plasmatherm (EML)

STANDARD OPERATING PROCEDURE

CORAL Name: Plasmatherm

Model Number: Shuttlelock System VII SLR-770/734

Location: EML

What it does: Deposits the following films via Plasma-Enhanced Chemical Vapor Deposition (PECVD):

- Amorphous silicon
- Silicon dioxide
- Silicon Nitride

Removes the same films, as well as metals and photoresist, via Reactive Ion Etching (RIE)

Safety:

1. In case of emergency, hit the large RED button on the left side of the Plasmatherm and then notify staff.
2. This machine requires several sequences, like venting, stabilizing an MFC or reflected RF power, or pump-down, to be reached within a limited time period, which may be exceeded, caUsing a machine error to flash on the CRT.
3. Push the "hold" button to clear this error message, and make required adjustments.
4. Never reset (by pressing the "Hold" button) the reflected power more than twice, as damage to the machine may result.
5. Always wear gloves in EML; put new pair on before touching inside the chamber. Generally keep the loadlock closed, open only briefly: moisture or dust will drastically increase your pump-down times and alter results.
6. Select the turbo pump as "default pump" for RIE (right chamber), and the low pressure pump (no turbo) as default pump for the PECVD (left chamber).
7. All Toxics and flammables must be labeled "OPEN" when in use. The cylinders are "CLOSED" by MTL Staff in the evening and reopened in the morning.

Procedure: **Pre-run checklist:**

1. Engage the machine in CORAL to remove the "Gas Panel Off" interlock fault.
2. Inspect the handle wafer. If contaminated, discard that wafer in the sharps container and choose another one from the cassette box on top of the system controller (the cabinet with the CRT)
3. This wafer should be coated in a test run of whatever PECVD process you plan to run. If you plan to run an RIE process, the handle wafer must not have the same surface exposed that you are trying to remove. For example, if you plan to do an RIE process to etch silicon, the handle wafer must have a coating of either oxide or nitride. The silicon cannot be exposed to the plasma, or the etch rate will suffer.

Notes-PECVD: Chamber 1

Before running your devices, you should do a 5 or 10 min dummy run of the film you plan to deposit without any samples present (only the handle wafer) prior to your actual run. This is to condition the chamber.

When done w/ PECVD, you must do a chamber clean. Look for the "Chamber Clean" disk. This recipe is comprised of a 20 min CF_4/O_2 process followed by an 8 min N_2 plasma as a defluorination step.

You MUST ensure the chamber is clean before leaving! This is only fair to the users that come after you.

Notes-RIE: Chamber 2

A. Before starting an RIE run, look at the most recent RIE user's run sheet to determine what chemistry they were Using. If their process was different from yours, you should do a 5 or 10 min dummy run with your chemistry without any samples present prior to your actual run. This is to reduce the contamination from their process onto yours. If their process was similar to yours, you don't need a conditioning run.

   If you use Ar and Cl, you may use the Alumina susceptor in the acrylic box instead.
B. Helium Cooling of RIE Substrate

This tool has the capability of cooling the substrate during RIE runs. This is especially important with longer run times when resist can get damaged due to excessive heating.

The Helium Cooling Panel is located below the RIE chamber, at knee level. The Helium Cooling capability is manually operated, and not automatic. Labels tell you which switch to turn On during the Process Steps of the recipe (as opposed to the Pumpdown, Purge and Evacuation Steps.)

Helium flows at 4 sccm (displayed on the left readout). The pressure should be in the range of 2-5 Torr (displayed on the right readout).

Operating Procedure:

1 Startup

Check active chamber in CRT, which will be highlighted by a white bar. Left Chamber=PECVD, Chamber 1. Right Chamber=RIE, Chamber 2.

If a process has been completed, the Ready and OnLine lights will be lit.

To change to the other chamber:

Press in this order:
Standby
On (you'll hear a loud pneumatic release)
Menu
On the Tool Screen, Select Active Chamber,
Use the arrow key to select PECVD (Ch 1) or RIE (Ch 2)

Screen will display “Chamber 1 or 2 is selected”.

It may also display “Recipe is not for selected chamber”. If this is displayed, you will need to load your program. See Section 3 below.

