Oxford ICP-RIE

User Manual

Manufacturer: Oxford Instrument
Instrument: ICP-RIE
Location: 2F Cleanroom, Etching Bay, Complex for Research Excellence
Contact number: 02-3366-5064; nems@mail.nems.ntu.edu.tw
Author: Yu-Ta Chen / Jheng-Ru Wu
Version: 1.1 (Nov 2023)

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1 Usage Restrictions

- Only trained and certified users are permitted to operate this equipment.
- Users employing chlorine gas must remember to fill in the chlorine usage record (the record sheet is placed on the wall in front of the equipment).
- After the process is completed, it is mandatory to place a dummy wafer during **chamber cleaning**.
- Please bring your own 4-inch/8-inch dummy wafer.

1.1 Material Restrictions

- Chamber 1: Primarily silicon-based materials; iron, cobalt, nickel, copper, gold are prohibited.
- Chamber 3: Mainly metallic, III-V, and II-VI group materials; iron, cobalt, nickel, copper, gold are prohibited.

1.2 Size Restrictions

- Chamber 1: 4-inch wafers or less with a carrier
- Chamber 3: 8-inch wafers or less with a carrier

1.3 Sample Preparations

- When using broken pieces, use PI tape to fix each corner or apply a small amount of thermal grease under the wafer, then place it on the dummy wafer for stabilization. Excess thermal grease can be cleaned using denatured alcohol and lint-free swabs.

2 Pre-Use Inspection Checklist

☐Cooling water pressure > 2 kg/cm^2
☐Chlorine gas detector showing a green light.

After check-in,

☐Check all status indicators are green.
☐Check Arm home & Peg Switch 1 are green.
☐Check load lock indicators and pressure < 8 $x10^{-2}$ Torr
☐Check process chambers indicators and pressure ~10^{-7} Torr

3 Standard Operating Procedures

3.1 Introduction to Oxford ICP-RIE

As shown in Figure 1, the Oxford ICP-RIE includes a transfer load lock and two process chambers (Chamber 1 and Chamber 3). Chamber 1 performs reactive ion etching (RIE) exclusively, while Chamber 3 additionally features an inductively coupled plasma (ICP) module.

Transfer loadlock: Connects Chamber 1 and Chamber 3, holds the sample, and transfers it to the respective reaction chambers.

