CORAL: RIE-Mixed-SAMCO-230iP

Location: Bay 6U, room 12-3110B
Purpose: Etching
Contacts: Bob Bicchieri, Eric Lim, Donal Jamieson

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Introduction

The purpose of the RIE-Mixed-SAMCO-230iP system is to etch semiconductor grade thin films using mainly either fluorine or chlorine containing gases. The RIE-Mixed-230iP utilizes high-density, inductively coupled plasma that is created using two RF power supplies. Additionally, the system utilizes a load lock chamber for faster sample loading, reduced etch chamber pump-down times and also to prevent accidental exposure to hazardous gases and etch byproducts. This tool has 11 process gases and is intended to be less restrictive than the RIE-F-SAMCO-230iP and the RIE-Cl2-SAMCO-200iP. Baseline recipes are set up to etch Silicon, Silicon Dioxide, Silicon Nitride, Silicon Carbide, Silicon Oxynitride, as well as graphene and other 2D materials. We can also work with users to develop etches for other materials. The temperature of the lower electrode can be changed anywhere from 10-200 C via the HUBER Controller, but the system idles at 20C. There is also a Horiba Optical Endpoint System (OES) which can possibly be set up when etching whole wafers.

Note: Chlorine Users must add an additional 30 minutes to their reservation just in case they have to run the chlorine clean recipe!
Note: Users operating at temperatures above 100C need to add additional time to their reservation so that the chamber has sufficient time to cool to 20C!

The system software runs through a web interface to the main computer. At the bottom of the browser window, there are 6 buttons that are always present:



Figure 1 screen navigation buttons

These buttons are how we navigate between the different screens for the tool. To run wafers, the important screens are **Jobs** (1), **System** (2) and **Recipes** (3).

The system has a secondary screen and number of buttons below the monitor:



Power On:	Re-energizes system after shutdown
Power Off:	Turns off the power to the system – only qualified staff should press this and only after the system has been placed in a safe state.
EMO:	Emergency Machine Off - Press if the tool is behaving dangerously, or making loud noises. **If you pressed the EMO, then do not attempt to re-energize the tool!**
BZ STOP:	Press this on the secondary screen to silence the machine



Safety

Hazards

Hazards present on system are high voltage, RF radiation, and pressurized gases. Ar, N2, CF4, and SF6 can displace oxygen and cause rapid suffocation, while CH4 and H2 are highly flammable, and O2 is a strong oxidizer and can cause or intensify a fire. There are corrosive gases as well: Cl2, BCl3, NF3, and HBr, these gases are irritants to skin, eye, nose and lung. Under normal operation the user is protected from these hazards by the tool panels and interlocks, and the Toxic Gas Monitoring System (TGMS). Do not attempt to open or remove any panels as you risk exposing yourself (and others) to these hazards.

Mechanical pinch/crush points exist with the loadlock lid and robot arm. Exercise care when loading/unloading samples and carriers from the loadlock.

User Qualifications and Responsibilities

During training you will learn to run wafers and edit batches. To be considered qualified you need to be trained by the staff in charge, be up to date with your safety trainings and have a PTC approved process. Running processes/materials that have not been approved by the PTC can lead to disqualification from the tool.

Users are expected to leave the system with the 8” carrier in the loadlock and to pump down the loadlock before disengaging from CORAL.

If you encounter any problems while operating the machine, report them immediately in CORAL so that the staff can address them in a timely fashion.

Operating Procedures

Reserve and engage the RIE-Mixed-SAMCO-230iP on CORAL. CORAL disables the lid sensor on the loadlock, so you need to engage in order to run any process on the tool. Verify that the system is not being used and the 8” quartz carrier is in the loadlock.

