



IIT Bombay Nanofabrication Facility

Tool Name: ICPRIE, Location -1.1 Lab **Standard Operation Procedure (SOP)**

IITBNF is responsible only for maintaining and providing baseline processes. If a baseline process is working, the tool is considered functional. Development, modification, and optimization of individual user processes are the sole responsibility of the respective users.

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 경고 도어 및 커버 개폐금지 허가된 자 외 접근금지.	A minor injury or damage to the product may occur in case these instructions are not observed.
 경고 전기 위험 접촉시 전기적 충격/ 화상 위험 있음. 서비스 전 주전원 차단 및 잠금장치 체결할 것.	Care shall be taken not to get a shock or burn by coming into contact with a part where high-voltage current flows on the electric wire.
	No access for people with active implanted cardiac devices
	Do not touch when the pump is running
 경고 표면온도에 의한 화상위험 취급시 주의할 것.	Care shall be taken not to get burned by coming into contact with hot surfaces, including a heater or a part that emits hot heat.
	Heavy Object can cause muscle strain or back injury. Use lifting aids & proper lifting techniques when removing or replacing.
	Moving Parts Present- Moving parts can crush and cut. Keep hands or feet away from moving parts

Checklist and Precautions for Dry Pump

Checklist and precautions to be taken for Pfeiffer make Dry pump (A124H) connected to ICPRIE-Dia

SOP for Pfeiffer make Dry Pump:

1. Regular monitoring and Extra care need to be taken for the pump to avoid any condensation inside the pump on the PCB boards.
2. The following are the checklist to be done on a regular basis by SO/operator
 - A. Pump is ON
 - B. Water flow is ON (it should be 4LPM on the chiller manifold)
 - C. N2 / CDA purge is ON (at ~ 1 bar)

Precautions to be taken

A. If the pump has to be turned OFF (planned or emergency shut down), follow the below steps:

- (1) Turn OFF the pump from software
- (2) Wait for 1hr for the pump to cool down
- (3) Turn OFF water from chiller manifold with the help from facility team
- (4) Open the water connection - IN and OUT (push-fit connection)
- (5) Flush the line using CDA. Procedure is as follows:
 - (a) Make sure water IN and water OUT valves in the chiller manifold is OFF
 - (b) Remove the pipes (inlet and outlet) from the push-fit
 - (c) Make CDA ready (CDA is available near every pump in the service corridor)
 - (d) Hold the Water OUT pipe in the bucket (to collect water which will be flushed out of the pump)
 - (e) Insert the CDA pipe in Water IN pipe
 - (f) Pressurize CDA slowly to 2 bar
 - (g) Water will be drained through the water OUT pipe. After couple of mins, all the water will be drained and air will be released
 - (h) Once no water is there in the water OUT pipe, close CDA. Keep the CDA

pipe to its original position

(i) Connect back the Water IN and Water OUT pipes to their original respective valves.

(j) DO NOT turn ON the water valve in the chiller manifold

B. For restarting the pump

(1) Start the tool

(2) Switch ON the pump from software

(3) Once the pump is started, TURN ON water OUT and water IN valves in the chiller manifold

(4) Check water flow on the Flow Meter in the Water OUT of the chiller manifold.

It should be 4 LPM

(5) Check the water flow value in the pump controller display. There should be no alarm on the display

Checklist (Before starting the tool):

1. CDA Check, it should be ON. (At 6 bar), by default it is ON at 6 bar
2. The waterline should be ON. (It should be 4LPM on the chiller manifold) by default it is ON - Pls refer
3. Helium, PN2 should be ON – At 2 bar pressure- facility team to install gauges later
4. Check the gasses required for your recipe / process with the facility team on duty.
5. Make sure that the processes you want to run are contamination protocol compliant and comply with the tool usage policy.
6. Any failure runs and equipment malfunction must be reported to SO / process committee / EMT, as per the equipment up/down policy
7. Physical & Online logbooks must be filled immediately after the process.

Critical Precautions and Common Mistakes to avoid:

1. Never place a material that is not in the list of allowed material into the chamber (please refer to the tool document regarding allowed materials).
2. Make sure you are up to date on the latest restrictions and requirements on the tool, including sample preparation and mounting.
3. Always be careful about placement of carrier wafer in the load lock
4. Always use 4" carrier wafer to place small pieces of samples only by using Fomblin oil available near to the tool.
5. Always return the heat exchanger to standby default temperatures i.e 24°C after you are done with your process.

System Operational Range /

Specifications:

1. Maximum Process time should be 20 minutes.
2. One can execute 10 min cycles with a 10 min gap.
3. Maximum RF supply = 600 W
4. Maximum ICP supply = 2500 W
5. Maximum allowed process gas flow = CL2 - 172 sccm, BCL3 - 82 sccm, CHF3 - 100sccm, O2 - 99sccm, N2 - 100sccm, CF4 - 84sccm, Ar - 145sccm, SF6 - 130sccm.
6. Water flow requirement = 6 lpm for main system, 6 lpm for control rack
7. Heat Exchanger = Max Temperature 40°C (Heat exchanger temperature should always be 10°C lower than the process temperature)
8. Before running any process in the chamber following recipes has to be done
 - O2 cleaning 10 minutes - For Chamber cleaning
 - Chamber conditioning - Actual process to be done to condition the chamber for actual run