Chamber 1: RIE chamber

Chamber 3: ICP-RIE chamber

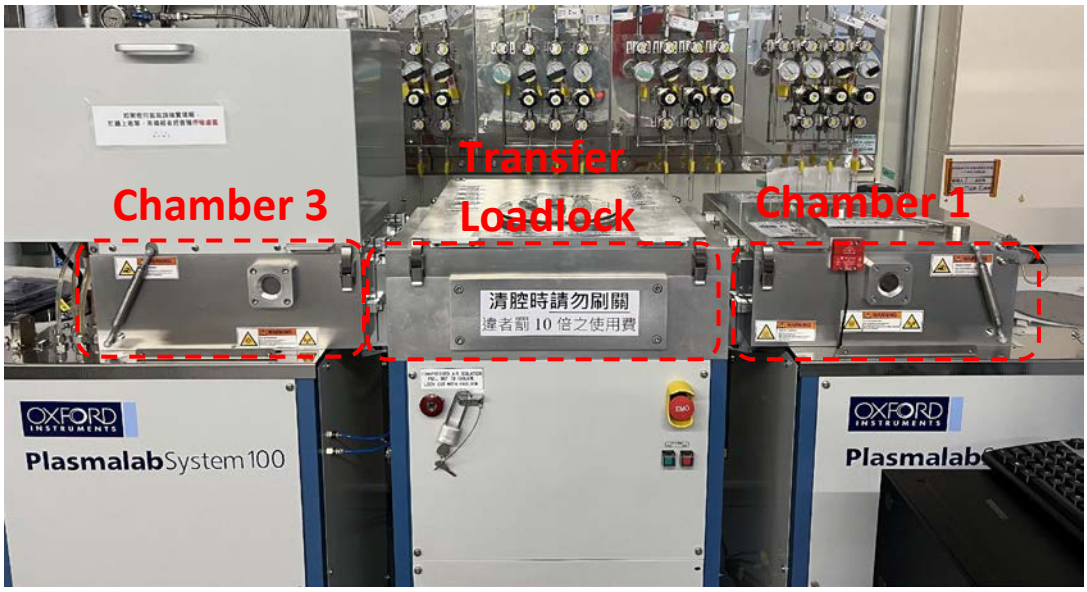

Figure 1 Transfer loadlock and reaction chambers

3.2 Software Interface

Figure 2 represents the system operation interface, accessible through System → Pumping in the top left corner of the interface. It primarily allows monitoring of the pressure, valves, valve connections for transfer loadlock, Chamber 1, Chamber 3, as well as tray transfer and mechanical arm status. This allows operations such as vacuuming, venting, tray transfer, etc. You can access the operation interface for Chamber 1 & 3 from the top left corner of the interface to set process parameters

and time. Users are only permitted to access System → Pumping, Processing → Chamber , and Chamber 3 interfaces for operations; other pages are restricted from user access."