Set correct User Level:

To edit run time or other parameters, you must be logged in at “BATCH” permission level. Select “BATCH” from the dropdown menu labeled “**User Level**” in the upper right of the screen and enter the password: mit

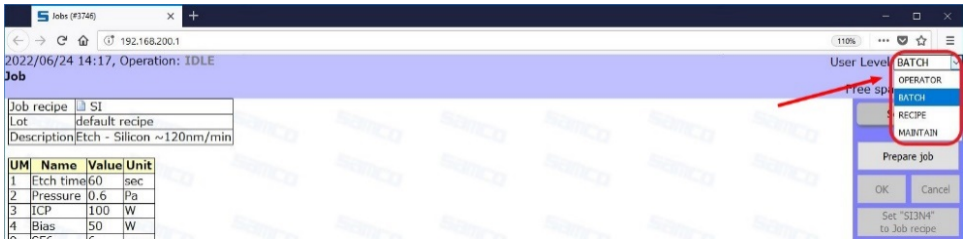
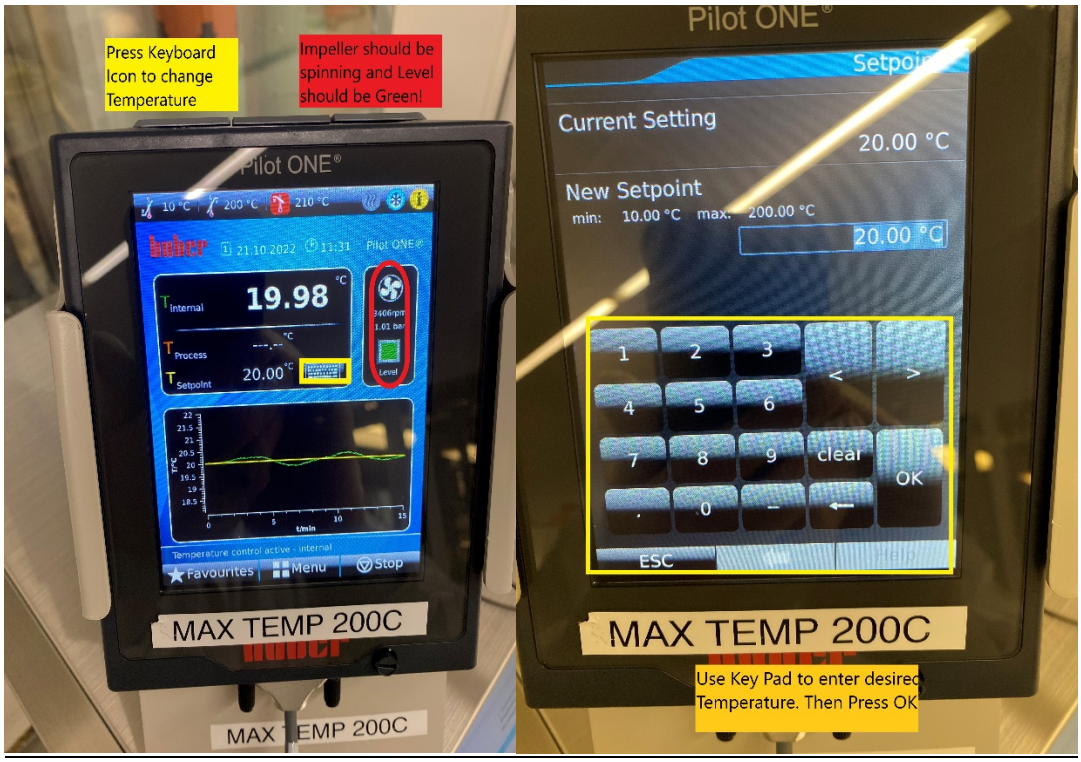
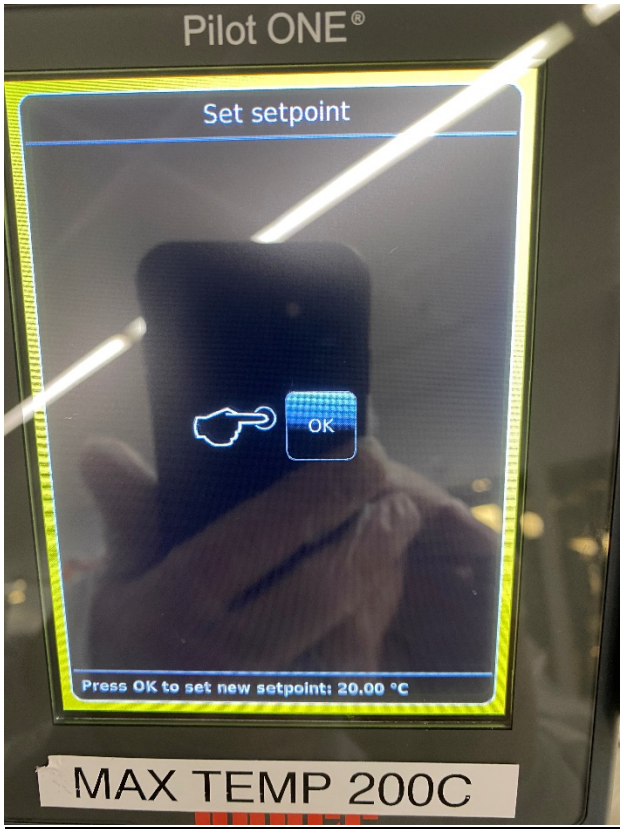