System Overview

Front view of Tool

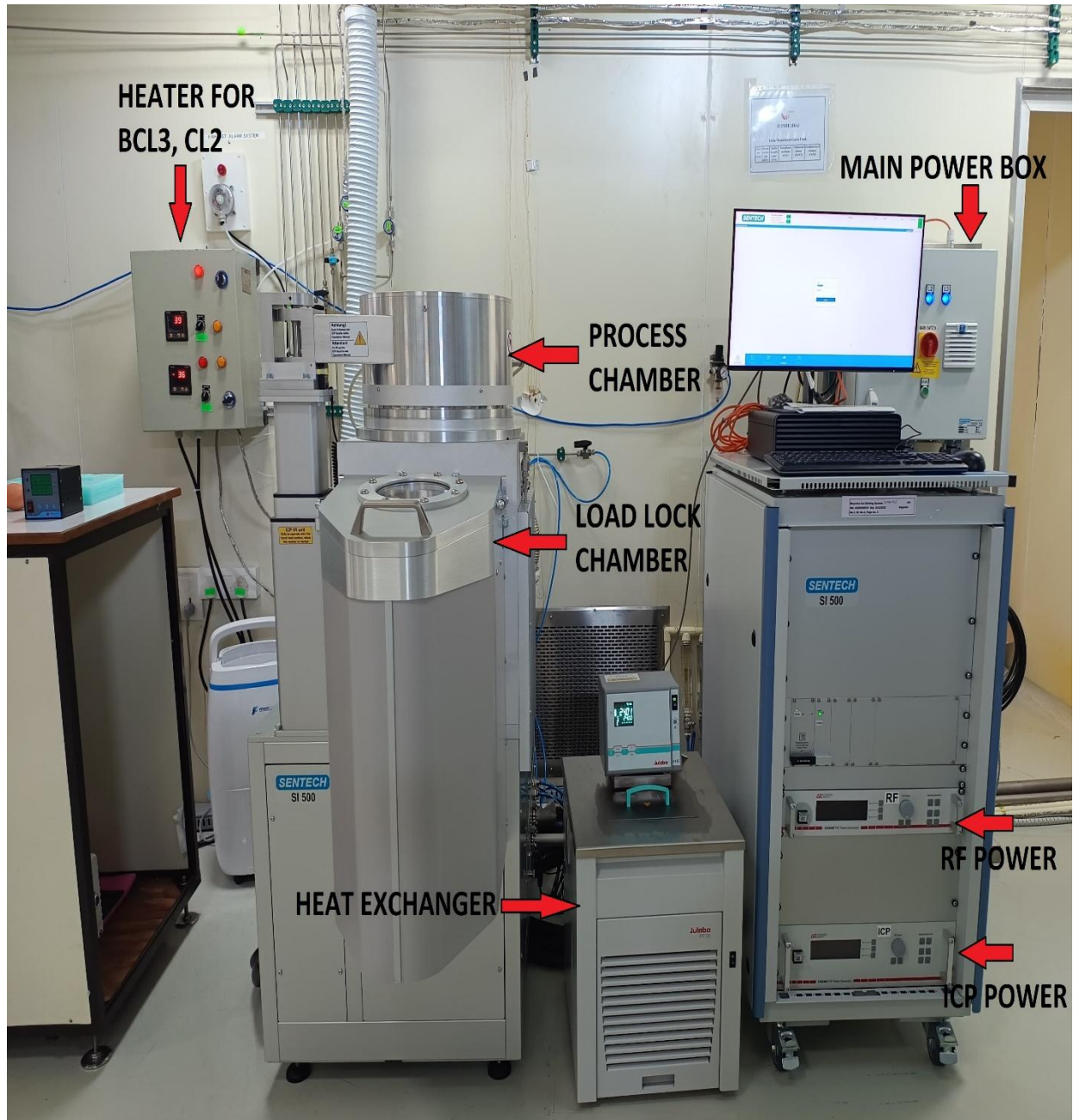


Figure 1: System Overview

Gas lines

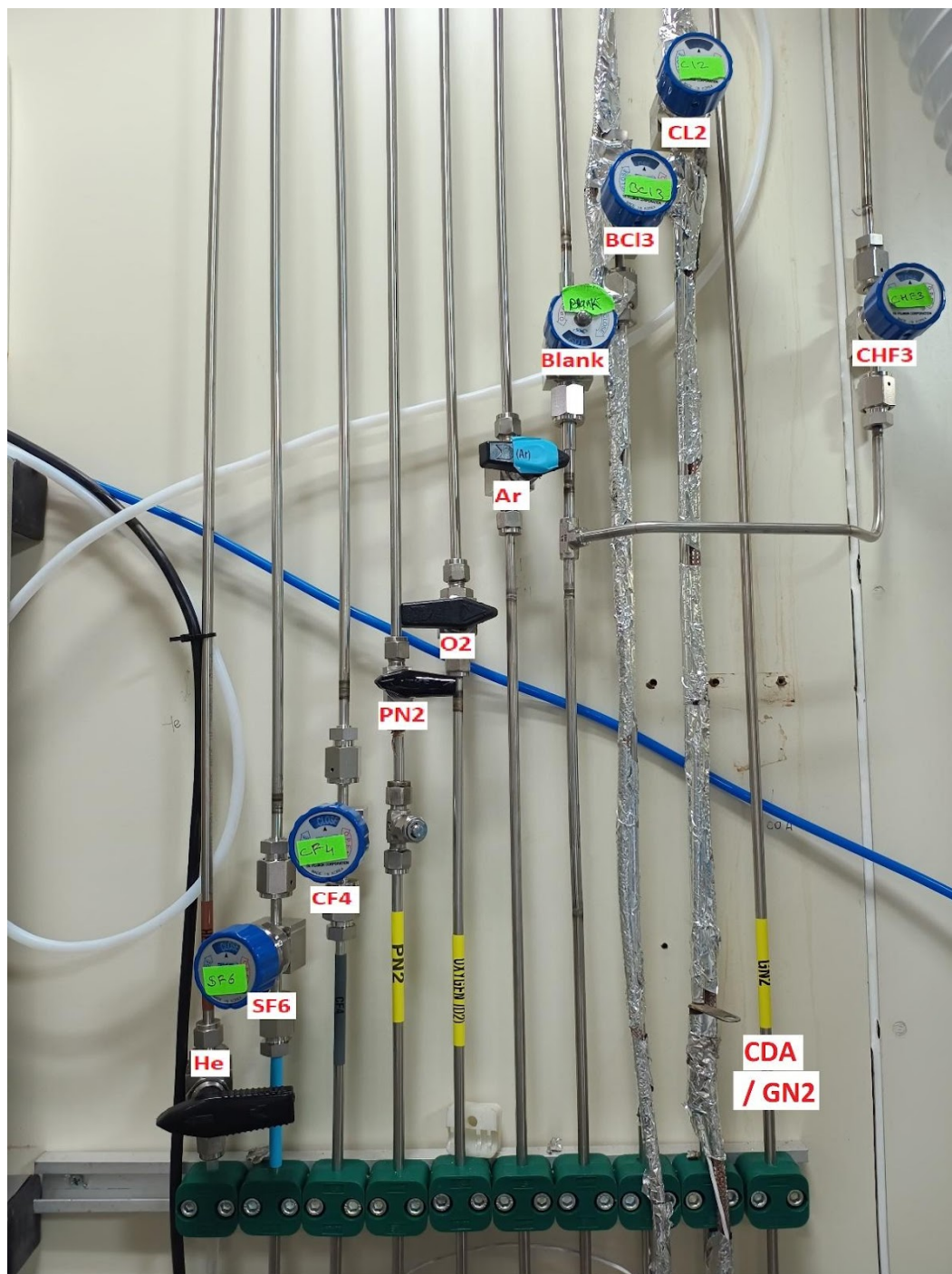


Figure 2: Gas Lines

Software Overview of the System

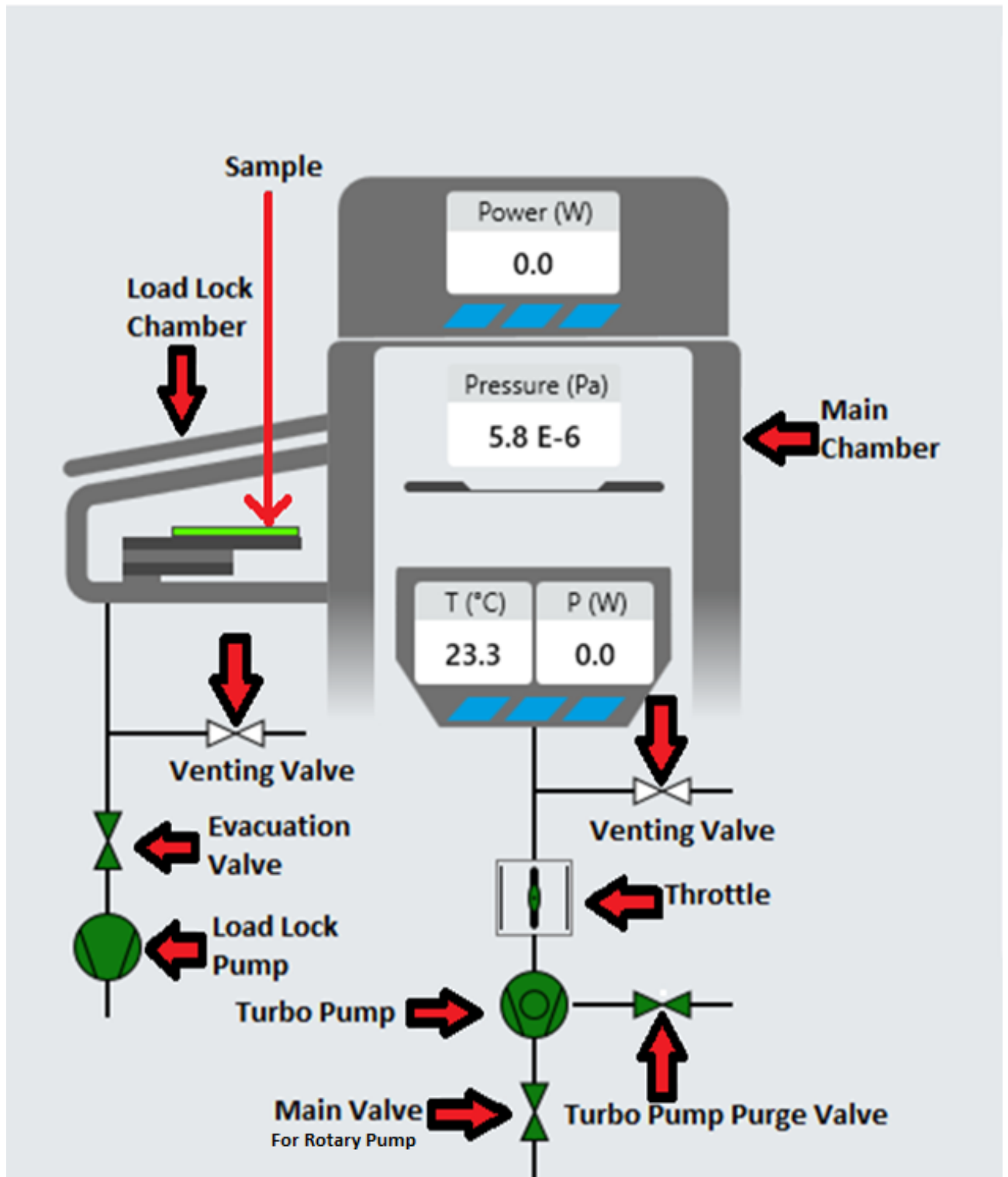


Figure 3: Software Overview

Important Note:

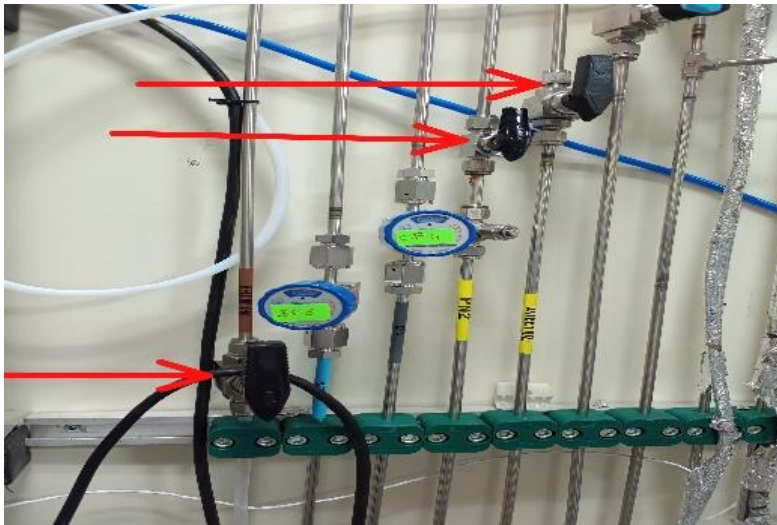
- Before running any recipe in the system, process chamber conditioning has to be done by running the same recipe without your actual sample, but with a carrier wafer.
- After completion of the process, it is mandatory to run O2 cleaning recipes. Please refer to page no. 22 to 23 for more details.

Chamber Conditioning Procedure:

1. Follow step no. 1 to 8 of “Recipe run Procedure”.
2. Follow step no. 16 to 26 of “Recipe run Procedure”.

Recipe run Procedure:

1. Check with the facility team and get the required gases turned ON from the cylinder side.
2. Inside the clean room, Turn ON Helium, PN2 and required process gas valves.
(For e.g. O₂ / CF₄ / SF₆, etc.)



3. Set the Heat exchanger temperature required for your process.
(Always, on the heat exchanger unit Set 10°C less than the required process temperature, For eg. If the process temperature is 25°C set it to 15°C on the heat exchanger display).
4. Initially the heat exchanger will be at its default temperature i.e 24oC.



5. Use the Up & Down key to increase or decrease the temperature as per required process temperature.



6. Press the “OK” button to set the value and again press the “OK” button to confirm the set value. Proceed further once required temperature will be achieved.



7. Login to Software

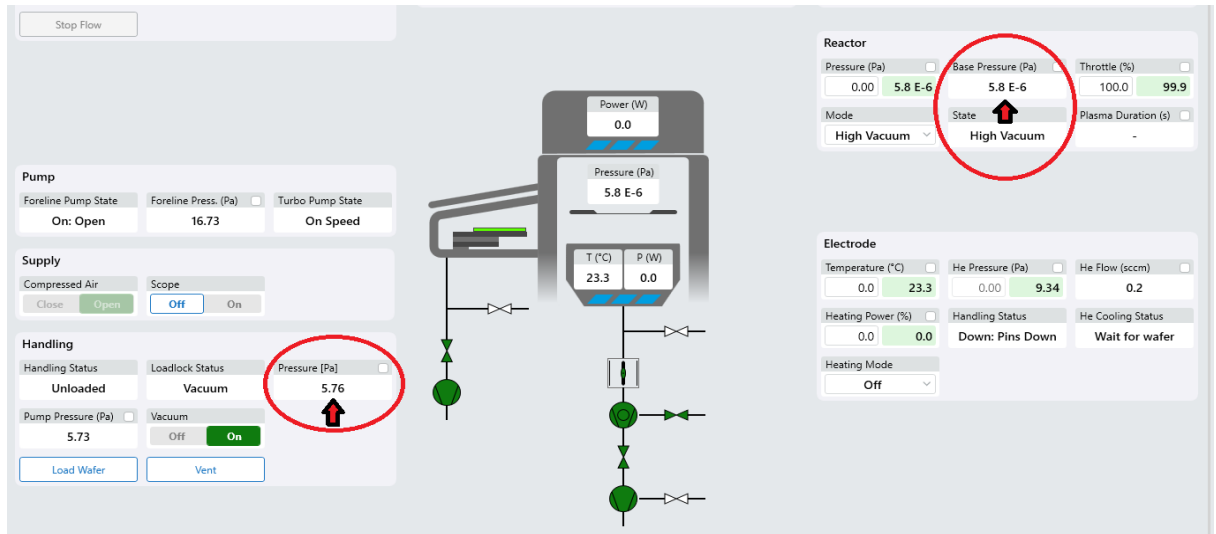
A screenshot of a software login window. It has a light gray background. In the center, there is a white box containing two input fields. The first field is labeled 'User' and contains the text 'Operator'. The second field is labeled 'Password' and is empty. Below these fields is a blue button with the text 'Log In' in white.

User - Operator

Password – (there is no password, Press Enter)

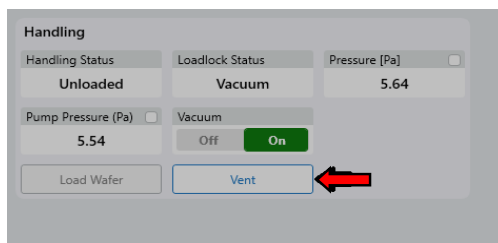
8. Check and note down process chamber and LL chamber vacuum details in the log book

The expected vacuum range (Process Chamber = less than 8 E-6 Pa, Load Lock Chamber = less than 6 Pa).

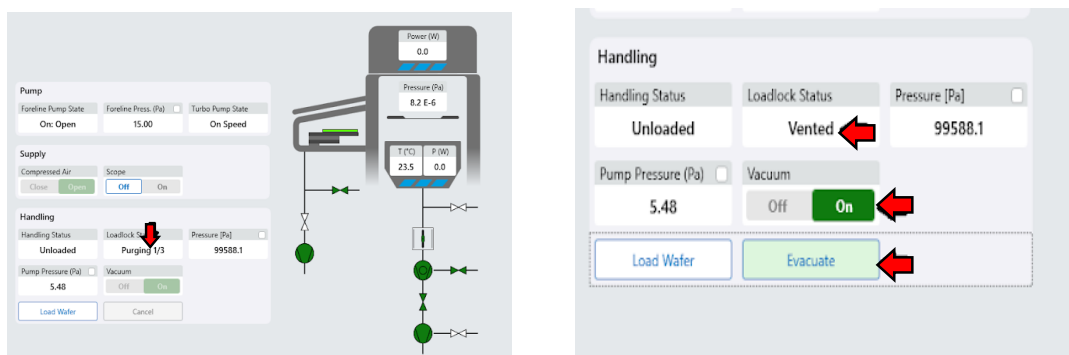


9. Sample Loading:

Vent the chamber by clicking the vent button in handling mode.