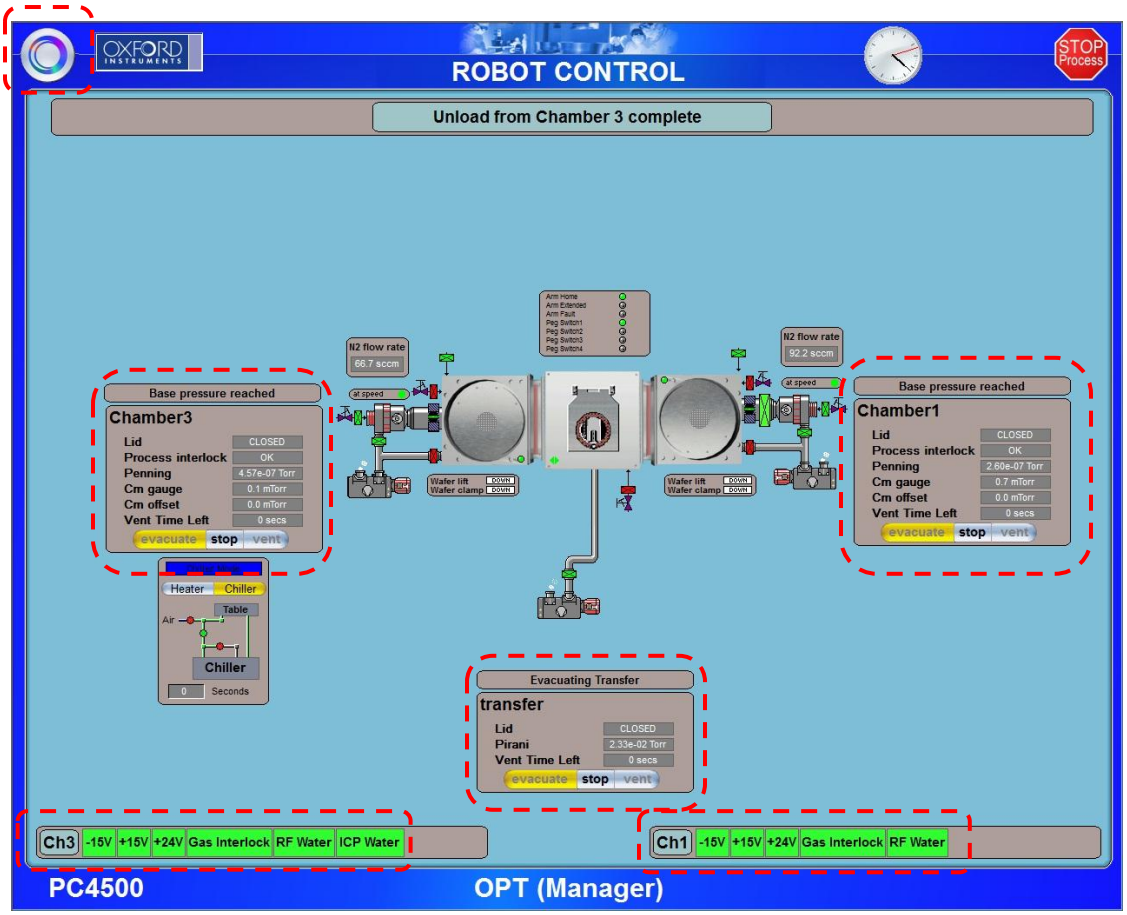

Figure 2 System operation interface

3.3 Vacuum Venting

When breaking the vacuum in the transfer loadlock, please press stop, wait for two seconds until there's a release of gas, then press vent to break the vacuum. Approximately 30 seconds of nitrogen purging will occur, followed by a countdown of 200 seconds to break the vacuum. If it's solely a vacuum release and the preceding process doesn't involve chlorine, it's permissible to open the chamber at around 120 seconds remaining. For processes involving chlorine, it's recommended to wait for the complete vacuum break time.

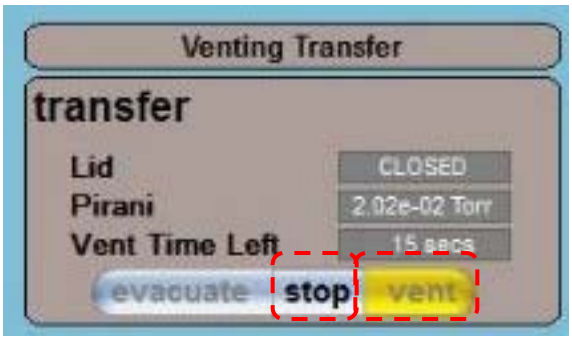

Figure 3 Transfer loadlock pump operation options

3.4 Sample Loading

In Chamber 1 (RIE), 4-inch wafers can be placed, whereas Chamber 3 (ICP-RIE) accommodates 8-inch wafers. As illustrated in the diagram below, when placing a 4-inch wafer, align it with the marker line, ensuring the flat edge is at the bottom (facing oneself). For an 8-inch wafer, align it with the top and bottom alignment pins, ensuring not to exert excessive force to avoid moving the robotic arm. Once placed, ensure that the green light for ARM HOME remains illuminated. ◦