Figure 2 User level dropdown menu

Determining the cleaning and conditioning routine:

1. Check the logbook, to see what gas was used previously (chlorine or fluorine). Now consult the Flow Chart in the Appendix. Follow the instructions for cleaning, conditioning, and etching. The cleaning and conditioning will be done using the 8” Quartz tray, that should already be in the loadlock.
2. Change the temperature on the lower electrode using the HUBER controller (if necessary). Most fluorine recipes are at 20C. Many of the chlorine recipes are at 40C. Some of the recipes for III/V materials are over 100C.See the following figures on how to change the temperature using the HUBER controller. **Note:** It is your responsibility to return the temperature to 20; so, the tool is ready for the next user. You may have to add time to your reservation to accomplish this if you’re operating at elevated temperatures!


Press Keyboard Icon to change Temperature
Impeller should be spinning and Level should be Green!
Pilot ONE®
MAX TEMP 200C
Current Setting
20.00 °C
New Setpoint
min: 10.00 °C max: 200.00 °C
20.00 °C
clear
OK
ESC
Use Key Pad to enter desired Temperature. Then Press OK


Pilot ONE®
Set setpoint
OK
Press OK to set new setpoint: 20.00 °C
MAX TEMP 200C

Clean or Pre-condition chamber, then vent to load sample:

3. In the system software, go to the **Recipes** screen (3), click the "**Batch**" button (4) then click the "**List**" button (5) then select the Batch (sequence) you want to run. Valid Batches are indicated with "etch" in the ID field.

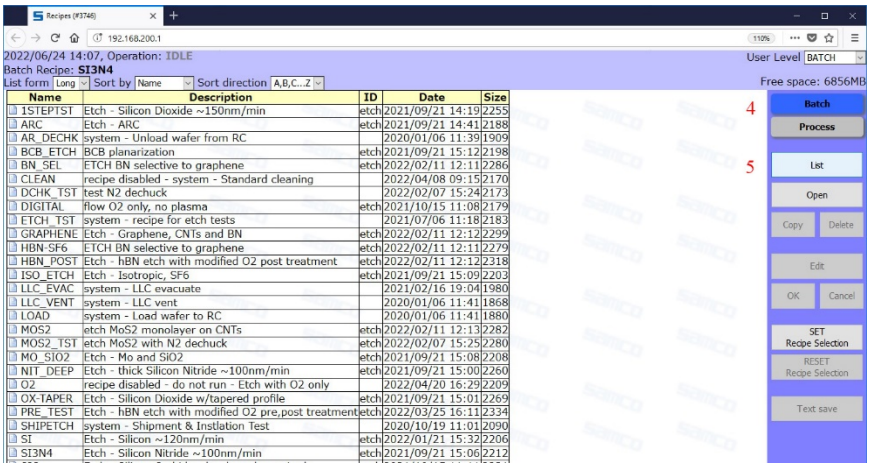


Figure 3 Recipes->Batch->List screen

The Batch details should appear on the screen:

