

Unaxis 790 Series RIE Silicon Plasma Processing System Users Manual



Coral name:	Unaxis RIE 2
Model:	Unaxis 790
Location:	Nanofab, Building 215
Contact:	nanofab_dryetch@nist.gov
Revision:	1.0

OVERVIEW:

- The 790 series RIE (reactive ion etcher) is used to etch various materials, such as silicon dioxide, silicon nitride, and various polymers from the surface of a substrate using several reactive gases in a RF (radio frequency) induced plasma.
- RIE combines plasma and ion beam removal of the surface of a substrate. The etching gas (as in plasma etch) enters the reactive chamber and is ionized by the application of an electric field such as RF. Individual gas molecules are accelerated to the substrate surface. These charged particles remove the top layer of the material by the combined efforts of mechanical and chemical reactions. This process often has high selectivity to the etched material (some materials will etch much faster than others), but the etch is isotropic.
- The RIE uses O₂ (oxygen), N₂ (nitrogen), SF₆ (sulfur hexafluoride), CHF₃ (trifluoromethane) and N₂O (nitrous oxide) as etching gases. The flow rate for each gas is set by a mass-flow controller (MFC), and the pressure is controlled separately by a butterfly valve between the chamber and the pump. The maximum RF power is 500 W. The control program has both manual and automatic modes. You can program frequently used sequences and run them in automatic mode.

SPECIAL NOTES OR RESTRICTIONS:

- Must be qualified to use tool by super-user.
- Substrates allowed in tool include: Si, SiO₂, glass, sapphire, mica, ceramic. Masking materials allowed in tool include: PMMA, PR, metals such as Al, Au, Ti, Cr, and W. Any other materials require permission from super-user.

SAFETY PRECAUTIONS:

To avoid contamination these practices must be followed

- Never touch any part inside the chamber or part going into the chamber with bare hands or contaminated gloves.
- Handle samples going into the chamber with gloves and/or tweezers.
- Load only clean substrates into the vacuum chamber
- When you leave the system for any length of time, especially overnight, make sure that the chamber is pumped down and **close the gate valve by clicking ON**.
- Never leave a dirty chamber for the next user. If your process leaves any flaky or colored deposits on the plates, clean them after you have finished. Use solvents or

plasma; in bad cases you may have to take the top plate out of the chamber and scour it with ScotchBrite, followed by a thorough rinse.

- Emergency shut off: In the event of an emergency, shut off the system power with the emergency power off button on the front of the system.

SYSTEM CONTROL OVERVIEW:

The system contains many electronic, electromechanical and pneumatic devices. Proper operation of these system devices is dependent upon three sequential control setting phases of operation by the operator. These control setting phases are performed in the following steps:

- System initialization
- Process Programming
- Process Operation

System Power On:

When the system is turned on, power is applied to the computer and the Boot up sequence is started. When the Power on Self Test finishes, the operating system is loaded into the memory. Once the operating system is loaded, Windows and System Monitor are started. The system goes through an on initialization. Once this is completed the operator is presented with the login dialog box. The default entry for operator and password is 2222. This can be changed in the configuration. After logging in, the operator has access to all functions assigned during the configuration.

System Status Group:

The system status group consists of the *ON*, *STANDBY* and *READY* button legend pairs. The *ON* indicator will only light when all necessary system equipment is turned on and there are no system failures. The *ON* button cannot be used to turn equipment on, but may be used to exit a *STANDBY* or *READY* modes.

- The *STANDBY* mode of the system may be activated by clicking the standby button or pressing function key <F2>. The key will light to acknowledge the operator command. The system will be in the process of achieving the standby condition. Once the standby condition is achieved, the standby indicator will light. During standby the pumps are running and the heat exchanger is approaching the prescribed temperature.
- The *READY* mode means that the system is process ready. To enter this mode either *STANDBY* or *ON* should be lit. If any of the above button is lit on, clicking the *READY* button or pressing function key F3 while holding the <CTRL> key it will light to acknowledge the operators command and indicate that the system is in the state

of achieving the *READY* button. During the *READY* mode the system is at the prescribed temperature of the process program and all pumps used by the process is ready.

Process Group:

The process group consists of the *ABORT*, *END STEP*, *HOLD* and *RUN* legend/button pairs. The *RUN* button is used to start the system processing. When the system is processing, the *READY* and *RUN* legends are lit. The system will continue processing unless there is operator intervention by clicking the *ABORT*, *END STEP*, *HOLD* and *RUN* buttons or system intervention caused by a failure.