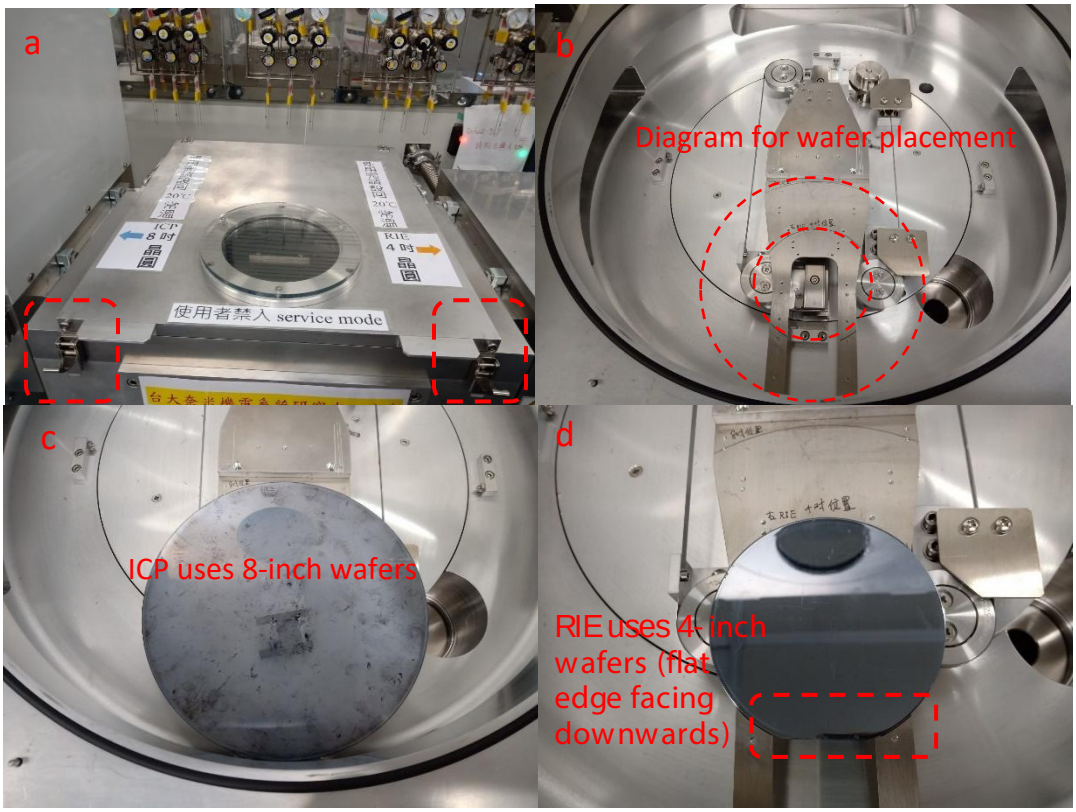

Figure 4 a. Chamber switch positions, b. Illustration for placing 4-inch and 8-inch wafers, c. ICP uses 8-inch wafers, d. RIE uses 4-inch wafers, and the flat edge should face yourself."

3.5 Vacuum Evacuating

After placing the wafer, when vacuum extraction is required for the transfer loadlock, press 'stop' first, wait for two seconds, then press 'evacuate.' This action initiates the vacuum extraction. When the vacuum reaches the required level, the green arrow indicator light will illuminate, and the pressure should be less than7 x 10^{-2} Torr。

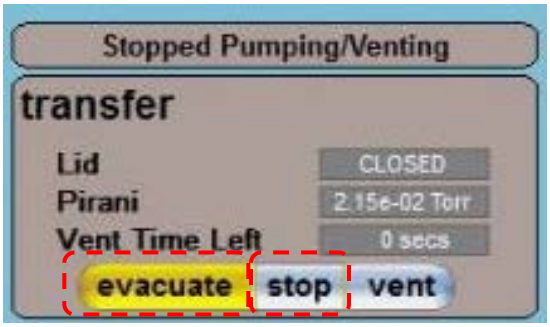

Figure 5 Executing the vacuum extraction. Please press stop → evacuate

When 'evacuate' is pressed, a window will prompt to input the 'Wafer name.' Enter any number and press 'Ok.' The green circular tray symbol will then appear on the transfer loadlock.

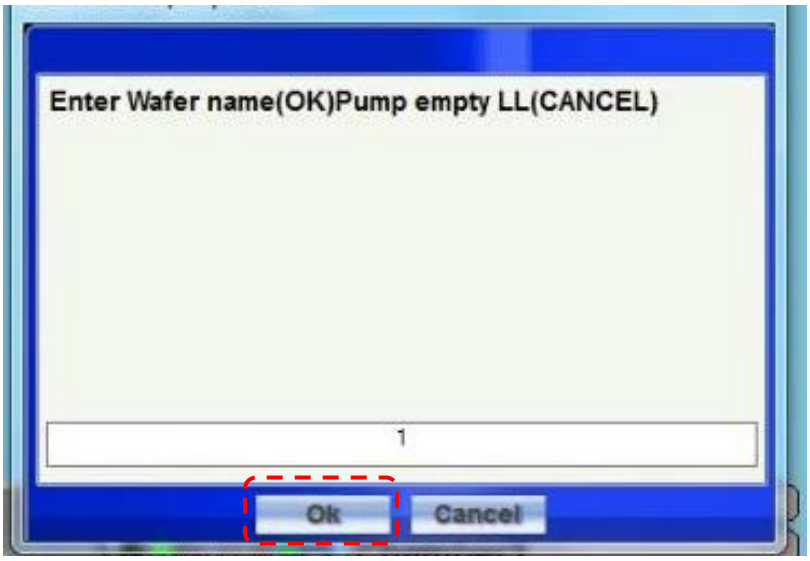

Figure 6 Window for entering the wafer name.

3.6 Wafer Transfer

If you need to transfer the tray to the reaction chambers, click on the green tray. This will bring up options for the blue moving path, as shown in the diagram below.