The chamber may need to be pumped down. If so, press in this order:

Ready
Menu
Select "Pump Chamber"
Select "Low Vacuum Pump" for CVD or "Turbo" for RIE

Check Loadlock Process indicator. If not at atmosphere press Vent

2 Loading a Recipe From Disk and Reviewing It

Once pumped down, insert the disk with your desired recipe into the floppy drive.

Press in this order:

Standby
Program
The security code is 3333

Choose Load from the options displayed.

To review the recipe, press Review. Use the down arrows to step through it. The expected values for the Basic Recipes are shown in the Appendix. After reviewing the last step, press “Ent”.

Note: If the disk fails to read, in other words, if the green floppy drive light stays on for more than 60 seconds, see the Troubleshooting Section.

3 Editing a Recipe

The steps below pertain to Editing an existing recipe. To create a new recipe, or learn more about how recipes are constructed, see Section 6 Creating a Recipe

Press Standby
Press Program
Enter the security code: 3333

The options displayed are: Build Edit Load Save Review Exit

Select Load to load the recipe from the disk. It takes a few seconds to read the disk.
Select Edit to review the recipe. The recipe steps will display as a list.

The options displayed are: Program Flow Edit Step Insert Step Delete Step Exit

Select Program Flow. Use the Up Arrow and Down Arrow to move up and down the recipe to select the step(s) you want to edit.

When pointing at the desired step, press the ENT button then select Edit Step

You can make changes to:

- Gases used
- Gas flow rates
- Pressure
- RF power On/Off
- RF Power level
- Step Time

Once changes are made, select Exit

To Insert a Step:

Place the cursor below the desired insertion point. You can insert the following types of steps:

Process Purge Evacuation Pumpdown Unload Load

To save the changes to the floppy disk:

- Make sure the Write-Protect switch on the floppy disk is Off (You can see through the little box if Write Protect is Off. If the window is blocked, then the Write Protect is On.)
- Select Save
- Select Exit

4 To Run a Process

To run, press Ready, then Run. Online should already be lit.

Be sure to fill in the Process Logbook completely.

If the process fails to run automatically, see the Troubleshooting Section.

RIE Processes: Remember to turn On the helium cooling circuit at the start of the Process Steps, and Off when the Process Steps end.

5 Completing a Recipe, Securing the Tool:

After finishing processing, including test runs and Chamber Cleans, simply unload your samples and latch the Load Lock.

Remember to run a Chamber Clean on the PECVD chamber. There is no chamber clean for the RIE chamber.
The loadlock usually sits at atmosphere when the tool is Idle.

6 Creating a Recipe

Background

A typical recipe sequence for either chamber may be:

- Choose the process temperature*
- Load the wafer into the chamber
- Optionally allow time for the sample to reach temperature after loading
- Purge the chamber
- Evacuate chamber to base pressure
- Flow process gases without RF for 1 min, to allow system environment to stabilize
- Flow process gases with RF on, the actual process step
- Unload, optionally pump to base pressure
- Optionally Evacuate the chamber
- Optionally Purge the chamber
- End step, including turbo chamber pump-out. Do not clean out the lines, do vent at the end

* Only the PECVD chamber can control to a temperature, in the range of 150-300C. Climbing to 300C is very slow, on the order of 1 hr. Idle temperature is 200C.

The RIE chamber allows for selection of a substrate temperature, but in fact there is no heating capability. When creating an RIE recipe, set the temperature to 200C to avoid having to needlessly wait for the temperature to change in the PECVD chamber, which will have absolutely no bearing on your RIE process.

Example

This example is an RIE Oxide Etch program, which is similar to etch programs in sequence, but not in chemicals or flow-rates. A small amount (~3 sccm) of CF_4 (HC-14, RIE gas #6) for SiO_2 removal, can be used in addition to O_2 (~30 sccm, RIE gas #5), but may not be needed. If you want to process at a pressure lower than 30mT, you may have to add a step to strike a plasma at 30+ mT, w/ a 1min termination time, followed by your actual process step with the lower pressure desired.

