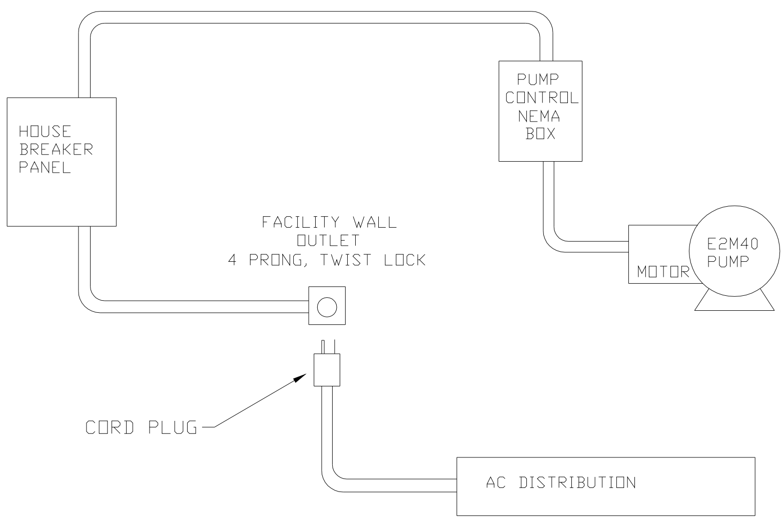


Figure 7: Main Electrical Distribution Diagram

The AC distribution is connected to the housebreaker panel via a 4-prong twist-lock cord plug. The three-phase process chamber-roughing pump is connected to the housebreaker panel via the Pump Control NEMA Box. The power cord from the pump motor is hard wired through a knockout in this box to the main contactor inside. Just upstream of this contactor is a 15 Amp, 3-pole circuit breaker. The incoming power from the house is wired to the “LINE” side of this breaker. This NEMA box is to be pad-locked closed unless the housebreaker has been locked out as described below.

PROCEDURE FOR SERVICE:

1. If any service work is to be performed on the system other than routine system maintenance, the user must first press the EMO button on the front panel of the system.

2. Next, the user must unplug the cord plug from the wall outlet.

3. The Cord lockout cap must be locked onto the cord plug. This lockout cap must have the tag “DANGER DO NOT OPERATE” attached to it and visible.

This will prevent any system component from turning on. It is now safe to remove modules and/or repair them in place following proper guidelines set down by TRION TECHNOLOGY. Although the Pump Control NEMA Box still has electrical power coming into the contactor, with the AC distribution unplugged this contactor can never be energized.

However, if service work needs to be performed on the process chamber roughing pump OR the NEMA control box, the following procedure must ALSO be followed.

1. Shut off the main house circuit breaker feeding the Pump Control NEMA Box.

2. Using the circuit breaker lockout, lock this circuit breaker in the OFF position. This lockout must have the tag “DANGER EQUIPMENT LOCKED OUT TO PROTECT WORKERS” attached and visible.

3. The user is now free to unlock the NEMA box if necessary and perform any service as needed.

EMERGENCY OFF SYSTEM

Figure 8 shows a diagram of the electrical control circuitry and buttons. There are 4 control buttons as labeled in the figure; EMO, OFF, MAIN, PUMP and PUMP EMO.

MAIN This button energizes the AC relay (K2) inside the AC distribution (ACD) module and:
- distributes 208VAC to the outlets
- turns on the computer

PUMP This button energizes the Pump relay (K1) inside the AC distribution and the 3-phase contactor (K5) inside the Pump control NEMA box. The results of pressing this button are:
- turns on the 3-phase chamber roughing pump and the single-phase load lock pump.

OFF This button de-energizes the AC relay (K2) and therefore shuts off the following:
- computer
- RF generators
- Turbo pump

- E-chuck power supply

PUMP EMO This button de-energizes the AC relay (K2), Pump relay (K1) and the 3-phase contactor (K5). This in turn shuts off all components and instruments on the Minilock-Phantom III system.

EMO This button de-energizes the AC relay (K2), Pump relay (K1) and the 3-phase contactor (K5). This in turn shuts off all components and instruments on the Minilock-Phantom III system.