You can choose to transfer it to Chamber 1 (RIE on the right) or Chamber 3 (ICP on the left). After selecting the destination, the robotic arm will start the transfer process.

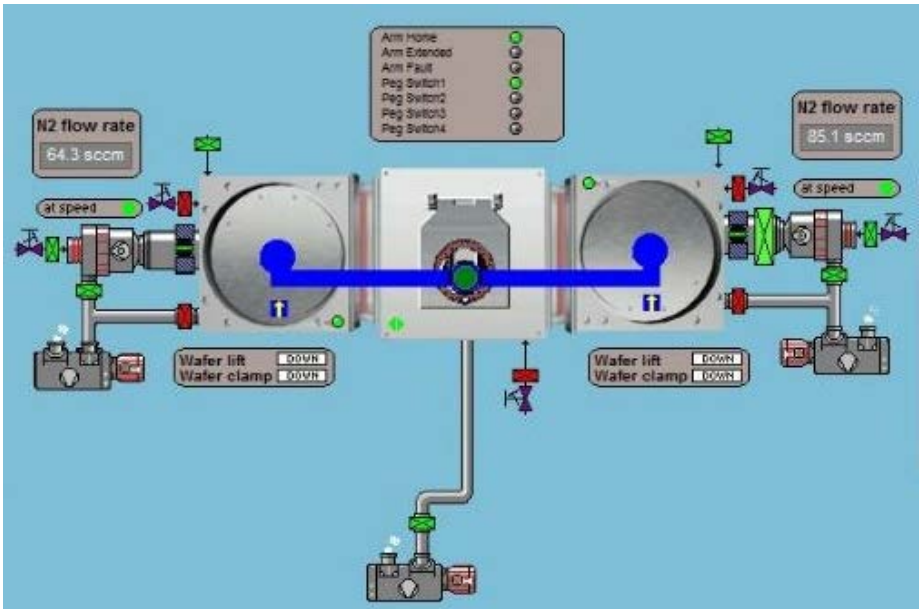

Figure 7 Path available for the tray's movement

Once the tray completes the transfer, in the case of Chamber 1, the green tray will appear in Chamber 1 on the right. You'll also receive a message in the upper message box confirming Load complete wafer loaded to Chamber 1。

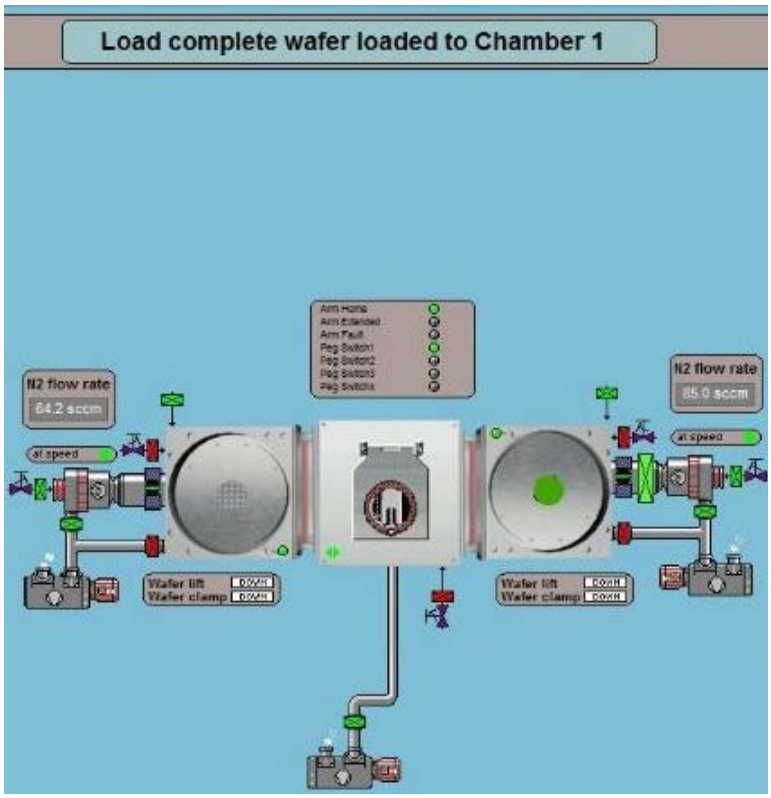

Figure 8 Transfer of the tray completed, with a message appearing in the upper signal box confirming the completion of the transfer.