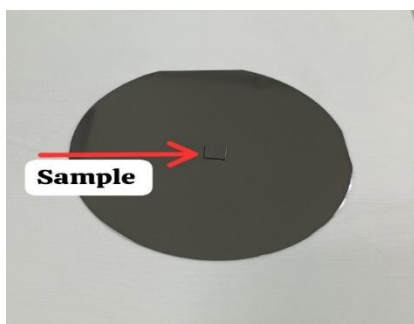
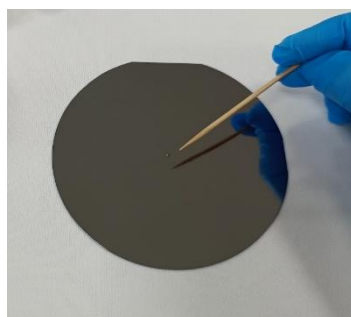
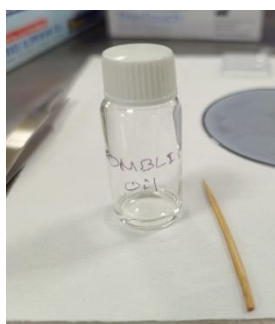
10. Once you click on Vent LL, software will start three purging cycles. Once this is completed, the LL chamber gets vented completely. “Load lock status” will show “vented” and the vacuum option gets highlighted in handling mode. “Evacuate” option will be enabled.



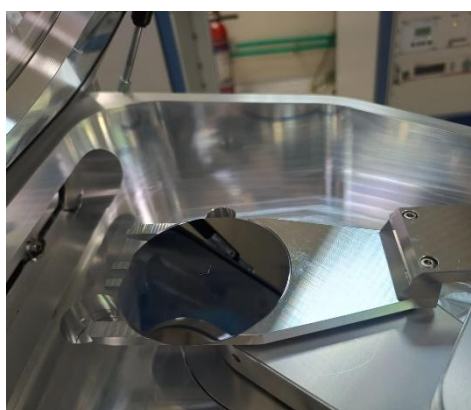
11. Open the chamber, remove the carrier wafer.



12. Clean the carrier wafer with IPA. On the carrier wafer put a tiny drop of Fomblin oil with the help of a toothpick, then keep your sample above the oil so that the sample(s) are mounted properly & do not fall inside the chamber. Make sure that the Fomblin oil doesn't spill beyond the sample and it should not expose to the plasma. After completion of their process, the user must clean the carrier with Acetone followed by IPA on a lint-free by gently rubbing the spot to remove the trace of Fomblin oil.

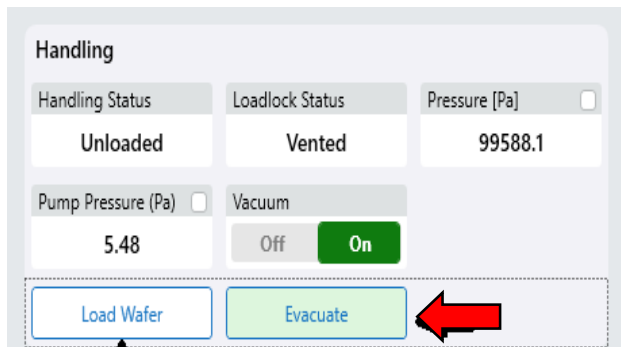


13. Load the carrier wafer along with the sample in the load lock chamber in proper orientation so that it fits properly on the sample holder.

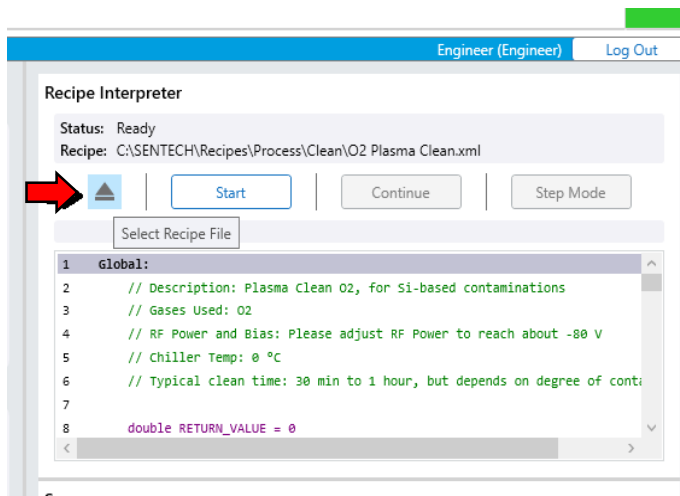


14. Close the chamber.

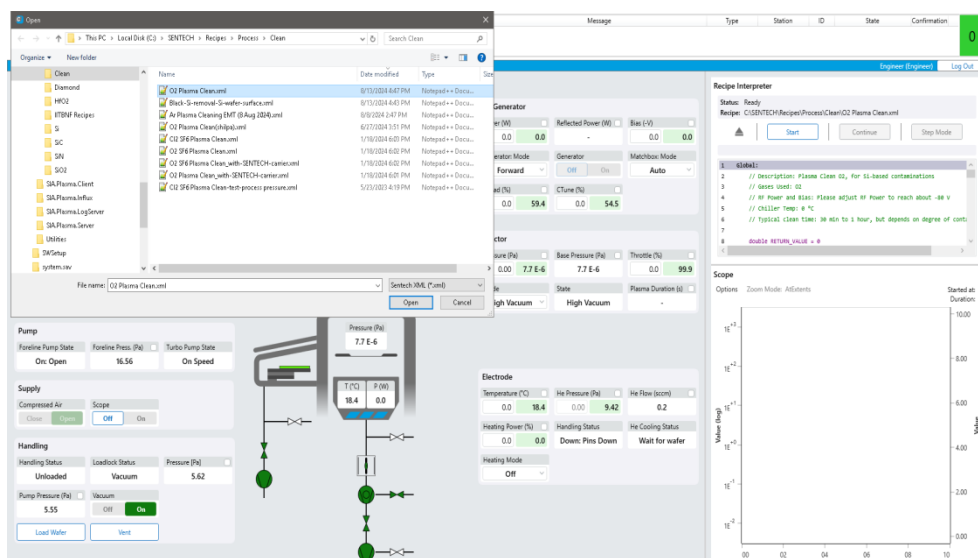
15. Evacuate the LL chamber and wait till “Loadlock Status” shows “Vacuum”.
Now proceed with the process.



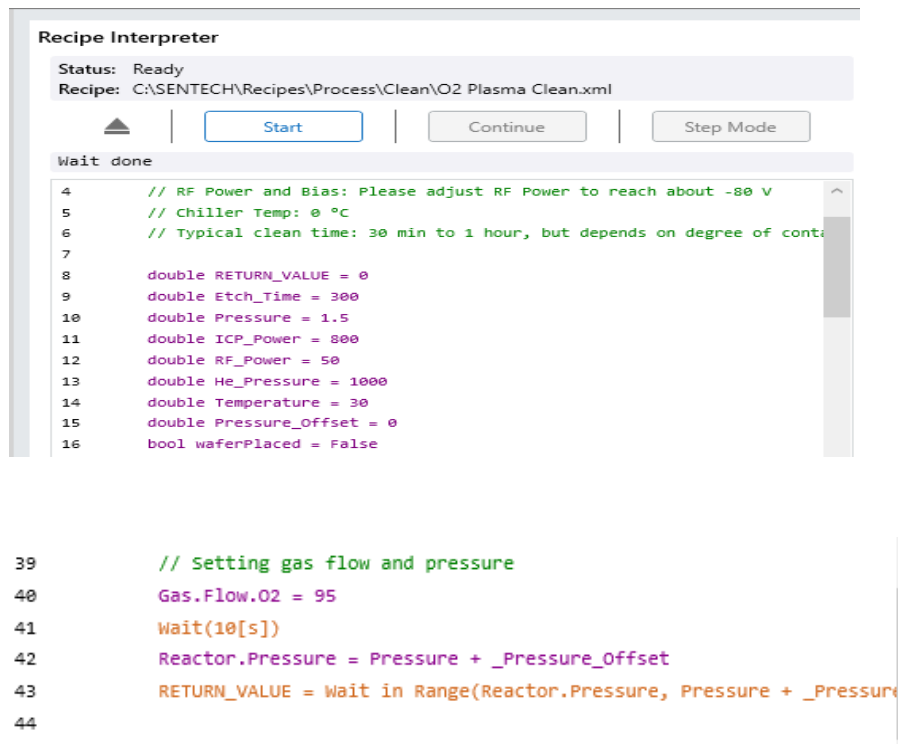
16. Select the required recipe.



17. Select the recipe from the required folder .



18. Important parameters to be checked for the process are as shown in image.



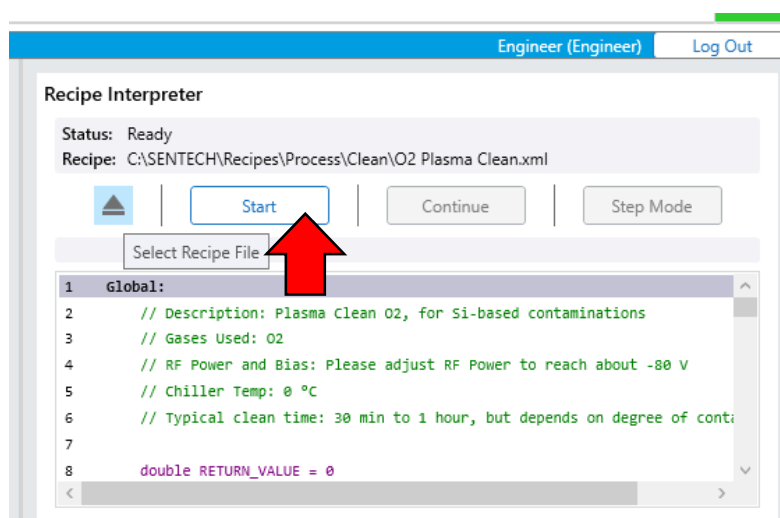
The screenshot shows the 'Recipe Interpreter' window. At the top, it displays 'Status: Ready' and 'Recipe: C:\SENTECH\Recipes\Process\Clean\O2 Plasma Clean.xml'. Below this are three buttons: 'Start' (highlighted with a blue border), 'Continue', and 'Step Mode'. A 'wait done' status bar is visible. The main area contains a list of parameters to be checked, numbered 4 through 16:

```
4 // RF Power and Bias: Please adjust RF Power to reach about -80 V
5 // Chiller Temp: 0 °C
6 // Typical clean time: 30 min to 1 hour, but depends on degree of conta
7
8 double RETURN_VALUE = 0
9 double Etch_Time = 300
10 double Pressure = 1.5
11 double ICP_Power = 800
12 double RF_Power = 50
13 double He_Pressure = 1000
14 double Temperature = 30
15 double Pressure_Offset = 0
16 bool waferPlaced = False
```

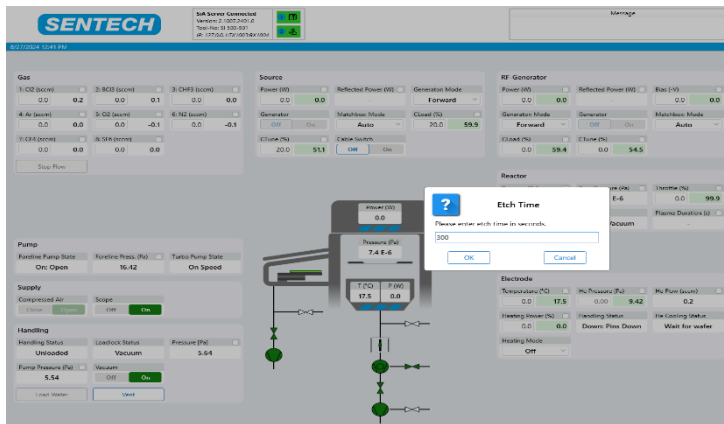
Below this, lines 39 through 44 show additional parameters and actions:

```
39 // Setting gas flow and pressure
40 Gas.FLOW.O2 = 95
41 Wait(10[s])
42 Reactor.Pressure = Pressure + _Pressure_Offset
43 RETURN_VALUE = Wait in Range(Reactor.Pressure, Pressure + _Pressure
44
```

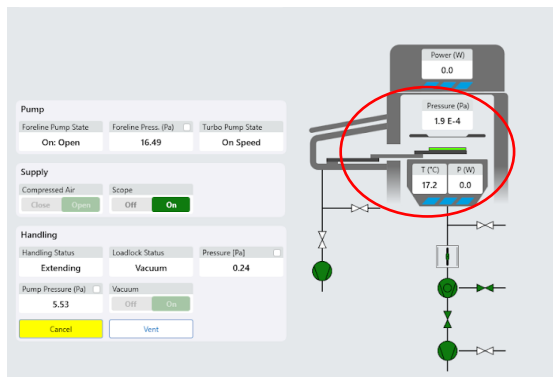
19. To run the recipe click on the start button.