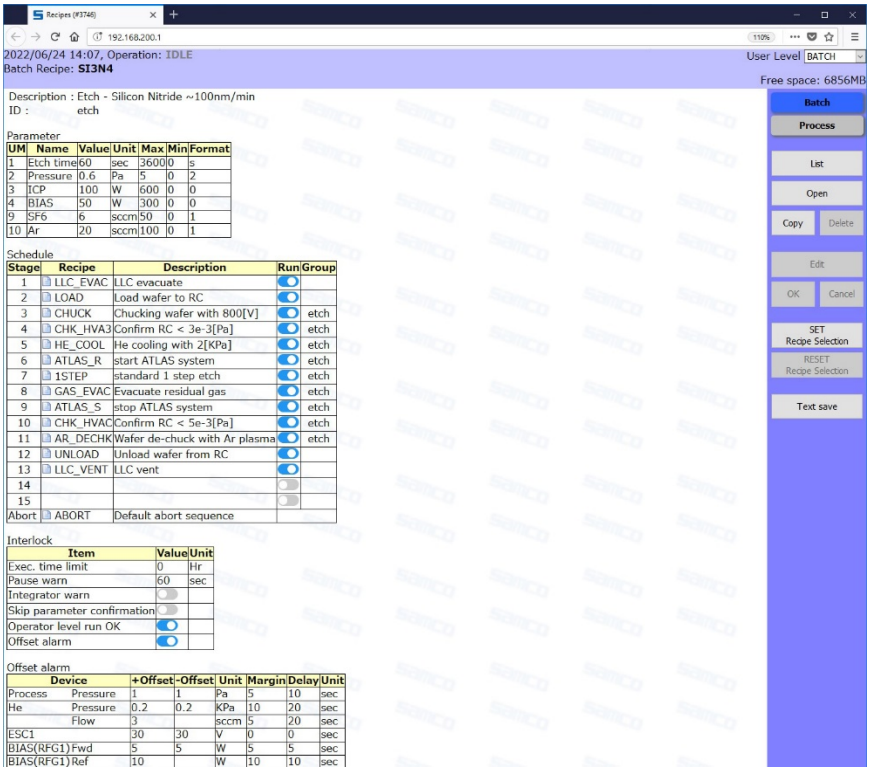


Figure 4 Batch details

4. Go to the **Jobs** screen (1) and click on “the “**Prepare Job**” button (6).

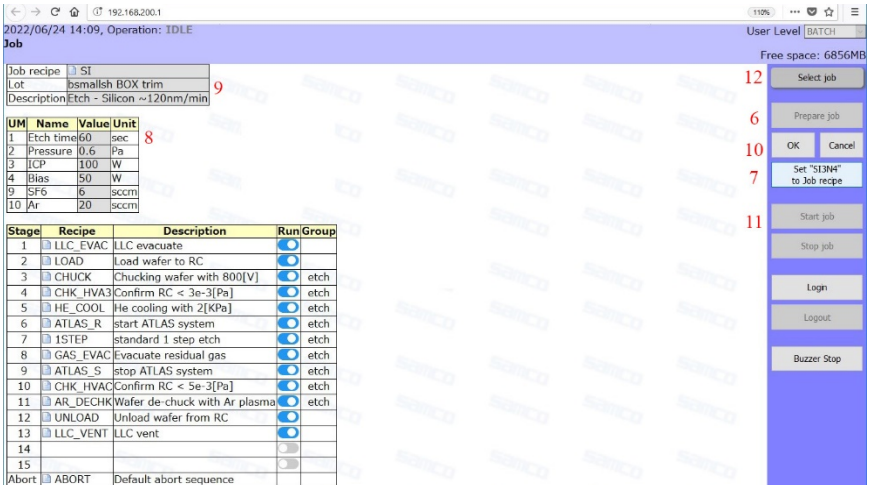


Figure 5 Jobs screen in prepare job mode

5. Click the button labeled “**Set ‘xxx’ to Job recipe**” (7) where ‘xxx’ is the Batch you selected in Step 2. This will load the selected Batch with default process parameters.
6. Click on the **Etch time** value field (8) to open a popup window. Enter a time for the etch process. Depending on the Batch, you may be able to change other process parameters as well.
7. Click on the **Lot** field (9) to open a popup window. Enter your Coral ID and a description of your run or any other comments you want to save.
8. Click “**OK**” (10) and the system will beep twice.
9. Click “**Start Job**” (11) then click “OK” in the popup window. The system will beep once and start the Batch. Processing details are available on the “**System**” screen (2).