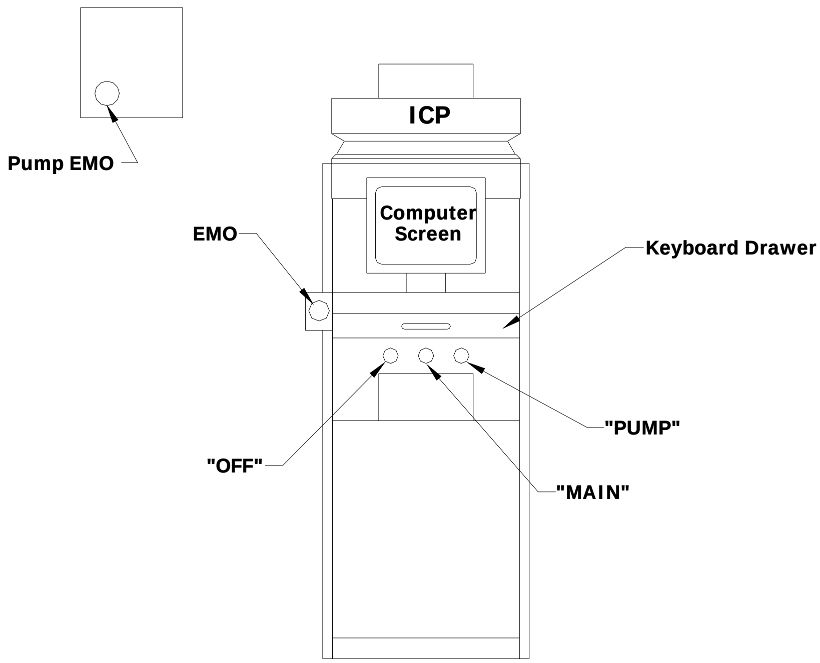


Figure 8. - Control Buttons

INTERLOCKS

The Minilock-Phantom III system has hardware interlocks that place the machine in a safe mode when tripped. These interlocks protect against a loss of water coolant flow and a loss of the house exhaust to the gas cabinet and pumps.

The table below describes the interlocks, their location and what they control in the advent of an error or alarm condition.

Interlock	Location	Purpose	Actions
Water flow switch.	Mounted to the chamber coolant outlet port.	To detect a loss of water coolant flow.	N.C. switch opens when the water flow stops. This tells the computer to shut down the gas valves and RF power.
Exhaust flow switch. (Customer supplied)	Mounted to the cabinet exhaust duct.	To detect loss of flow exhaust system.	N.C. switch opens when the exhaust flow stops. This tells the computer to

			shut down the gas valves and RF power.

EQUIPMENT ELECTRICAL DESIGN

All of the Minilock-Phantom III modules have been designed to be easily removed from the system. This design allows the user or the service engineer to remove and replace the module without exposing any electrical components.

Internal to the Minilock-Phantom III modules, all components with voltages greater than 24 Volts have either protective plastic or metal covers. The electrical distribution module has no user serviceable parts and is riveted closed at the factory. All covers that house dangerous voltage have ANSI Z535 complaint warning labels.

All electrical components, wiring, and grounding comply with National Electrical Codes.

CHEMICAL USE

The following gases can be used in the Minilock-Phantom III system:

BCl_3	100 sccm maximum
CF_4	100 sccm maximum
O_2	100 sccm maximum
Ar	100 sccm maximum
SF_6	100 sccm maximum
NF_3	100 sccm maximum
CHF_3	100 sccm maximum
H_2	100 sccm maximum
Cl_2	100 sccm maximum

When the etch process is complete, the process controller automatically maintains a vacuum in the chamber for 20 seconds after processing to insure complete removal of any residual by-products. (This time can be increased through software if desired). A follow on process step can be added that purges the chamber with nitrogen to further clear out residual gases. The controller is also designed such that the reactor remains under vacuum when the system is idle.

The load lock eliminates the need for the user to ever open the chamber during normal operation. Therefore there is no contact with process gases during normal operation.

EMISSIONS

There should be no harmful chemical emission during the normal operation of this equipment. The reaction chamber and vacuum pumps are sufficiently exhausted to prevent this occurrence.

LABELING

All piping is labeled with the name of the gas contained within. All system wiring is color coded in accordance to NEC requirements. All hazardous locations are labeled with ANSI Z535 compliant labels.

EARTHQUAKE PROTECTION

The system will not overbalance until it is tipped more than 22^{o} and is sturdily built into a 1.5" square extruded aluminum frame. In addition, the system should be bolted to the facility floor.

MECHANICAL SAFETY

There are no sharp protruding edges, which can be hazardous. The only moving parts are the robot end effector and the gate valve between the load lock and the process chamber. The robot motor's stall torque is low enough that no injury will occur should the end effector move while the user's hand is in the way. The reactor and load lock lid switches cut off 12VDC to the pneumatic solenoid valve that controls the gate valve movement. This opens the valve and prevents the valve from ever closing on the user's hand should it be placed in the passage between chamber and load lock.

"WHAT IF" HAZARD ANALYSIS

The following table shows the risk assessment of the Minilock-Phantom III system.