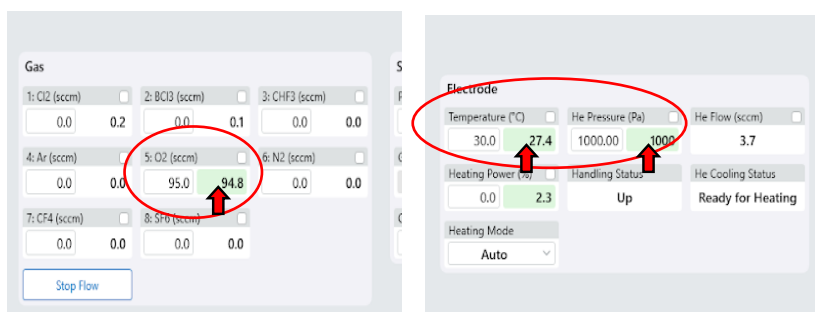
20. Give etch time as per the requirement of the run.



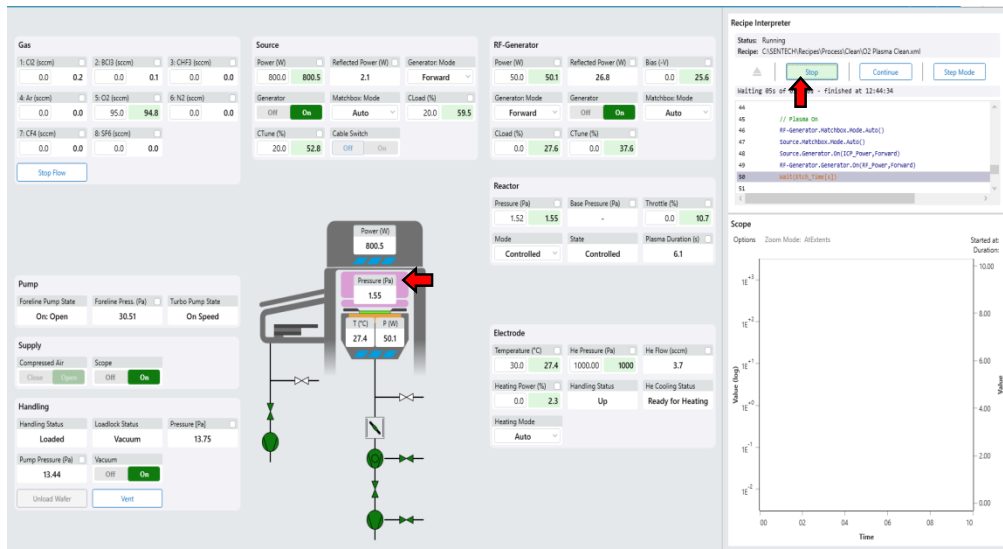
21. The process will start for the required time. Sample will start getting inside the process chamber.



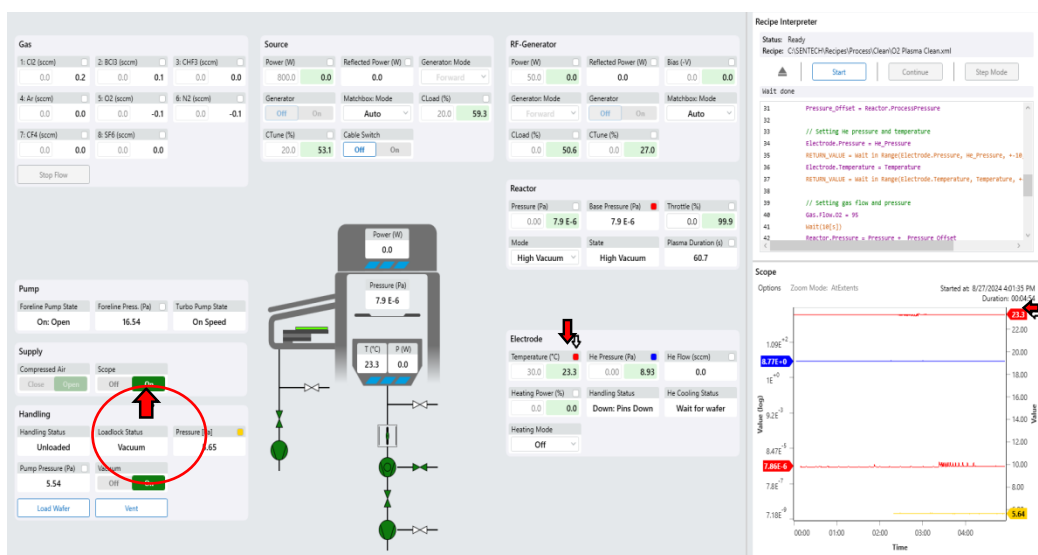
22. Gas value will be shown in the Gas section. "He" pressure started increasing. The required process temperature started increasing.



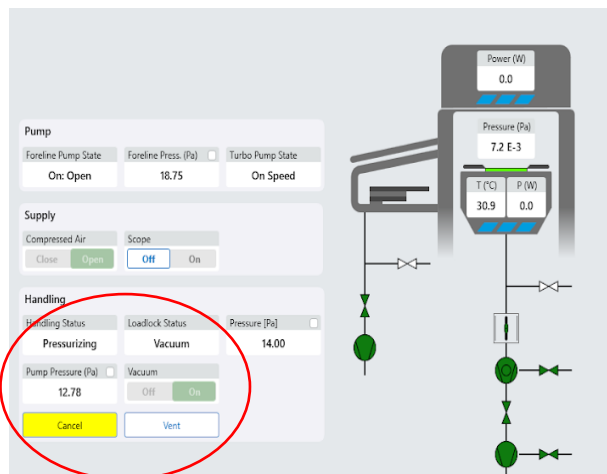
23. Once all the parameters reach to its respective values, plasma will generate inside the process chamber and etching process will be done for the required time.



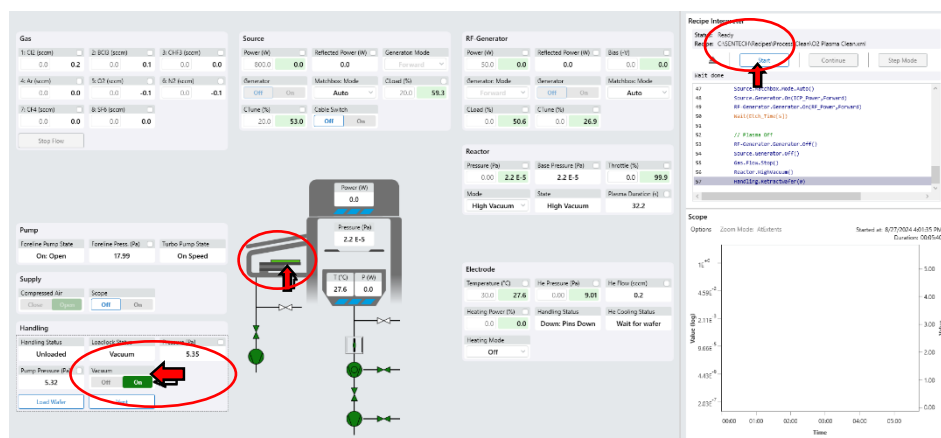
24. Turn ON the “Scope” if you want to view the parameters like Pressure, gas flow, RF, etc.. on the graph and tick the corresponding parameters you want to see. Selected parameters will be shown on the scope graph according to its respective color as shown in the image.



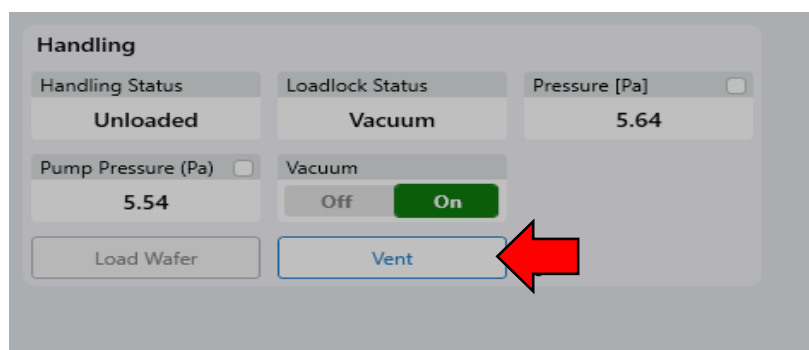
25. Once the process is completed, plasma will get turned off. Sample (Carrier wafer) will start coming back to the load lock chamber.



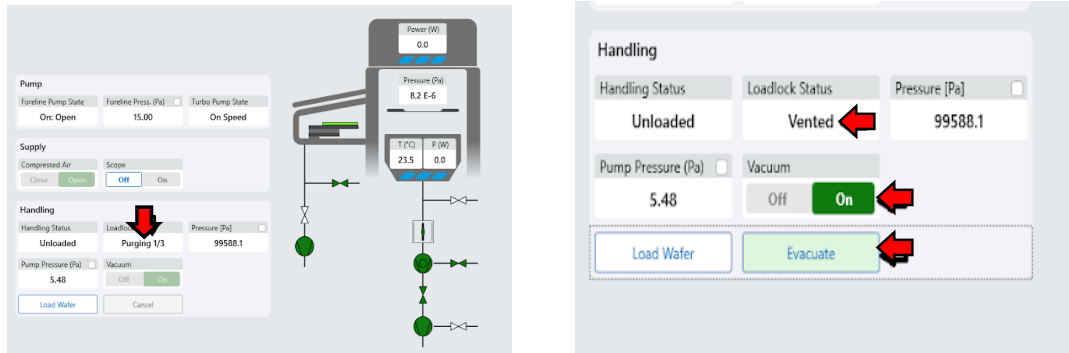
26. Wait for the sample (Carrier wafer) comes back to the load lock chamber and “vacuum” gets highlighted in handling mode and In the Recipe Interpreter “Start” will be displayed. This means, recipe is completed, and sample is unloaded in LL



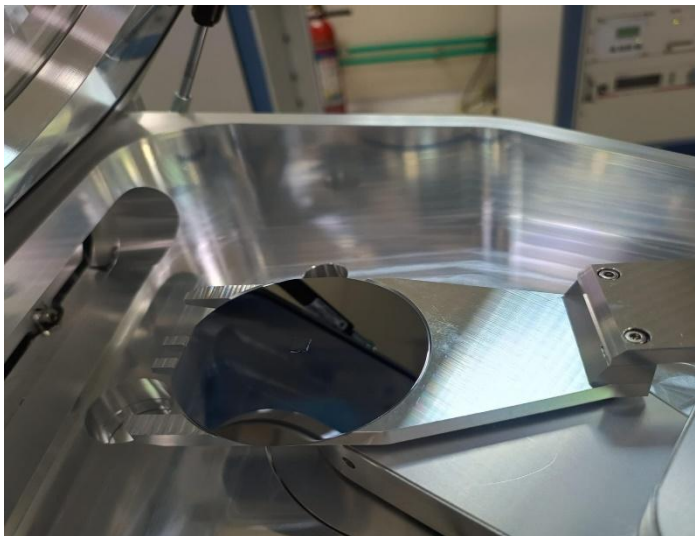
27. Sample Unloading - Vent the chamber by clicking the vent button in handling mode.