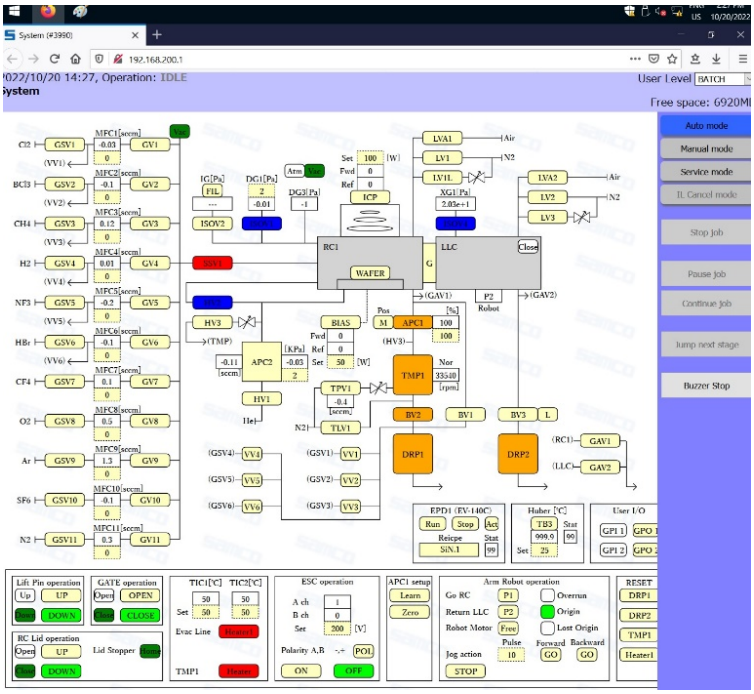


Figure 6 System screen

When all the stages in the Batch are complete, the system will sound 2 fast then 5 slow beeps. At this point, the loadlock will be vented and the system will be ready for you to load and run your samples.

Running your samples:

10. Open the loadlock, place your sample(s) on the carrier. Unless you are running whole (4,6 or 8") wafers, then, remove the carrier, place your wafer on the robot arm, then place the appropriate cover ring on top (metal side down). Close the loadlock lid.
11. Click on the "**Prepare Job**" button (6) on the **Jobs** screen (1).
12. Click once on the **Etch ti**me field (8) and enter the etch time in the pop-up window. Update the **Lot** field (9) with new comments, if necessary.
13. Click "**OK**" (10) and the system will beep twice.
14. Click "**Start Job**" (11) then click "OK" in the pop-up window. The system will beep once and start the Batch. When all the stages in the Batch are complete, the system will sound 2 fast then 5 slow beeps. You can then open the loadlock and remove your sample.
15. Repeat from Step 9 to load and run your next sample.

Enter Data in the Logbook:

16. Please enter your CORAL Name. Date, Recipe, Temperature and any Observations in the Logbook. This is a record of what you did. Please list all the clean, conditioning and etch details; the next user needs this information to determine their cleaning/conditioning routine!

Finishing your run:

17. Once your last sample has finished and is removed, make sure that the carrier is loaded on the robot arm with the metal side down, then close the loadlock lid. Go to the Jobs screen (1), click on "Select Job" (12) and click on "LLC EVAC" (4).