What If?	Consequences	Protection
Computer lockup	Process continues to run at last set points	none
Computer failure	Set points go to zero and all normally closed valves close	Failsafe
Loss of cooling water	RF generation ceases, process is impacted, potential o-ring damage	Flow switch that cuts off all RF power and gas flows
Chiller coolant leak	Wet floor	Small coolant volume, well placed and baffled electrical enclosures
Toxic Gas Leak	Hazard to personnel	Customer supplied gas detectors are wired into Trion system and EMO the system in the event of a toxic gas leak

INSTALLATION

INSPECTION

The Minilock-Phantom III is completely tested and inspected at the factory before shipping. It is packed in specially designed shipping containers to protect it from damage in normal handling. **Save these containers, if possible.** Inspect the shipping containers before unpacking the instrument. If there are signs of damage to the containers, make note of the damage and report it to the shipping company and TRION TECHNOLOGY immediately.

Inspect the instrument for any damage to the enclosure, the chamber, switches, and other components. If there are any damaged or missing components, notify your sales representative or the TRION Service Department.

FACILITIES

The Minilock-Phantom III requires the following facilities for operation:

AC POWER	208VAC 15A, THREE PHASE - 4 PRONG TWIST LOCK 1 Ground 3 Hots 208VAC 20A THREE PHASE – PUMP CONTROL BOX 1 Ground 3 Hots (Note: Amperage requirements subject to change depending on pumps.)	
EXTERNAL GASES	NITROGEN	- 80 psi, 1 lpm (For Pneumatic actuation)
	OXYGEN	- 15 psi, 100 sccm (Process Gas)
	CF_4	- 15 psi, 100 sccm (Process Gas)
	ARGON	- 15 psi, 100 sccm (Process Gas)
	NF_3	- 15 psi, 100 sccm (Process Gas)
	SF_6	- 15 psi, 100 sccm (Process Gas)
	CHF_4	- 15 psi, 100 sccm (Process Gas)
	H_2	- 15 psi, 100 sccm (Process Gas)
	(Note: all fittings are 1/4" VCR)	
INTERNAL GASES	BCl_3	- 15 psi, 100 sccm (Process Gas)
	Cl_2	- 15 psi, 100 sccm (Process Gas)
PUMP EXHAUST	Flow rate and fitting size depend on pumps supplied or purchased	
CABINET EXHAUST	200 cfm per cabinet, 6” ID Duct. Duct material must be non-flammable. if local authorities require abatement then follow the pertinent regulations for the chemistries used.	
COOLING WATER	2.0 LITER/MIN, 3/8” SWAGELOCK FITTINGS	

50/50 Mixture of Ethylene Glycol and DI water

INSTALLATION PROCEDURE

1. Place the chamber-roughing pump as close to the chamber as possible to minimize conductance losses. Place as shown in Figure 9.

2. Place the smaller load lock roughing pump also as shown in Figure 9.

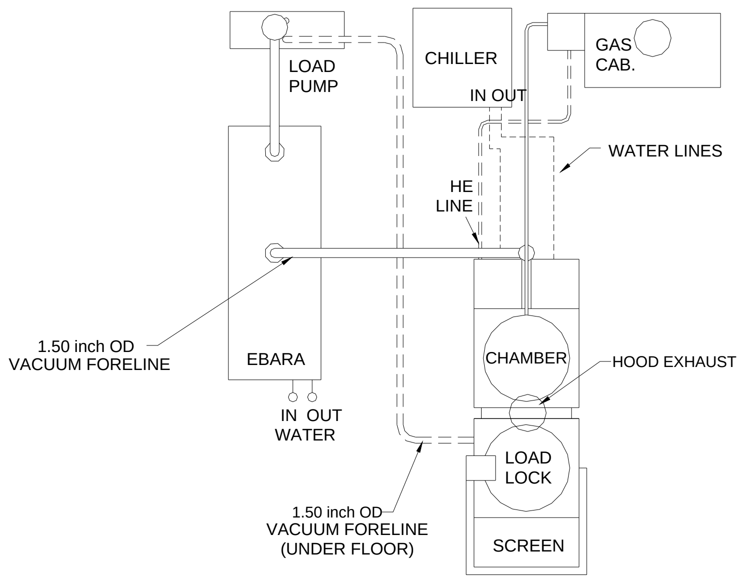


Figure 9. - System Layout

3. Use the flexible vacuum hose to connect the load lock vacuum valve to the inlet on load lock pump. Since the line is flexible the pump can be located anywhere that is convenient.

4. Connect the NW-40 stainless flex line to the outlet of the chamber-roughing valve.

5. Connect a solid 1.5” stainless section of pipe from the flex line to the inlet flange on the pump.

6. Mount the Pump Control NEMA box to the facility wall near the system.

7. Wire both the three-phase chamber pump and the load lock roughing pump to the contactors inside the Pump Control NEMA box.