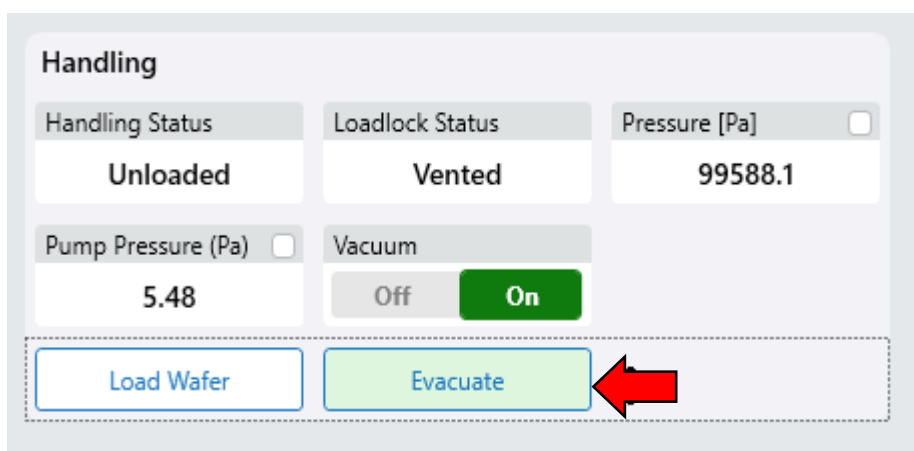
28. Once you click on Vent LL, software will start three purging cycles. Once this is completed, the LL chamber gets vented completely. “Load lock status” will show “vented” and the vacuum option gets highlighted in handling mode. The evacuation option will be enabled.



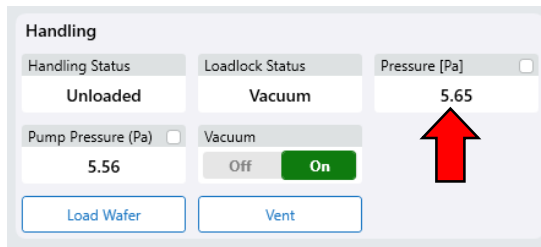
29. Open the chamber, unload the carrier wafer. Unload the sample, Clean the carrier wafer with Acetone then IPA. Keep the carrier wafer back in the chamber.



30. Close the chamber & Evacuate it.

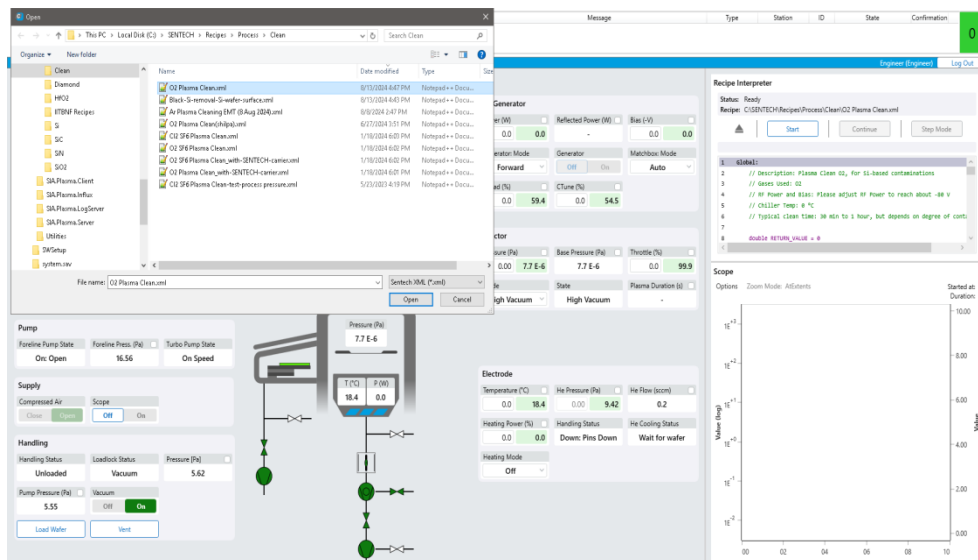


31. Wait till load lock status shows Vacuum. Pump pressure will reach around 6 Pa .

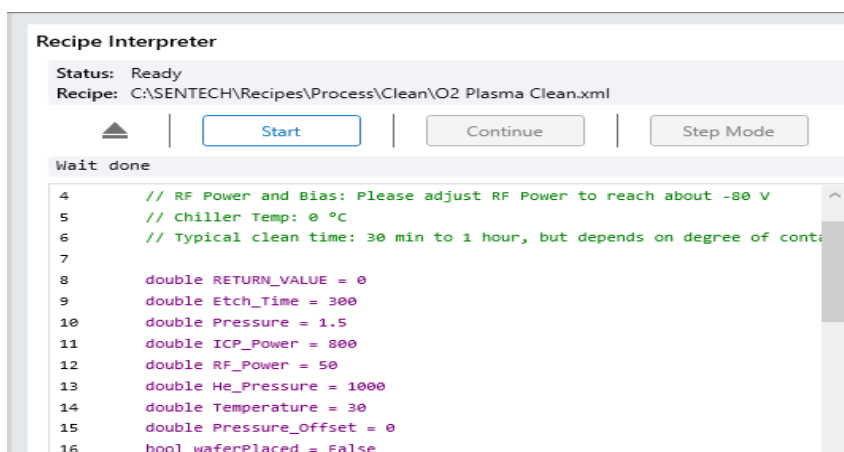


32. Run O2 clean recipe for 5 minutes. (After completion of any process, O2 cleaning recipe has to be run)

33. Select the O2 clean recipe from the following folder.



34. O2 cleaning recipe parameters are as shown in image.



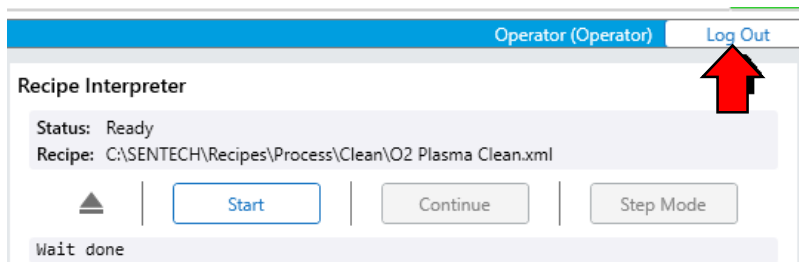
```

39      // Setting gas flow and pressure
40      Gas.Flow.O2 = 95
41      Wait(10[s])
42      Reactor.Pressure = Pressure + _Pressure_Offset
43      RETURN_VALUE = Wait in Range(Reactor.Pressure, Pressure + _Pressure
44      ...

```

35. To run the recipe, follow step no. 19 to step no. 23.

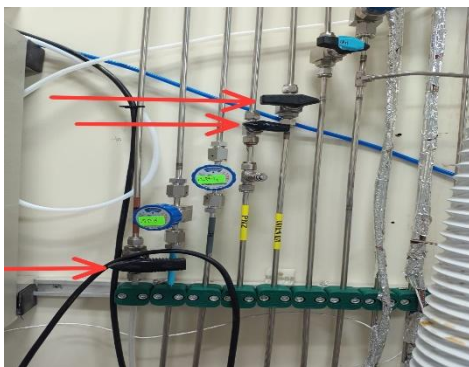
36. Once the process is completed, logout the system.



37. Return heat exchanger to standby default temperatures i.e 24°C .



38. Turn OFF all the gases. (PN2, He, O2)

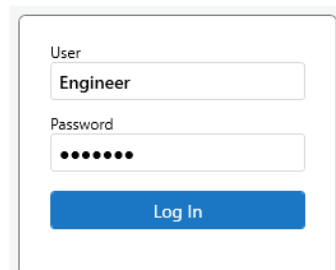


39. Inform facility to turn OFF the gases from cylinder side.

Recipe Modification:

Note: Recipe modification is restricted for Authorised Users. Only System owners can modify the recipes.

1. Login to Software



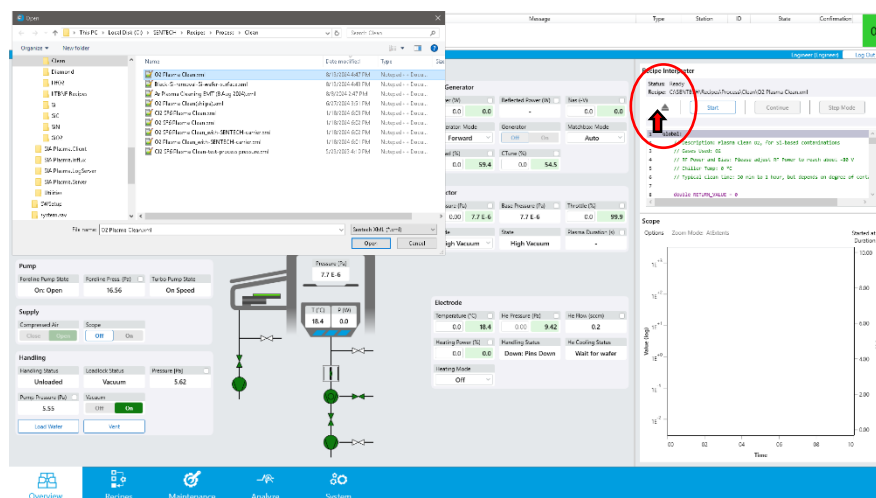
User - Engineer

Password –

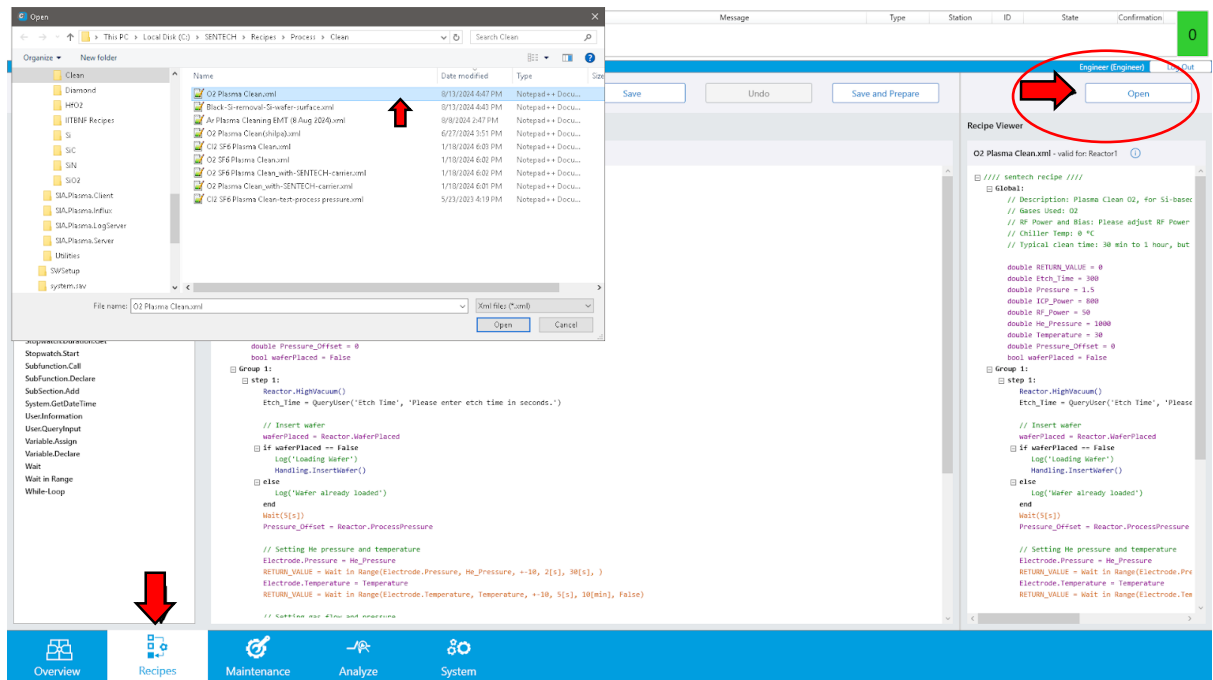
2. After login operating software will show five modes (Overview, Recipes, Maintenance, Analyze, System). For recipe modification only Overview and Recipes mode can be used. Other three modes are restricted to use.