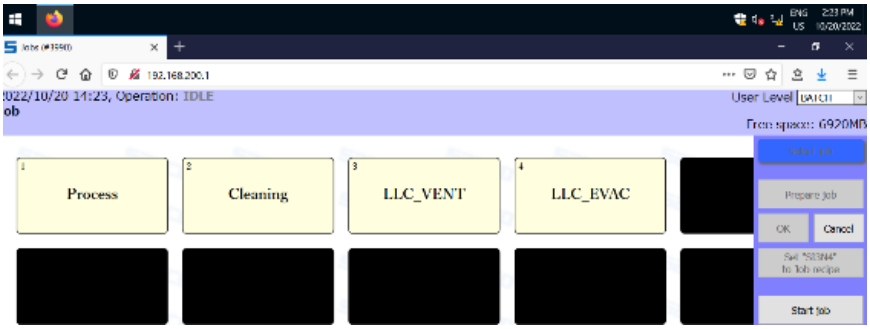


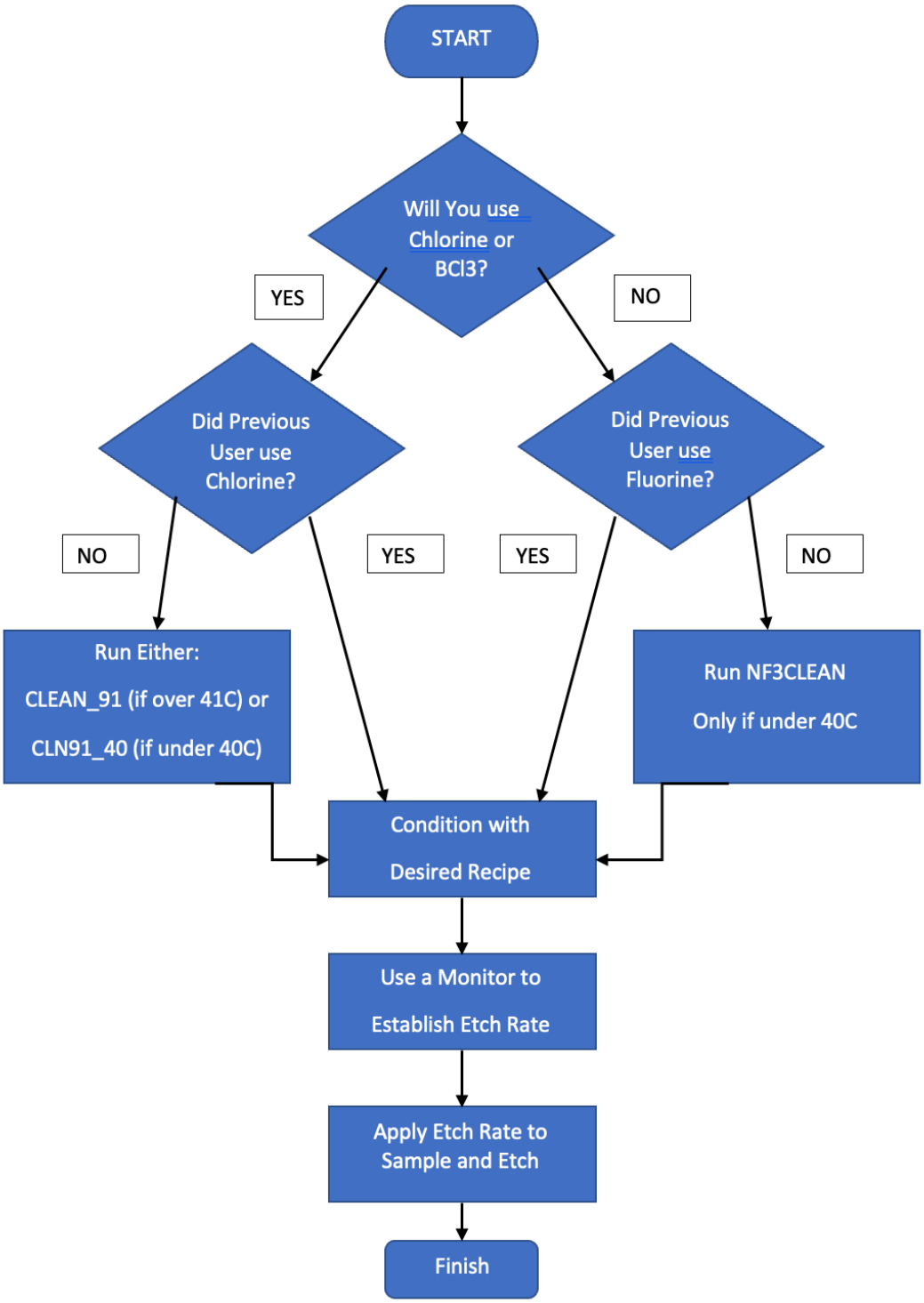
Figure 7 Select job screen - LLC pump

The system will return to the Jobs screen. Click "OK" and the system will beep twice.