8. After ensuring all circuits are de-energized, connect house power to the breaker inside the Pump Control NEMA box. This is three-phase, 208VAC with a ground and 20A service.

9. Connect the external gases to their appropriate inlets on the back of the system gas enclosure. These lines should be have 1/4" welded VCR fittings.

10. Connect house nitrogen to the inlet of the solenoid pack. Set line pressure to 80 psi.

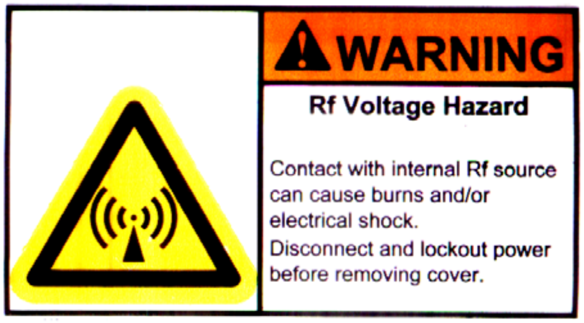
11. Connect the RG8 cable between OUTPUT on the RF Generator and the RF In on the RIE matching network. Connect the second RG8 coax cable from the outlet of the AE RF generator to the inlet on the ICP.

12. Connect the control cable between the process module and the USER port on the rear of the RF Generators.

13. Connect the 6" cabinet exhaust to the house exhaust. Connect the 1” chamber pump and load lock roughing pump exhaust to the house exhaust.

14. Plug AC distribution cord into wall socket with 208VAC, 15Amp, 3-phase service.

RF WARNING



This machine uses RF frequency power. Care should be taken in its use. DO NOT operate this machine with any RF component enclosures open. These components should be service by trained personnel only.

The frequency and power levels of the RF generators are as follows:

Advanced Energy RFG 3001 3000 Watts maximum power @ 13.56Mhz
Advanced Energy RFX 600A 600 Watts maximum power @ 13.56Mhz

PROCESS CONTROLLER OPERATION

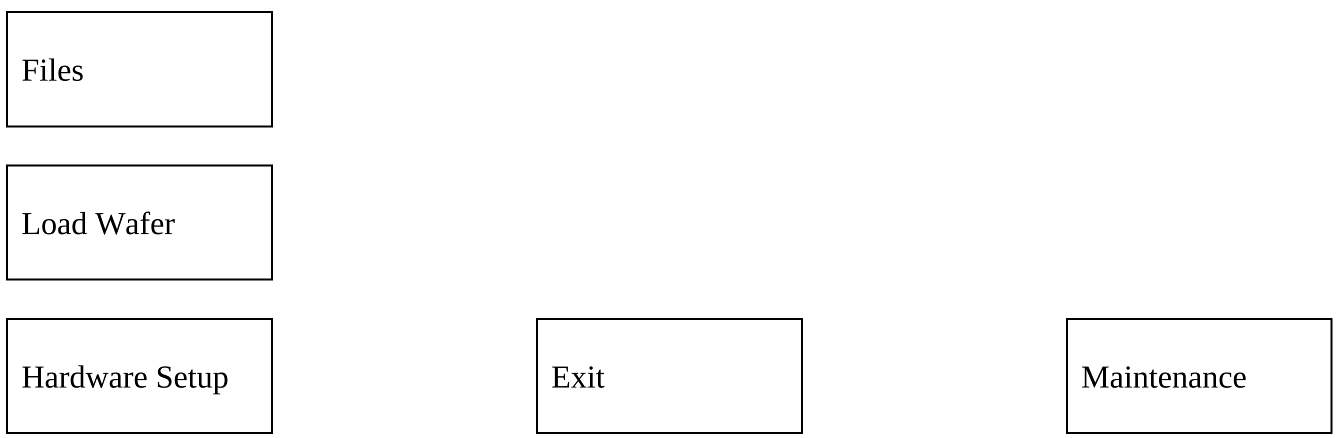
INTRODUCTION

LabView is a Windows based application that controls the I/O for the Minilock-Phantom III system. It is run on a Pentium based industrial PC.

The code starts up when power is supplied to the Minilock-Phantom III by pressing the ON button on the lower left front bar. The control software consists of a number of panels, or screens that will be described here in the order that they appear.

MAIN PANEL

When the machine is first brought up from no power, the Main panel will display 6 buttons;



In order to initiate a process, a recipe file must first be obtained from either the hard disk or a floppy. This is done by touching the Files button.

FILES PANEL

When this panel opens up, the current recipes on the hard disk located in the C:\RECIPES directory are displayed in the main boxes (or buttons). If you wish to retrieve a recipe from a floppy, touch the Floppy button on the lower portion of this panel and those recipes in the root directory of the floppy will then be displayed in the above boxes. Touching the Hard Drive button will of course, redisplay those files from the hard disk.