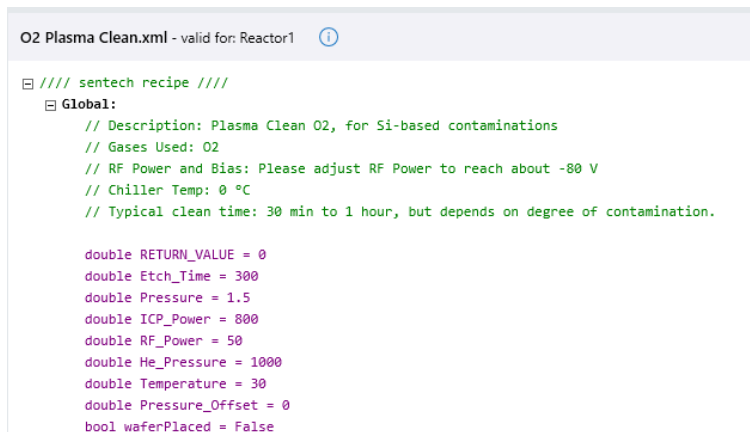
3. Select the recipe from required folder.



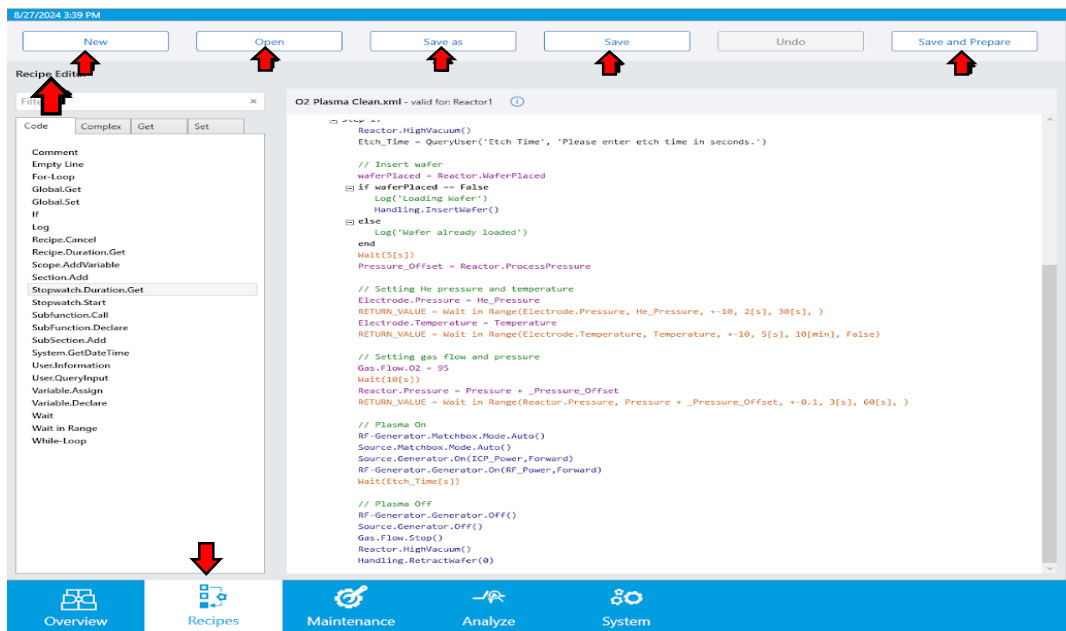
- If you want to view and check the parameters of the recipe, select recipe mode and “Open” recipe in the recipe view section.



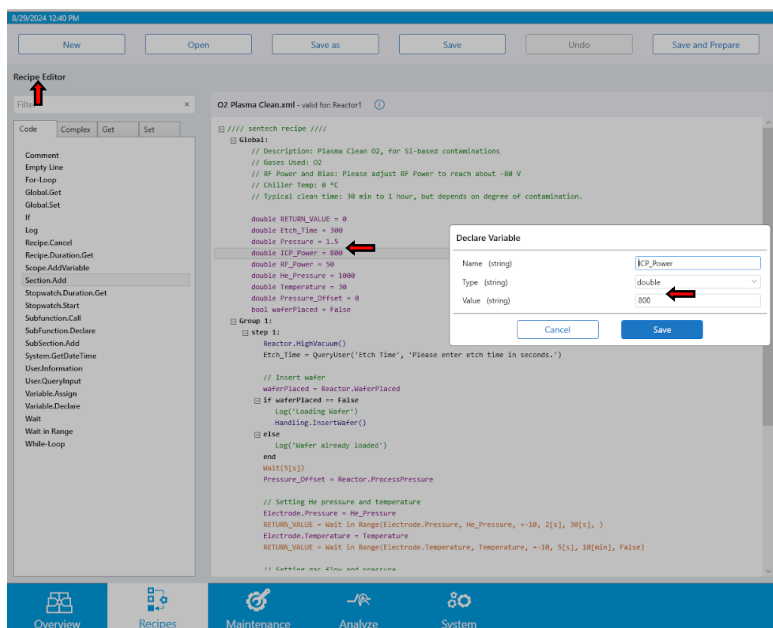
- Important parameters to be checked for the process are as shown in image.



- Recipes can be open, created, edited in the recipe section-“recipe editor mode”. (Recipe editing is disabled in operator mode).



- To make changes in any parameter of the recipe you just have to open the recipe from the respective folder in recipe editor mode. Double click on the parameter to be changed. A small window will open, make the change and save it. Changed parameters either you can save it in an existing recipe or you can save as it with different name.

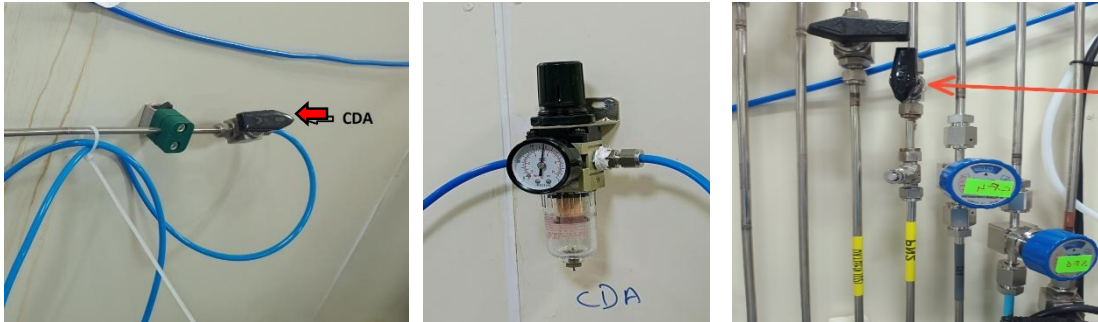


- Finally, after doing all the changes in the recipe, you can use the save and prepare option to use that recipe for run.

Tool Turn ON Procedure:

Please Note: System is ON 24X7. The system start procedure is to be followed only if the system was shut down due to maintenance activity (facility / EMT), in co-ordination with the facility & EMT team.

1. PN2 and CDA should be turned ON first, before starting the device or any process.

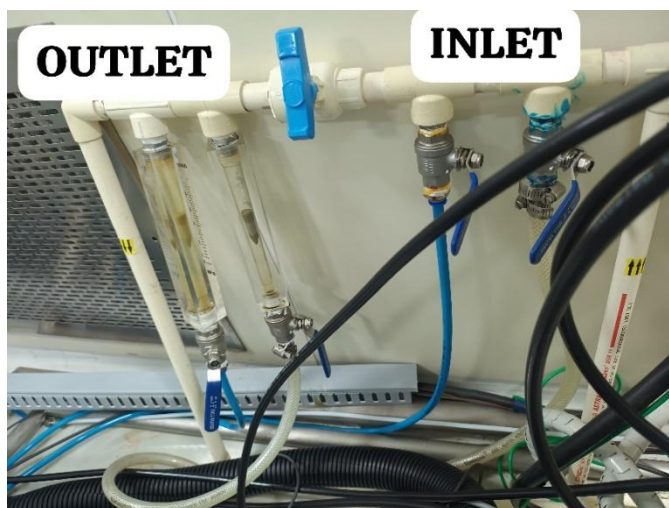


2. **Water Lines:**

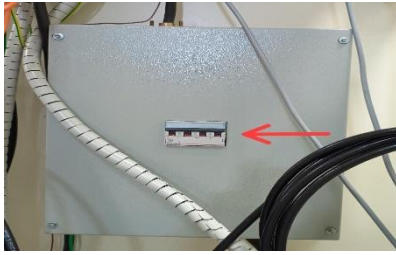
There are 2 water lines – One for main system, second for control rack

Main System: Open the water outlet valve first (has a flow meter) & then slightly open inlet water valve (blue waterline) on the manifold behind the system, adjust the flow to 6 LPM on the flow meter

Control Rack: Open the outlet water valve (has a flow meter) & then slightly open outlet water valve (white water line) on the manifold behind the system, adjust the flow to 6 LPM on the flow meter



3. Turn ON MCB (electrical power) of main MCB box on the clean room wall (back side of the tool).



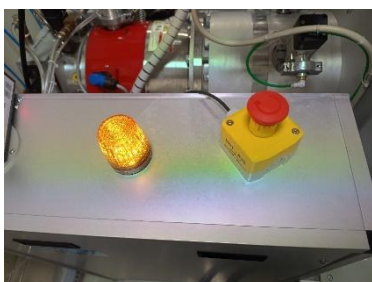
4. Turn ON the main power switch on the main power box.



5. Press the Start button (green button) below the main switch on the main power box.



6. Orange light will turn ON.



7. The turbo controller will start initializing.



8. Wait till "Ready to START" displays on the turbo controller.



9. Turn ON the heat Exchanger. Press power on the button.



10. The display will be turned ON. The display will show default temperature i.e 24°C.



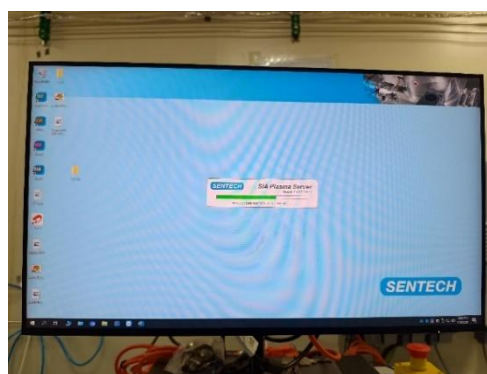
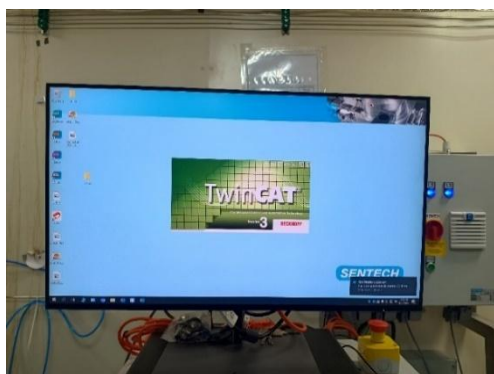
11. Press “OK” button to set the default temperature on the heat exchanger.