- During processing, the computer may suspend operation because of an equipment failure or compliance error. The system will be in a *HOLD* state with the *HOLD* button active. The operator may request that the machine re-establish conditions and try again by clicking the *HOLD* button or pressing the function key <F6> while holding the <CTRL> key.
- During processing, the *END STEP* button may be used to request an exit from an autohold state. This is only allowed when the process has reached the required state in the process and is just holding the condition.
- The *ABORT* function should be used with caution during processing since it will cause all processing to terminate. *ABORT* will take the system to the *READY* condition. It is used to terminate many functions in maintenance, programming and menu operations.
- During the process-run mode the abort button triggers an alert screen which gives the operator a chance to skip the *ABORT* and return to processing.

Run Process Switch Operation:

At the bottom center of the screen are the process buttons. During the *RUN* mode, only the process and *ALARM* buttons are recognized.

- **ABORT:** This key is used to exit the *RUN* mode regardless of what is presently occurring. The system will normally return to the *READY* mode or the *EQUIPMENT-ON* mode if aborting under error conditions. When the *ABORT* button is pressed the screen will display two options *YES* and *NO*. Select according to the situation.
- **HOLD (USER ACTIVATED):** Pressing the *HOLD* button requests the machine to hold (all gases RF and pressure control are turned off).
- **HOLD (Machine Activated):** The system is always put in a *HOLD* condition when an error is detected. After analyzing the problem, press the *HOLD* button to

deactivate it and the machine will try to continue from the point at which an error occurred.

- **END STEP:** By activating this key, the operator activates the termination of the current step and the system proceeds to the next step.

COLD START PROCEDURE

The following procedure can be used for the start up for a 790 System from a cold start, a power failure or an emergency off event:

1. Verify the operational status of all system utilities (eg compresses air, nitrogen, cooling water, ac power)
2. Switch wall mounted disconnect switch which is located on the wall on the left side of the RIE chamber to the ON position.
3. Ensure that all individual circuit breakers are in the ON position.
4. Depress the green MACHINE ON BUTTON ABOVE THE BREAKERS. The white light will illuminate indicating machine power.
5. Turn the chiller for RIE which is located at the back of pumps on the extreme right ON by turning the ON-OFF Switch On and then pressing the start/stop button which is on the right hand side of the switch
6. With machine power ON the core is powered. The core includes the control system, main frame power and the heat exchanger. At this time the computer, CRT and all front panel instruments should be ON.
7. To turn on the mechanical pump, depress the green MECH PUMP on button. The mechanical pump should start. This switch can only be activated after the MACHINE button has been activated and machine power is ON.
8. The control system will boot up and present a log in request. To log in use the appropriate two passwords and enter the control system. At this time the ON MODE utilities menu can be used to power up the turbo-molecular pump if one is present.
9. When the mechanical pump has been activated the turbomolecular pump can be turned on from the Utilities menu by clicking the Pump-On option

After a machine warm up period to permit the electronics to reach operating temperatures the machine is ready for routine operation.

OPERATION: Cleaning and Seasoning of the chamber

- Make sure STANDBY is on. If not click on the STANDBY button.
- Before performing any instructions make sure the chamber is in vacuum. If not go to Utilities, click on PUMP DOWN CHAMBER.
- Run Cleannie.prc if the person using the RIE tool before you has not done it or if you are not sure about it.
- Select LOAD under process menu and click twice on the cleannie.prc file to load the process into active status. Click READY and then RUN to start the cleaning program.
- After the process sequence is complete, a dialog box will appear stating that the process is complete. Select OK.
- Do seasoning of the chamber. Go to Process menu and Run your recipe with no wafers inside. Repeat the same procedure as you did it for cleaning process but now the program to be run will be your process recipe.

To Load the Samples

- Click Utilities ? Vent. Wait for 1-2 minutes
- Open the chamber and load sample(s).
- Close the chamber.
- Click Utilities ? Pump Chamber, then quickly go to the machine and press down HARD on the cover for a few seconds until the picture turns red. (This is to seal the O-ring so that pump can pull vacuum).

To run system in manual mode

- Make sure STANDBY is on.
- Click Service ? Manual Mode.
- Enter parameters. (If parameter is not accepted, it's out of range. For example, maximum flow rate for O₂ is 44 sccm).
- On top of the screen, click Gas On and Pressure On.
- Wait until all parameters stabilize and all boxes turn blue.

- Click RF On.
- After it's finished, click Exit in upper right corner.

To run a program

- Make sure STANDBY is on.
- Click Process? Click Load and select a program file. Make sure the process name appears in the box in lower right corner of main screen.
- On bottom of screen, click READY, then Select Run to start the process.
- If you desire to stop the process before its completion just click ENDSTEP. This will stop the process wherever it is and the remaining purge and evacuation steps will be completed.

Process Completion:

- After the process sequence is complete, a dialog box will appear stating that the process is complete.
- Select OK. Select "Vent" under the utilities menu
- After the chamber vent, lift the chamber lid and unload the sample with tweezers.
- Place the sample on the quartz boat to cool before putting in plastic holders.

Pump down chamber:

Select Pump Chamber from the utilities menu and hold down the lid to ensure vacuum seal.