To load the desired recipes, simply touch the button labeled with the file name you want. After a second or two, the Save button will become visible on the bottom of this panel and a message in the upper right will confirm the current selected recipe file name. Touching the Exit button will keep this recipe and return you to the Main panel.

There currently are only two methods of modifying recipes. The first is to use the buttons in the Manual Process panel described below. The other method is to Exit the Main panel, which will return you to the Windows environment with the Program Manager on the screen. From there, go back to DOS and change directory to C:\RECIPES and examine the contents. All recipe files have the filename extension .PGM.

To modify an existing recipe, simply Edit the file (they are in ASCII format). The recipe is grouped by steps and the process variables for each step can be changed with a simple text editor. A zero time entry in the Etch Time field will tell the software that the previous step is the last step to process. For example, if the Etch Time entry for step #2 is zero, then the program only processes the first step.

The only way to create a new recipe file is to enter DOS and copy an existing file to a new filename and then edit the process variables.

To re-enter the software from DOS, simply type WIN at any DOS prompt.

Once a recipe has been loaded and the Exit button has been touched from the Files panel, the Main panel will now have two additional buttons;

Files	Manual Process Control	Automatic Process Control
Vent Chamber		
Hardware Setup	Exit	Maintenance

To run a process in the manual mode, or to program in the process variables for a recipe, touch the Manual Process Control button.

MANUAL PROCESS CONTROL PANEL

The manual process panel displays all process variable set points and the corresponding reads. In addition to this, buttons on the bottom of the panel allow the User to selectively turn on and off vacuum, gas flow, and RF power. Buttons disappear when they are not allowed to be used in a particular sequence.

In order to change the value of a process variable, simply touch on that variable's Set point value box. A keypad will pop up for numeric data entry for the variable. Remember, any changes made to the process will only be kept until a new recipe is read in. In order to permanently save your changes to the current recipe file, you must go back to the Files panel and touch the Save button.

The “AIM GAUGE” button on the upper left of the screen turns on and off the AIM high vacuum gauge. The gauge can only be activated when the chamber pressure is below 10 mTorr and with the Vacuum On and Pressure On buttons on (or green). A few seconds after the gauge is turned on, then the “AIM READ” value will show the vacuum level in Torr, not mTorr.

The manual control panel has numerous buttons on the bottom of the panel. The Previous Step and Next Step buttons allow you to move to different steps within the recipe.

The Exit button will shut everything off and return you to the Main panel.

The Vacuum button opens the reaction chamber roughing valve and pumps down the chamber only. As the button is pressed, it shows you which state the valve in is, either On or Off. The Pressure button merely opens the Baratron isolation valve. After this is on, the reading for pressure on the upper left screen will show the current chamber pressure in mTorr.

Only after the Vacuum and Pressure buttons have been activated will the button for Gas come on. When you touch the Gas button, the gases that have been set to a non-zero value will begin to flow into the chamber. The exception to this is if either oxygen or nitrous oxide and diborane or phosphine are attempted to flow together. In either case, the diborane and/or phosphine will automatically shut off. This is controlled by the circuitry in the Gas Compatibility & Interlock box.

At this point the turbo pump will engage and the throttle valve will begin to regulate pressure to the value set. Turning off the gases is achieved by touching the Gas button again or by touching either the Pressure or the Vacuum buttons. This is to ensure that no gas flows unless the chamber is being pumped on. Changes to gas flows, or any process variable, can be made at any time during manual operation by simply touching the Set point valve and entering new data. Also after the Gas button is on, the Load and Unload Wafer buttons disappear so that you cannot perform those functions while gas is flowing.

The RF button becomes visible once the gases are flowing. When activated, the RF power is applied to the ICP and a plasma is generated. The etch timer will count up from zero. The RF power will NOT automatically turn off, no matter what the Etch Timer set point is. You must touch the RF button again to shut off the plasma. Turning off the gases or vacuum will also shut off the RF power. The reading for the Reflected Power is also displayed.

AUTOMATIC PROCESS CONTROL PANEL

This mode of control has the computer run the entire process (up to 16 different steps). This includes pumping down the chamber to a base pressure, turning on gases, adjusting pressure and turning on the RF for the requested Etch time. The etch timer will count down in the Automatic mode, which is different than the manual mode. Unlike the Manual process panel, the process variables are not changeable in this panel. The only button active here is the Abort button. This will shut everything off and return you to the Main panel.

If the pressure in the chamber cannot reach the base pressure set, then an error message will come up stating this and the process will abort. This is to prevent flowing gases when the chamber pressure it too high and a possible leak, or faulty pump, is present.

HARDWARE SET-UP PANEL

This panel can only be accessed by certain personnel with the proper pass code. The buttons on this panel allow certain settings to be changed for each system. The current values have been set by Trion and should not be changed without first consulting with Trion.