12. Turn ON the PC and wait till the software opens automatically.



13. Twincat software will start automatically, wait for 5 mins until it opens the login page.



14. Before logging in, errors / messages may pop up on the login page as shown below.

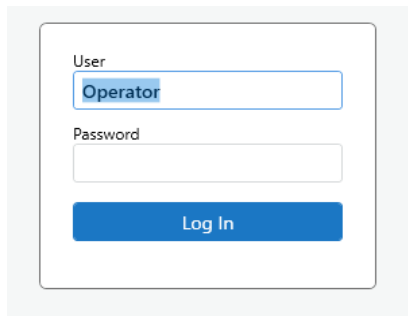


Message	Type	Station	ID	State	Confirmation
Gas box compressed air error: check door, exhaust switch, pressure and hoses	ErrorCritical	Reactor1	2601	ActiveUnconfirmed	Confirm
No Compressed Air	ErrorCritical	Reactor1	4600	ActiveUnconfirmed	Confirm

Logged Out Log Out

2

15. Login to Software



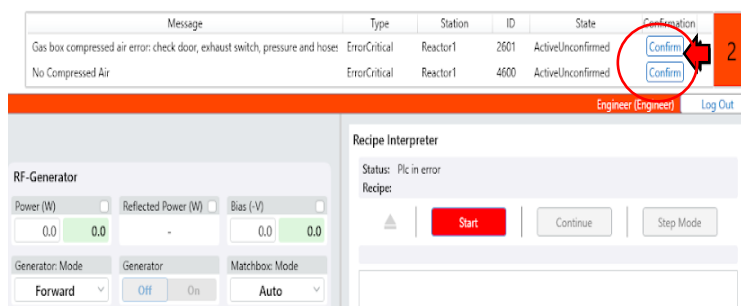
User

Password

User - Operator

Password – no Password required

16. Check the error message, check & after it is resolved click “confirm” after log in. (The process should proceed only when all the errors are resolved & confirmed.)



Message	Type	Station	ID	State	Confirmation
Gas box compressed air error: check door, exhaust switch, pressure and hoses	ErrorCritical	Reactor1	2601	ActiveUnconfirmed	Confirm
No Compressed Air	ErrorCritical	Reactor1	4600	ActiveUnconfirmed	Confirm

Engineer (Engineer) Log Out

RF-Generator

Power (W) Reflected Power (W) Bias (-V)

Generator Mode: Generator: Matchbox Mode:

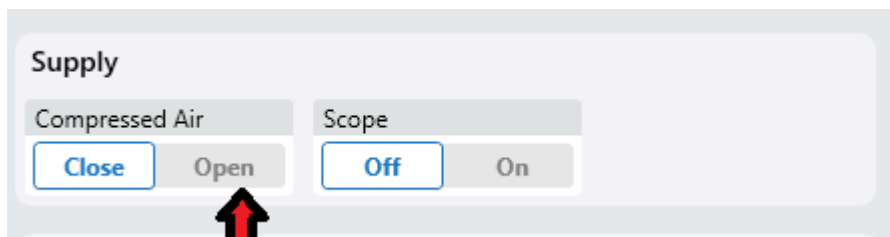
Recipe Interpreter

Status: Plc in error

Recipes:

**17. Open
“Compressed Air” from
the “Supply” section to**

resolve No compressed Air error.

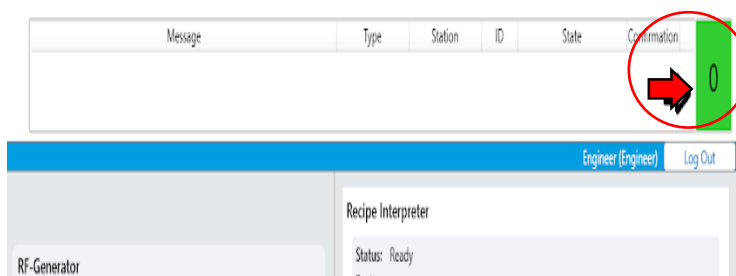


Supply

Compressed Air

Scope

18. Once all the errors become zero then proceed further.



Message	Type	Station	ID	State	Confirmation
					0

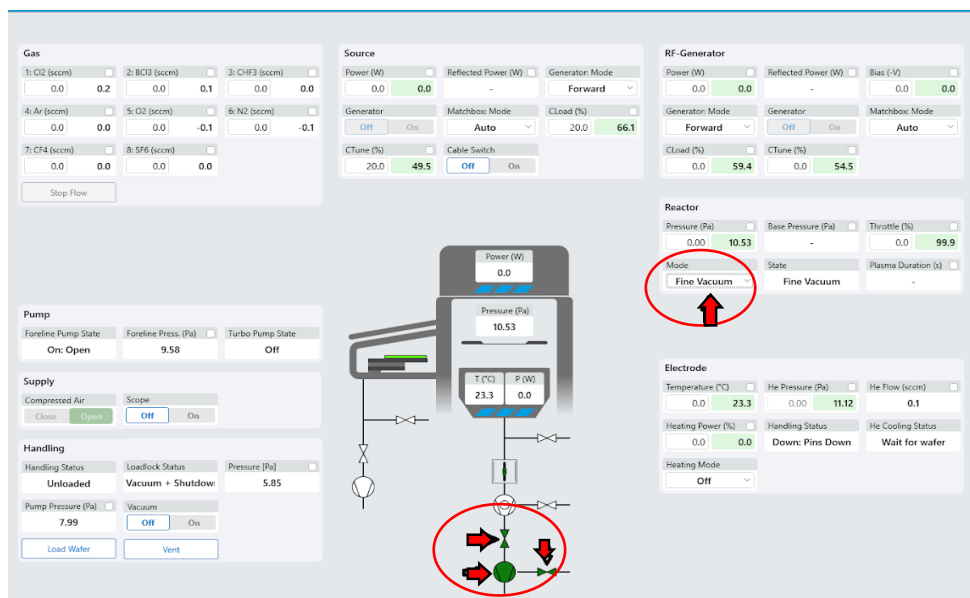
Engineer (Engineer) Log Out

RF-Generator

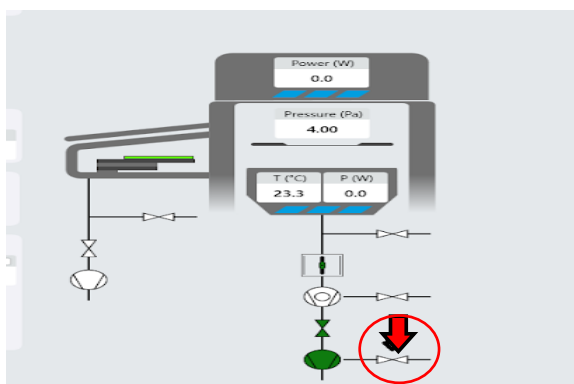
Recipe Interpreter

Status: Ready

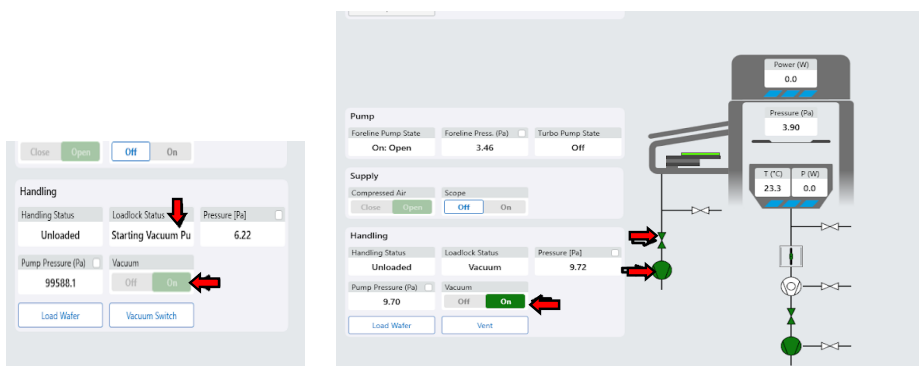
19. Switch the Reactor mode in Fine Vacuum. (Foreline pump, foreline purge valve and main valve will get turned on).



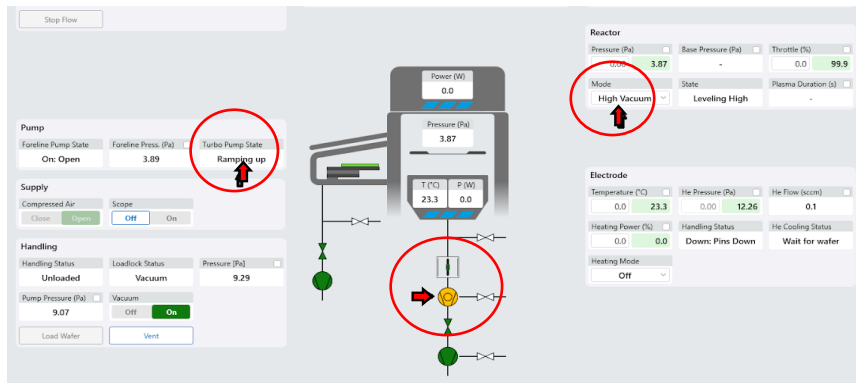
20. Wait till the foreline purging valve will turned OFF. It will take approx. 10 mins



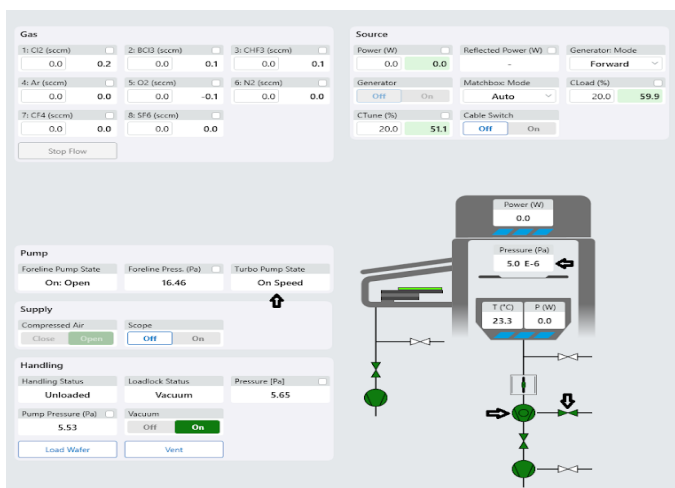
21. To create vacuum in the load lock chamber turn “vacuum” on in the Handling section. Load lock pump and Evacuation valve will turn on.



22. Switch the Reactor mode in High Vacuum. (Turbo pump, Turbo pump purge valve will get turned on and Turbo pump state will show ramping up.) Turbo controller speed will start increasing.



23. Turbo pump and turbo pump purge valve will get turned on. Turbo pump state will show “on speed”. Turbo controller speed will reach the highest speed. Wait till base pressure reaches to 8 to 5 e-6 Pascal.

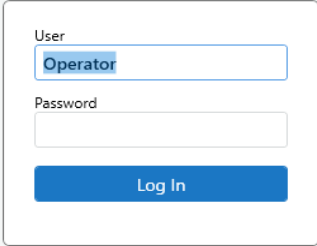


24. System is ready to run a process

Tool Turn OFF Procedure :

Please Note: System is ON 24X7. The system start procedure is to be followed only if the system was shut down due to maintenance activity (facility / EMT), in co-ordination with the facility & EMT team.