Press Standby & Program

- Select Build
  - Initial Data Step # 00 (basic parameters, chamber pump-out)
    - Program Build Chamber #2
    - Program Number: Enter any single digit
    - Temperature: 200C (see comments in Background section, above)
    - Default Pump: Turbo
    - Initial Pump down Pump: Turbo
    - Base Pressure (torr): ($1x10^{-4}$ or $5x10^{-5}$)
    - Hold After Base Pressure: Optional, normally Not Required
  - Purge Step #1: no RF – (30 sec-1 minute)
  - Evacuate Step #2: (30 sec-1 minute)
  - Process Step #03 (to flush gas lines, chamber)
    - Ch 5 sccm: 30 (Gas O_2)
    - Ch 6 sccm: 3 (Gas CF_4)
    - Pressure (mT): 30
    - Process Pump: Turbo
    - RF Generator Used: None
    - Termination Time: (30sec-1 min)
  - Process Step #04 (Etch Step)
    - Gases Ch 5 & 6, Pressure & Turbo same as Step # 01,
    - RF Generator Used: RF1
    - RF Configuration: RIE (for etch, PE for PECVD)
    - RF Controlled by: INCP (incident power)
    - RF1 set point (watts): 100 (Note: 300W is the Maximum)
    - Termination Time: Varies
  - Evacuation #05 (chamber pump-out)
    - Evacuation Time: (30 sec-1 min)
  - Purge #06 (N_2 Purge to flush chamber)
    - Purge Type: Normal
    - Time: (30 sec-1 min)
  - Unload #7
    - Pump to base pressure after Unload? No
    - Base pressure (torr): $1x10^{-4}$

        - Hold after base pressure? No

    - End Sequence #8
        - Gas Line Cleanup: None
        - Unload Wafer: Yes
        - Final Pump: Turbo
        - Base pressure (torr): 1x10 -4
        - Hold after Base Pressure? No
        - Vent Lock after Process? Yes

You may need to edit a step caused by a miss-type (sorry about the sticky keys!), and always review a program when done. To edit:

- Program Flow. Use the arrows to go to the step which needs editing, then hit "yes" and choose
- Edit. Follow prompts
- If you need to insert additional steps, select the step below the insertion point, then select Add Step

Variations for PECVD

- Pressures are typically between 200 and 900mT. The turbo is not available.
- The default plate temperature set point is 200C, appropriate for most work, which will be targeted when you turn on the heating element, the white breaker on the lower-left of the machine. If you want to run at higher temperature, like 300C, which can yield slightly better films, but with different deposition rates, your program will not target the higher temperature until it the recipe started. If so, include a long Hold After Base Pressure time, maybe 60 minutes, in the program to allow the correct temperature to be reached before starting.
- To cool to 150C, set a Hold After Base Pressure time of 20 min.

Appendix

Table of Basic Recipes

The recipes below are shown for reference. Run conditions may be modified temporarily for specific applications, but DO NOT OVERWRITE THE BASIC RECIPES STORED ON DISK.

If you would like a disk for your specific process, just ask for one.

Note 1: Always perform a test run to determine the current deposition rate. This run can double as the chamber conditioning run as described in the Pre-Run Checklist section.

Note: 2: As stated in the Pre-Run Checklist section, you must run a Chamber Clean when you finish Using this tool.

PECVD Processes:

SiO_2 Deposition. Typical Refractive Index: 1.46 in March 2012

Process Gases	150 sccm SiH_4
	600 sccm N_2O
Pressure, mT	500
Temperature, C	250
RF Power, W	25
Nominal Deposition Rate, nm/min	5
Run Time, min	10
Plasma Color	Purple

Silicon Nitride Deposition. Typical Refractive Index: 2.01 in March 2012

Process Gases	3 sccm NH_3
	100 sccm SiH_4
	600 sccm N_2
Pressure, mT	500
Temperature, C	250
RF Power, W	20
Nominal Deposition Rate, nm/min	8
Run Time, min	10
Plasma Color	

a-Si Deposition

Process Gases	150 sccm SiH_4
Pressure, mT	500
Temperature, C	150
RF Power, W	25
Nominal Deposition Rate, nm/min	5
Run Time, min	10
Plasma Color	

PECVD Chamber Clean

Process Gases	100 sccm CF_4/O_2 (20 min)

	100 sccm N_2 (8 min)
Pressure, mT	50
Temperature, C	200
RF Power, W	100
Nominal Deposition Rate, nm/min	N/A
Run Time, min	20+8
Plasma Color	Purple, then red

RIE Processes:

Note: As stated in the Pre-Run Checklist section, you must run a Chamber Conditioning Run before Using this tool.