Once the user enters the hardware setup panel, there are additional buttons for setting up various parameters for the system.

Initialization:

As the system initializes, if first homes the robot and then closes the reactor gate. Then it opens the chamber-roughing valve as the turbo is spinning up to speed. After 15 seconds the pressure isolation valve opens and the computer reads the chamber pressure. If it is not below 100 mTorr, then an error message is displayed on the screen. If the chamber pressure is below 100 mTorr, then the pressure isolation valve closes. All other valves are closed.

Manual Process Control:

When this screen is first entered every valve is closed except for the load lock turbo isolation valve. The reactor gate is closed and the chamber-roughing valve is closed also. The user has control over the roughing valve via the “Vacuum Off” button. When the user exits this screen, all valves are closed except for the chamber roughing valve and the load lock turbo isolation valve. This is in order to keep the chamber under vacuum and keep the chamber turbo pump up to full speed.

Automatic Process Control:

When entering this screen the chamber-roughing valve is opened along with the load lock turbo isolation valve. The computer-controlled sequence continues as described in the software control section. When either the process ends, or the “ABORT” button is pressed, all valves are closed with the exception of the chamber roughing valve and the load lock isolation valve.

EXIT PANEL

When the User presses the Exit button from the Main panel, a window will pop up asking the User if he/she is sure they want to exit the software. Touching OK will shut all solenoids and return the User to the DOS environment. To return to the LabView® software, either type WIN at any DOS prompt or cycle the AC power to the system.

MAINTENANCE

Like the Hardware Setup Panel, the maintenance panel is accessible only by trained personnel with the proper pass code. The functions on this panel allow the User to have a fine level of control over most aspects of the system, but do not have any logic to prevent non-sequential events. Therefore, the person using these panels must be trained and understand what each function does so as not to damage the system.

START UP PROCEDURE

After the machine has been properly installed, you can begin operation in the following manner:

1. Ensure that the reactor lid is closed.
2. Turn on the vacuum pumps by pressing the “PUMP” button from the front console.
3. Verify the pneumatic nitrogen supply is at 80 psi.
4. Turn on the main power by pressing the “ON” button from the front console.
5. Verify that the RF generator display and the computer console are lit.
6. Ensure that process gas bottles are open and their outlet pressure is adjusted to 15 psi.

The system is now ready for use. The software will automatically load and initialize the hardware. Following the procedures outlined in the Process Controller section above to run a sample.

VACUUM CHECK

When first starting a machine it is always advisable to check the vacuum integrity of the process chamber.

1. Enter the Manual Process Control panel.

2. Turn on “Vacuum” button so that it is green.

3. Wait 15 seconds.

4. Touch the “Pressure” button so that it turns green.

5. Monitor the chamber pressure on the left hand display, it should fall below 100 mtorr in less than 30 seconds.

6. Wait until the pressure has stopped decreasing and that any moisture present in the chamber has had time to outgas.

7. Note the base pressure.

8. Turn off the “Vacuum” button. The main vacuum valve is now closed, if the system has a leak the pressure will slowly rise in proportion to the size of the leak. The system pressure should not rise more than 15 mTorr/min over 5 minutes.

TYPICAL PROCESS CONDITIONS

Since the composition of semiconductor materials vary widely between companies; etch and deposition processes also vary. However, a good set of operating conditions can be developed by starting with the following typical conditions and varying them to suit your individual needs.

The following table is used to explain the basic trends involved with basic plasma processing of different materials.

Increase in Process Variable Condition	Etch Rate	Anisotropy	Pressure
Pressure	Increase	Decrease	-------
ICP Power	Increase	Decrease	No effect
RIE Power	Increase	Increase	No effect
Gas Flow	Increase (slightly)	No direct effect	Increase

All etch recipes include an ICP, if you system does not include an ICP disregard the ICP power setting and keep all other variables constant.

Silicon Dioxide (SiO_2)

IE Power	50 watts
ICP Power	300 watts
Pressure	50 mtorr
Gases	CHF_3-47sccm, O_2-3sccm
Etch Rate	1000Å/min

During a skeleton etch the following problems can occur: aluminum grass, polymer grass, gold grass and lifting. Photos of the different conditions are shown in the technical papers included in the manual.

To avoid aluminum grass, remove the oxygen from the process recipe. Aluminum grass is formed by a combination of oxygen, fluorine and aluminum. If you want to learn more about aluminum grass please refer to included technical papers.

To avoid polymer grass, lower the pressure to 25mtorr or below. Oxygen can also be added to remove the polymer grass although it is not recommended because the oxygen may cause aluminum grass to form.