1. Login to Software



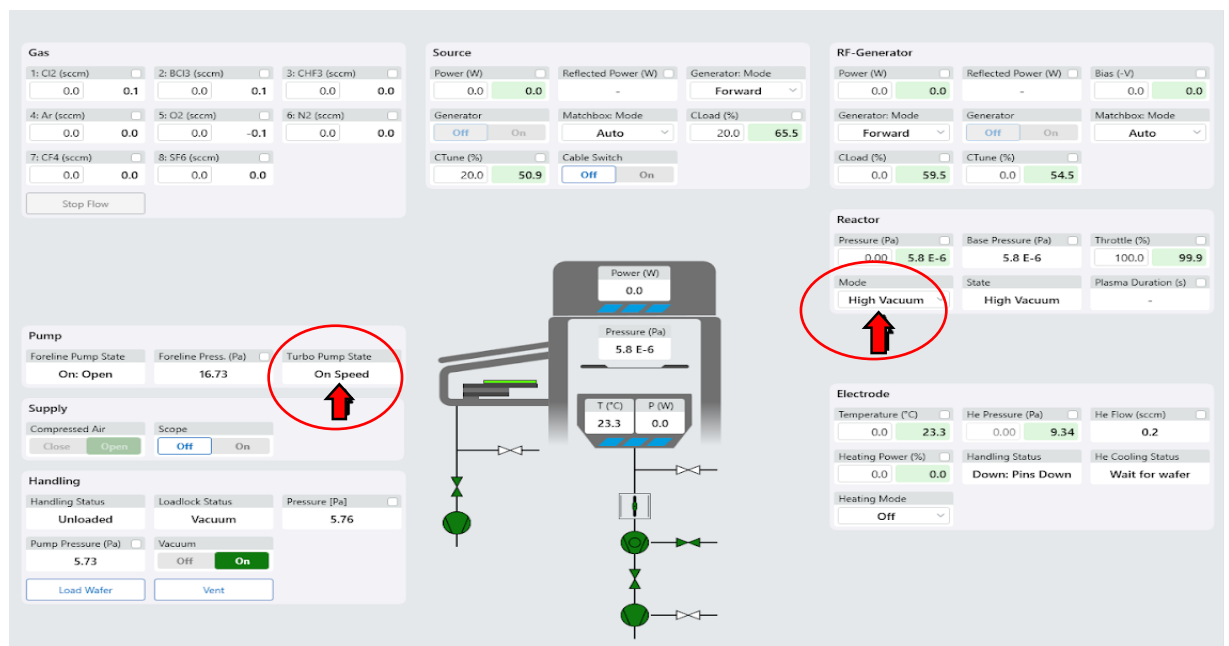
User

Password

User - Operator

Password – (there is no password, Press Enter)

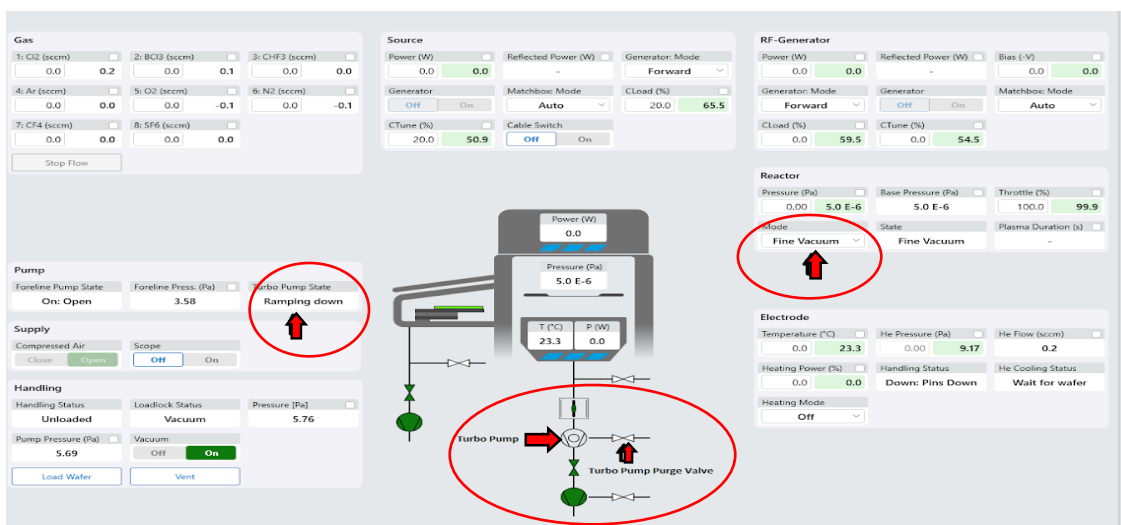
1. Below the window will open, Initially the reactor will be in High Vacuum Mode. The turbo pump state will be on speed.



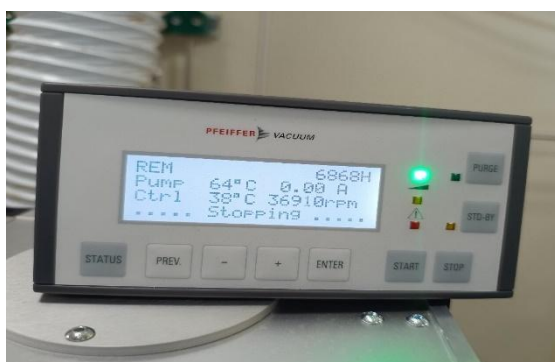
- The turbo controller will be at its full speed (39050 rpm, 1.90 A) and will show “Ok for process” .



- Switch the Reactor mode in Fine Vacuum. Turbo pump and Turbo pump purge valve will be turned off automatically. The turbo pump will start ramping down (Turbo pump state – “Ramping down”) (the speed can be seen on the turbo controller – image below).



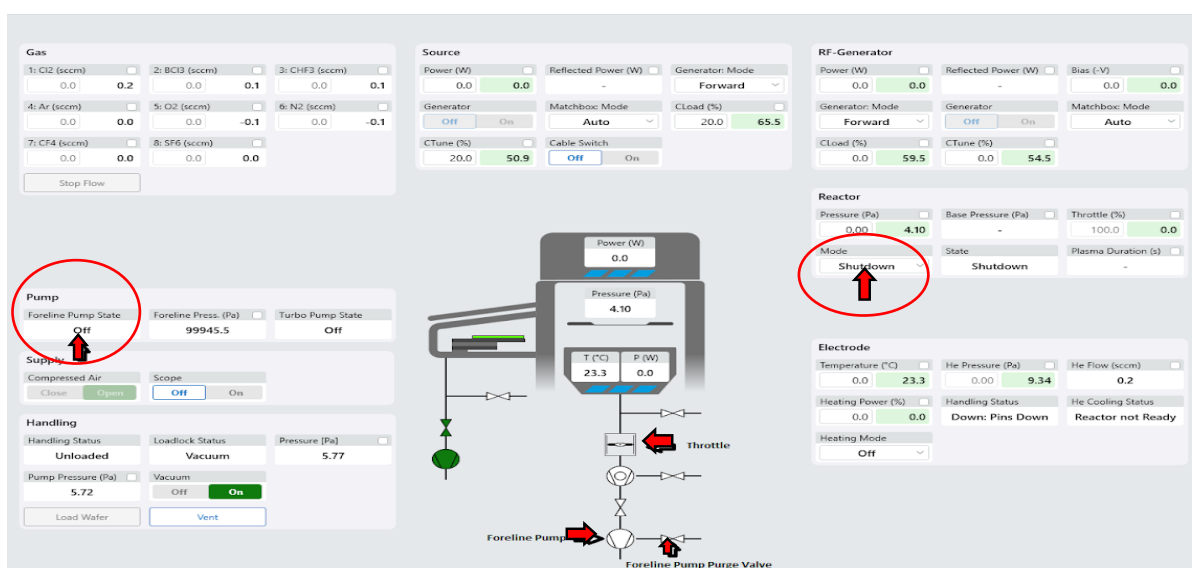
- Turbo speed on the controller will start decreasing. Display will show “Stopping”



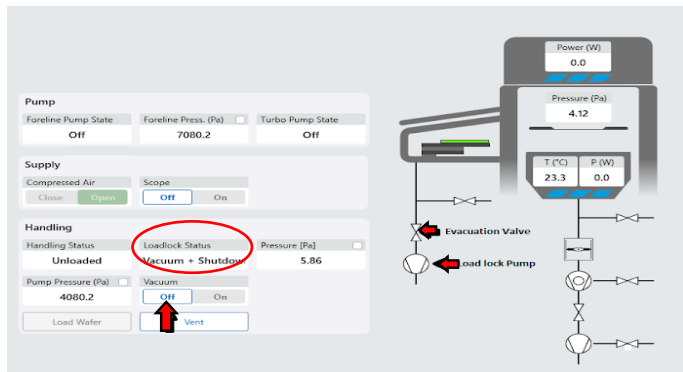
- Wait till “Turbo pump state” becomes “OFF” in the software and Turbo controller speed reaches to 0rpm (It will take approx. 20 mins)



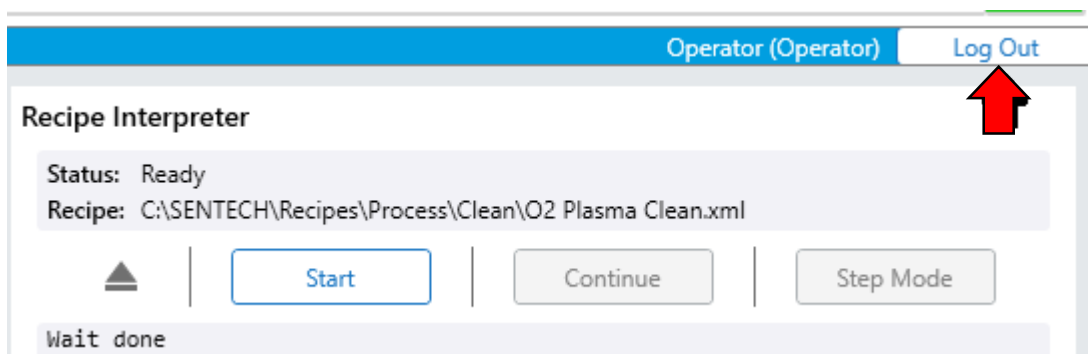
- Once turbo controller speed reaches 0 rpm, switch the Reactor mode to Shutdown. Foreline pump and Foreline pump purge valve will get turned off. Foreline pump state will become off. The throttle valve will reach to 0 position.



- Turn off load lock vacuum by clicking the vacuum off button. The load lock pump (Rotary) and evacuation valve will be turned off. Load Lock status will show “Vacuum + Shutdown” status.



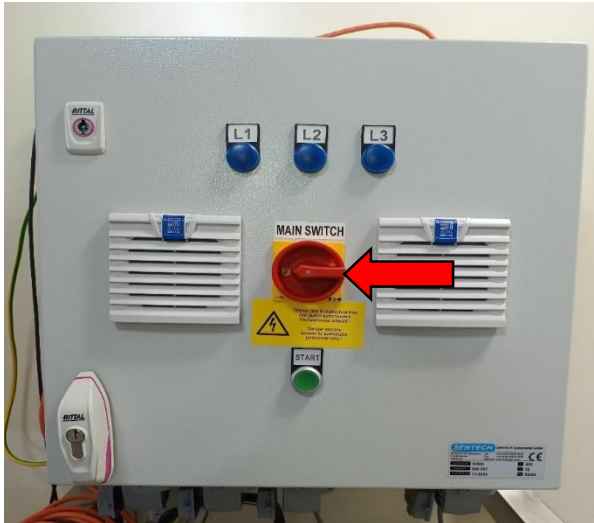
40. Logout the system.



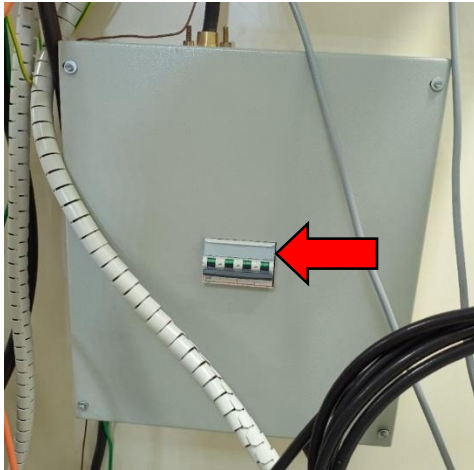
- 8. Press the Windows button on the keyboard and close the software. Shutdown PC.**
- 9. Switch OFF the heat exchanger . Press the power button OFF.**



10. Turn off the main power switch on the main power box.



11. Turn off the MCB (electrical power) on the clean room wall (back side of the tool).



12. Close all the gas valves (Except CDA)

13. Inform EMT to do water flushing of the dry pump after 1 hour.