Descum

Process Gases	35 sccm O_2
Pressure, mT	95
Temperature, C	200*
RF Power, W	100
Nominal Etch Rate, nm/min	??
Run Time, min	5
Plasma Color	Purple

Oxide Etch, Low Power

Process Gases	3 sccm O_2
	30 sccm CF_4
Pressure, mT	30
Temperature, C	200*
RF Power, W	100
Nominal Etch Rate, nm/min	26
Run Time, min	5
Plasma Color	Light blue

Oxide Etch, High Power

Process Gases	3 sccm O2
	30 sccm CF4
Pressure, mT	30
Temperature, C	200*
RF Power, W	200
Nominal Etch Rate, nm/min	74
Run Time, min	5
Plasma Color	

* 200C is programmed as the substrate temperature, even though temperature control does not exist for RIE.
See Section 7, Creating a Recipe, Background, for an explanation.

Silicon Etch

Process Gases	3 sccm O2
	30 sccm SF6
Pressure, mT	40
Temperature, C	200*
RF Power, W	200
Nominal Etch Rate, um/min	0.6
Run Time, min	5
Plasma Color	

Metals, Si Etch-1 (also known as Break Through Etch)

Process Gases	30 sccm BCL3
Pressure, mT	30
Temperature, C	200*
RF Power, W	200
Nominal Etch Rate, nm/min	30 nm/min Si
Run Time, min	5
Plasma Color	

Metals, Si Etch-2 (also known as Speed Etch)

Process Gases	20 sccm CL2
	20 sccm BCL3
Pressure, mT	30
Temperature, C	200*
RF Power, W	200
Nominal Etch Rate, nm/min	XX nm/min Si
Run Time, min	5
Plasma Color	

* 200C is programmed as the substrate temperature, even though temperature control does not exist for RIE.
See Section 7, Creating a Recipe, Background, for an explanation.

Non-Volatile Etch (for Ni, au, Pt, Pyrex, etc)

Process Gases	10 sccm CL2
	10 sccm BCL3
	10 sccm Ar
Pressure, mT	30
Temperature, C	200*
RF Power, W	300
Nominal Etch Rate, nm/min	XX nm/min Si
Run Time, min	5
Plasma Color	Whitish gray

* 200C is programmed as the substrate temperature, even though temperature control does not exist for RIE.
See Section 7, Creating a Recipe, Background, for an explanation.

Troubleshooting

Below is a list of common errors seen while Using the Plasmatherm, and suggested solutions to these problems.

Problem	Solution	Comment
Wafer fails to Load or Unload and alarm sounds You will see the Alarm light flash Red and hear a repeating beep. A comment will appear on the screen saying: "Sequencer Error Detected Arm cannot get into chamber position" or "Arm cannot get into home position".	Pressing the "Hold" button once or twice will load the wafer and clear the alarm.	
RF Reflected Power High	Pressing Hold will restart the RF Power Supply. Note: • Reflected Power is most often at its highest level when first running a test run or process. Here it may take 3 times to get the Reflected Power to pass. • If Reflected Power goes high in the middle of a run after being stable at the start, you need to pause 10 min to let the RF power supply cool down.	Usually seen when 300 Watts of RF power or more is selected.
System is frozen	Reset system by pressing the RESET button. This is behind a door at about waist-level on the system controller (the tower hoUsing the CRT)	You may need to restart the turbopump after resetting the tool. To do this: Press in this order: -On (you'll hear a loud pneumatic release) -Menu -Power Up High Vacuum Pump

		-Turbopump On

Troubleshooting, cont'd

Problem	**Solution**	**Comment**
Recipe fails to Load from disk. Disk drive appears to "freeze" with green light on.	Do the following: • Eject the disk • Reset the tool Using the Reset button. (SEE A STAFF MEMBER) • After resetting the tool, you may need to restart the turbo. Do this if the green light is NOT lit on the gray turbopump controller. To restart the turbopump, Press in this order: On (you'll hear a loud pneumatic release) Menu Power Up High Vacuum Pump Turbopump On	
Particles on the wafer after PECVD dep	Notify a staff member. This requires venting and manually cleaning the deposition chamber. Following the manual clean, do a: • 20 min Chamber Clean and inspect • 10 min SiO2 dep and inspect	

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