Gold grass occurs in package parts when the leads are not properly masked. The gold grass is caused by re-deposition of sputtered gold. The only solution to this problem is to mask all the gold.

Lifting of aluminum lines is an indication of undercutting or an isotropic etch. This can be fixed a number of ways. The first solution is to lower the pressure. If this doesn't solve the problem increase the RIE power and lower the ICP power. It is important to make sure the sample does not become hot. Ensure that the piece is in good contact with the aluminum chuck.

Silicon Nitride – Si_3N_4

RIE Power	100 watts
ICP Power	0 watts
Pressure	250 mtorr
Gases	SF_6-45sccm, O_2-5sccm
Etch Rate	2500Å/min

Any Fluorine containing gases can be used. Sulfur Hexafluoride is preferred due to its selectivity to SiO_2. Increasing the ICP power will increase etch rates significantly.

Polysilicon or TiW

RIE Power	100 watts
ICP Power	0 watts
Pressure	300 mtorr
Gases	SF_6-50sccm
Etch Rate	5000Å/min

Polyimide or Photoresist

RIE Power	100 watts
ICP Power	250 watts
Pressure	150 mtorr
Gases	O_2-45 sccm, SF_6-5sccm
Etch Rate	10000Å/min

If you do not wish to etch into the passivation layer, the SF_6 can be eliminated. In eliminating the SF_6, the pressure needs to be lowered to 30 mtorr to ensure a clean etch.

Aluminum

RIE Power	75 watts
ICP Power	0 watts
Pressure	180 mtorr
Gases	BCl_3-30 sccm, Cl_2-30 sccm, CH_4-2sccm
Etch Rate	1000Å/min

The CH_4 is not necessary but ensures a smooth sidewall passivation on the aluminum. To increase the etch rate, increase the Cl_2 amount. Be sure to rinse the wafer after processing because the residual chlorine will combine with moisture in the atmosphere to form small amounts of HCl.

SYSTEM CLEANING

The RIE reactor should be cleaned every day by running the CLEAN recipe given above. The clean time should be at least 10 minutes. The chamber will occasionally need to be hand cleaned. This is performed as system maintenance as described below.

SYSTEM MAINTENANCE

GENERAL

The Trion Minilock-Phantom III was designed in a highly modular form. There are eight fundamental modules:

1. The AC Distribution Module
2. The Process Control Module (Computer)
3. The RF Generators
4. The Reactor
5. The Load Lock and Robot
6. RIE Matching Network
7. The Chamber Vacuum Pump and the Load Lock Vacuum Pump
8. The ICP

Each of these modules has been designed for easy removal. This design concept eliminates the necessity of field repair work on the component level.

MODULE REMOVAL

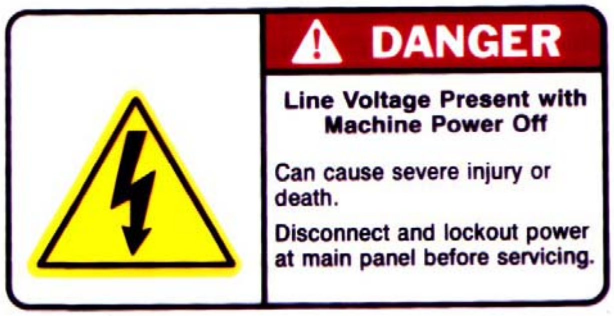
If a module has become faulty or damaged it can easily be exchanged with a new one. However, the following modules should only be removed and replaced by trained TRION TECHNOLOGY personnel:

- ICP
- RIE Matching Network
- Process Controller
- Robot

All other modules can be removed by any trained maintenance personnel on site and replaced with new or loaner units from Trion Technology. The general procedure for removing any module is the following:

1. Turn off the system power by pressing the EMO button on the front panel.
2. Disconnect any cables to the module.
3. Disconnect any water coolant hoses to the module and secure loose hoses so that they do not spill water over the equipment.
4. Unplug the module's power supply cord if applicable.
5. Remove any mounting bolts from the system and slide the module out.
6. For pumps, disconnect the inlet and outlet lines and use 2 people to lift or move a pump.

AC DISTRIBUTION



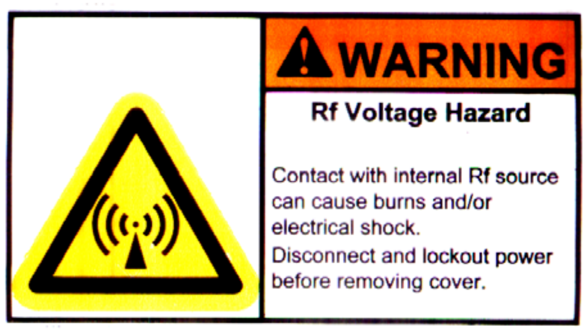
ONLY TRION TECHNOLOGY PERSONNEL SHOULD EVER WORK ON INTERNAL COMPONENTS TO THIS MODULE.