Cleaning Program:

Once you are done with your etching recipe, RUN a cleannie.prc program by following the above procedure for cleaning.

Log Out of System:

Select Log out under the utilities menu and ensure that the Log in box appears on the screen.

Recipes

Overview

In general, your recipe should have four steps: an initial step, two process steps, and an end step. The initial step evacuates the chamber, removing the air inside, and brings the chamber walls to the process temperature. The first process step performs your process without RF power for about 30 seconds. This fills the chamber with the process gases and removes any remaining air from the chamber before the actual process starts. It also allows the chamber pressure and gas flows time to stabilize. Because the RF power is off, no processing will actually take place during this step. The second process step performs the process.

Instructions

From the **Process** menu, choose **Build** to create a new recipe or **Edit** to edit an existing one.

A list of the recipe steps will be displayed on the right side of the screen. To edit a step, double click on it. To create a new step, select the step that will go after the new step and click the appropriate button for the type of step you want at the bottom of the screen.

Initial Step

All recipes start with an initial step. This step will evacuate the chamber and bring the chamber to the desired operating temperature.

Set the pressure to 50mTorr and set the time to 30 seconds. This will cause the system to evacuate as much air from the chamber as possible before starting the process. Do not attempt to use pressure setpoints below 50mTorr. The chamber will be evacuated as much as possible regardless of the setpoint.

Set the temperature to your desired process temperature. Note that the temperature is measured in degrees Celsius.

You may describe your recipe in the Description box. The first few words will be displayed by the filename when you are loading your recipe.

Process Step

You will usually want two process steps. They should be identical with a few exceptions. The process step dialog box has five major areas: time, temperature, pressure, gas flow, and power.

Time

The first process step should be set to "Fixed Time" This step will be used to stabilize the chamber conditions. The time for this step is not critical, but 30 seconds is sufficient.

The second step will actually perform your process. If you set it to "Variable Time" you will be prompted for the process time each time you run your recipe. This is usually more convenient than editing the recipe each time. However, you can set the process to "Fixed Time" and set the time here if you prefer.

Temperature

Set the temperature to your desired process temperature for both process steps. Note that this should probably be the same as the temperature set in the initial step.

Pressure

Set the pressure to the process pressure you want for both process steps.

Gas Flow

Set the flow rate for each gas here. The flow rates are given in sccm (standard cm³/min). The flow rates should be the same for both process steps.

Power

Leave the power set to zero in the first step. Set it to the power you want for your process in the second process step.

Purge Step:

- The Purge Step allows the chamber to be backfilled with the gas plumbed to the purge inlet. Data entry permits control of the pumping configuration, chamber pressure of the RF.
- The purge flow is controlled by a needle valve located in the gas cabinet. Use of the purge step should, therefore be limited of cases where accurate control of the gas flow is not necessary. Such cases may include cleaning operations, post-etch resist strips and substrate treatments and passivations, either before or after processing.

Process Item	Remarks
Description	Used during Process list to describe the Process

Pump	Enter the desired Pump
Purge time	Enter time in minutes and seconds
Pressure	Enter Pressure in mTorr
RF control	RF1 or RF2

Evacuation Step:

- The Evacuation step pumps the chamber to the base pressure. The desired base pressure, the pumping configuration and the duration of the step are user programmable.
- A chamber evacuation may be useful in multi-step processes, where gases from the previous step are incompatible with the next process gases to be introduced into the chamber or where gas residuals can cause shifts in the process performance.

Process item	Remarks
Description	Used to describe the process step
Pump	Enter the desired pump (Generally LOVAC)
Time	Enter time in minutes and seconds
Pressure	Enter Pressure in mTorr

End Step:

All recipes have an end step that evacuates the chamber. Set the pressure to 50 millitorr and set the time to ten seconds. The automatic vent feature does not work properly and should not be used. When you modify a process, you only change the copy on the disk. If the process is already loaded, you will need to reload it for your changes to be reflected.

Shut down Procedure:

The following procedure can be used for the shut down of the 790 system for the weekend or the plant shut down.

1. After the desired vacuum status of the chamber has been established using the PUMP CHAMBER or VENT utilities, the system should be placed in ON mode by

clicking on the ON button in the lower left hand corner of the screen. This will close all system gate valves and prepare the system for shut down.

2. Before turning any switch off make sure the process chamber is isolated from the pumps. This is done by turning the isolation valve off by bringing the system in the ON condition.
3. The turbomolecular pump should be turned off by clicking Utilities and then clicking Pump off. This would make the turbomolecular pump off.
4. Turn the mechanical pump off by depressing the red button on the MECH PUMP switch.
5. Turn the chiller OFF by pressing the START/STOP button and then turning the ON/OFF switch OFF.
6. Turn off system power by pressing the red button on the MACHINE switch
7. Place the switch on the wall mounted disconnect box in the OFF position.