18. Click "Start Job" then click "OK" in the pop-up window. The system will beep once and start the loadlock pumpdown sequence. Once the loadlock pumpdown has completed, the system will sound 2 fast then 5 slow beeps.
19. Once the loadlock has pumped down and the system is idle, disengage the RIE-Mixed-Samco-230iP system on CORAL. If you disengage before the pumpdown is complete, the system will think the loadlock lid has opened and will abort.

Appendices

Flowchart (consult prior to processing):



Loading of samples/carrier/cover ring:

Correct loading:

- Metal side of carrier or cover ring is facing down, samples placed on carrier.



Figure 8 correct loading of carrier

- If running 4” or 6” wafer, wafer goes on arm first, then cover ring is placed on top of wafer.

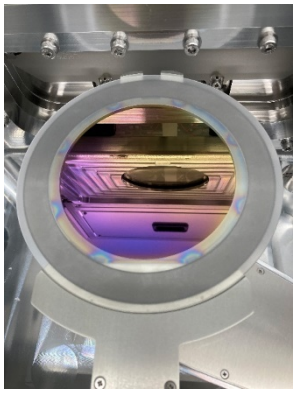


Figure 9 correct loading of wafer and cover ring

Incorrect loading:

- Cover ring underneath wafer - wafer will be lifted off arm, but cover ring will stay on arm and get stuck on lift pins.

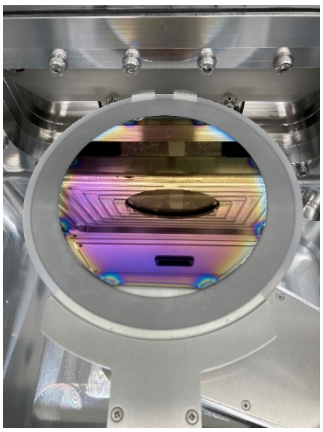


Figure 10 Incorrect loading - cover ring under wafer

- Cover ring or carrier is loaded with metal side up – cover ring or carrier won't be held down by electrostatic chuck.



Figure 11 Incorrect loading - Carrier metal side up

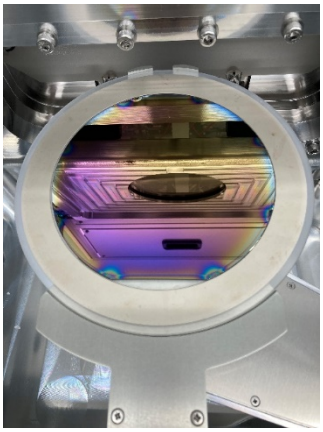


Figure 12 Incorrect loading - Cover ring metal side up, wafer on top of cover ring

- 4" or 6" wafer loaded with no cover ring, or cover ring loaded with no wafer - surface of electrostatic chuck won't be fully protected from plasma.

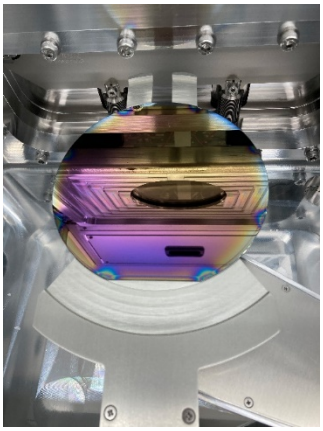


Fig. 13 Incorrect loading – 6" wafer with no cover ring

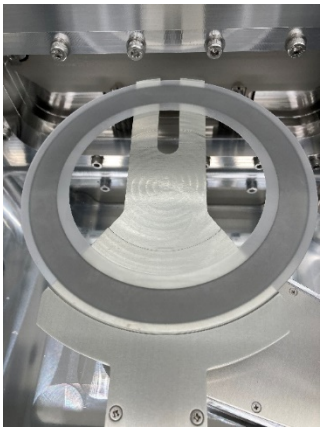


Fig. 14 Incorrect loading - cover ring with no wafer

Tips and Tricks:

- Larger samples may need guard pieces to prevent the sample from moving during pumpdown.
- If you are running whole wafers, remove the carrier, load your wafer onto the arm, then place the appropriate cover ring over your wafer with the metal side down.
- Santovac 5, a diffusion pump oil, is available as a heat transfer fluid when etching pieces. It gives better results than just placing the pieces on the quartz tray. The pieces are mounted onto a 6" Si dummy (provided) and the appropriate cover ring is used.
- Only disengage on Coral when the system is not running a batch and is idle. If you disengage before the batch is finished, the system will think the loadlock lid has opened and will abort.