The AC Distribution module contains two basic components, the breakers and the AC relays. Since the entire unit is riveted closed, it should be removed and returned to Trion in the event of a failure. A replacement module will be sent out immediately.

PROCESS CONTROL MODULE

In the event of failure, call the TRION TECHNOLOGY service department to schedule a visit to replace this module. If the system is out of warranty or faster service is required (as if overseas) then the computer can be removed and replaced by the customer. To do this, follow the general guidelines above, paying particular attention to the proper locations of each instrument cable.

RF GENERATOR

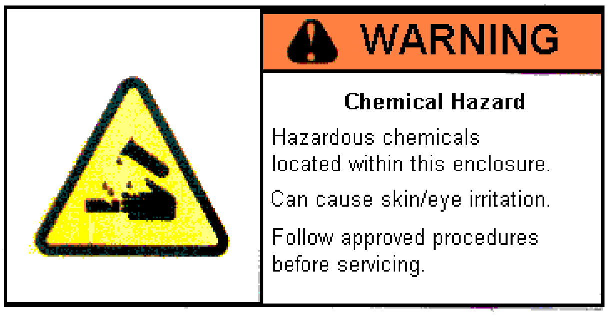


The RF Generator is a self-contained unit and should only be worked on by trained personnel. In the event of failure, disconnect the unit and send it to TRION for repair. Loaner modules are available.

REACTOR

The Reactor does require periodic, physical cleaning. The frequency of the cleaning will depend upon the process used and the frequency of use. Contact a TRION service engineer to determine how often the reactor should be cleaned. The cleaning procedure is similar to cleaning laboratory glass wear, the procedure is as follows:

Trace amounts or organic and fluorinated compounds may be present in the reactor after plasma cleaning. The physical cleaning of the chamber should be performed in a ventilated room. Gloves and eye protection should be worn.

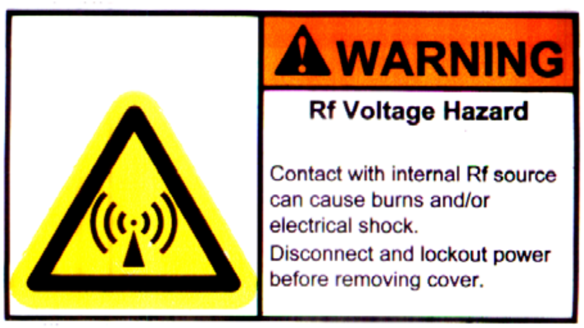


GLOVES MUST BE WORN BY MAINTENANCE PERSONNEL!

1. Run the preprogrammed plasma CLEAN process.
2. Vent the chamber to atmosphere and open the lid.
3. Scrub any hard to remove deposits with an abrasive pad.
4. Wipe out the chamber with DI water on a chem wipe.
5. Wipe out the chamber with Isopropyl Alcohol on a chem wipe.
6. Close the lid and rerun the CLEAN process again.

Any gloves and wipes used may be contaminated with IPA and/or deposition by-products and should be disposed of in accordance with local regulations.

RIE & ICP RF MATCHING NETWORKS



The RF matching networks on both the ICP and RIE are self contained and sealed assemblies bolted to the system. These modules should only be worked on by trained TRION TECHNOLOGY personnel. In the event of failure, remove the sealed module and send it to Trion Technology.

VACUUM SYSTEM

The TRION Minilock-Phantom uses a corrosive series fomblinized pumping system. This system is relatively maintenance free, and should only require periodic changing of the inlet dust filter and oil. If your pump was purchased from TRION TECHNOLOGY, reference the manufacturer's vacuum pump manual contained in this manual.

GLOVES MUST BE WORN WHEN FILLING OR CHANGING PUMP OIL!

Gloves and any wipes that are used may be contaminated with Fomblin or Krytox pump oils and must be disposed off in accordance with local regulations.

PERIODIC MAINTENANCE SCHEDULE

Below is a table of TRION'S recommended periodic maintenance schedule.

Task	Description	Schedule
Chamber Plasma Clean	O2 "CLEAN" recipe for at least 600 seconds	Daily
Chamber Hand Clean	Wiping inside of chamber & lid with DI water & light ScotchBrite. Cleaning with IPA and running O2 clean plasma	Bi-Monthly
O-ring Inspection	Remove, inspect and re-grease all o-rings (replace as necessary)	Yearly
Pump Oil Level	Check sight glass on chamber and load lock roughing pumps for oil level. Should be within marks. Fill as needed	Monthly
Pump Oil	The oil in both load lock and chamber roughing pumps should be replaced with new Fomblin YVAC 06/6.	Yearly