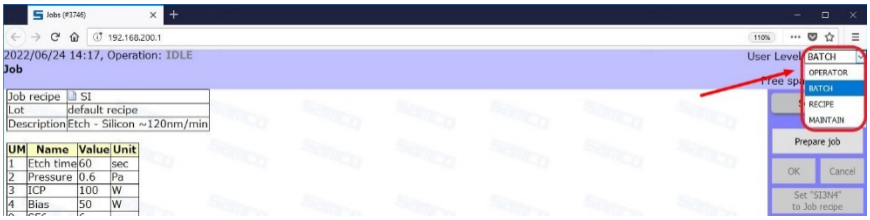
Common errors/failures:

System software not on screen

The system software runs through a web interface to the main computer. If the system software is not showing on the screen, open a Firefox browser window to 192.168.200.1.

Can't edit recipe time or other parameters

You should be able to edit the etch time for all batches, and for some batches you may be able to change other process parameters as well.
To be able to edit run time or other parameters, you must be logged in at "BATCH" permission level. Select "BATCH" from the dropdown menu labeled "User Level" in the upper right of the screen and enter the password: mit.



"APC2 offset low" error

This means the system is flowing more He then expected to maintain the backside He cooling pressure. This is normally due to residue or debris on the backside of the carrier.
To recover:

- Go to Jobs (1)->"Select Job"(12) and click on "Unload Wafer" (47) .



Figure 15 Select Job screen - Unload wafer button

- Click on "OK" (10) then "Start Job" (11), then "OK" in the popup window.

The system will then pump out any residual gas, dechuck and transfer the wafer to the loadlock then vent the loadlock.

At this point you can wipe the backside of the carrier or wafer with either methanol or acetone, then try to run again. You can retry wiping the backside twice or try using a different wafer. If the system still won't run, this means there is probably debris on the electrostatic chuck and the chamber will need to be wet cleaned by staff. Collect your samples, then put the system in Shutdown on Coral and disengage.

System aborts during process

If any of the process parameters are outside a pre-defined window for too long, the system will abort. The process will stop, and the sample will stay in the chamber.
To recover your sample:

- Go to Jobs (1)->“Select Job”(12) and click on “Unload Wafer” (47) .



Figure 16 Select Job screen - Unload wafer button

- Click on “OK” (10) then “Start Job” (11) , then “OK” in the popup window.

The system will then pump out any residual gas, dechuck and transfer the wafer to the loadlock then vent the loadlock.

Gas List

Gas #	Gas Name	Max Flow (sccm)
1	Chlorine (Cl2)	20
2	Boron Trichloride (BCl3)	50
3	Methane (CH4)	20
4	Hydrogen (H2)	20
5	Nitrogen Trifluoride (NF3)	100
6	Hydrogen Bromide (HBr)	50
7	Tetrafluoromethane (CF4)	50
8	Oxygen (O2)	100
9	Argon (Ar)	100
10	Sulfur Hexafluoride (SF6)	50
11	Nitrogen (N2)	100

The following gases are interlocked by the system for safety to prevent mixing incompatible gases in the chamber:
Boron Trichloride (BCl3) with Oxygen (O2)
Methane (CH4) with: Chlorine (Cl2) OR Nitrogen Trifluoride (NF3) OR Oxygen (O2)
Hydrogen (H2) with: Chlorine (Cl2) OR Nitrogen Trifluoride (NF3) OR Oxygen (O2)

Pressure Conversion Chart

Pascals	mTorr	
0.005	0.0375	
0.25	1.875	
0.5	3.750	
1	7.50	
2	15.00	
3	22.50	
4	30.00	
5	37.50	
6	45.00	
7	52.50	
8	60.00	
9	67.51	
10	75.01	
15	112.51	
20	150.01	
25	187.52	
50	375.03	
100	750.06	
2700	20251.67	
100000	750061.68	