3.7 Process Setup

The interface for Chamber 1 and Chamber 3 is similar, so Chamber 3 will be used as an example.

- Process Control (Run stop pause jump):
  Do not select 'ignore tolerance,' as this will disregard any parameter abnormalities and force execution.
- Process Time (Step time): h:r:s
- Logging Interval: 5s (regular); 1 s (with Cl_2)
- Plasma Power:
  HF:0~300 W
  ICP: 0~3000 W
  Reflected: Should be less than 13W within 7 seconds; otherwise, the process

will forcibly terminate. If terminated, please 1. remove the sample, clean the surface using nitrogen gun, and 2. run a 10-minute chamber cleaning.
DC bias: A value greater than 0 indicates plasma ignition. If the value is 0, discuss with the administrator.

- Process Pressure (Automatic Pressure Control - APC): Unit in mTorr
- Helium Backing for Table Cooling: Notify staff in advance if needed.
- Process Table Temperature:
  Ideal temperature:-30°C~30°C
  Actual temperature: -10°C ~30°C
  Default temperature is 20°C
  After the experiment, reset the default temperature for each chamber.
- Process Gases:
  Total gas flow limit is 200 sccm. Gas Presets can be used to check the flow limit for each gas.

Note: During the experiment, monitor any abnormal changes throughout the process!!

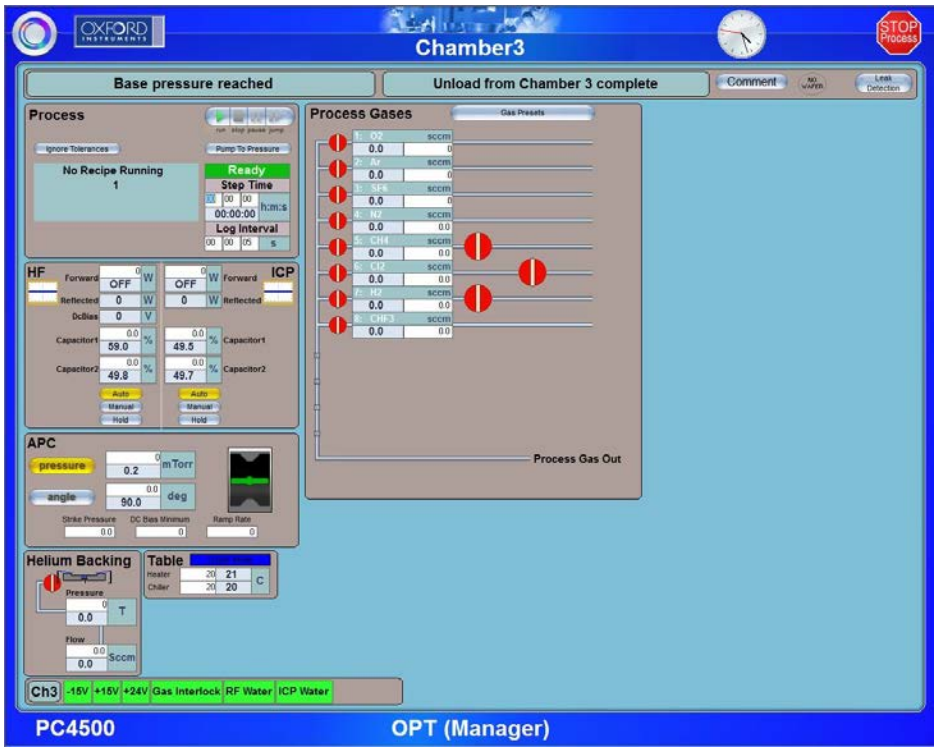

Figure 9 Process setup interface for Chamber 3

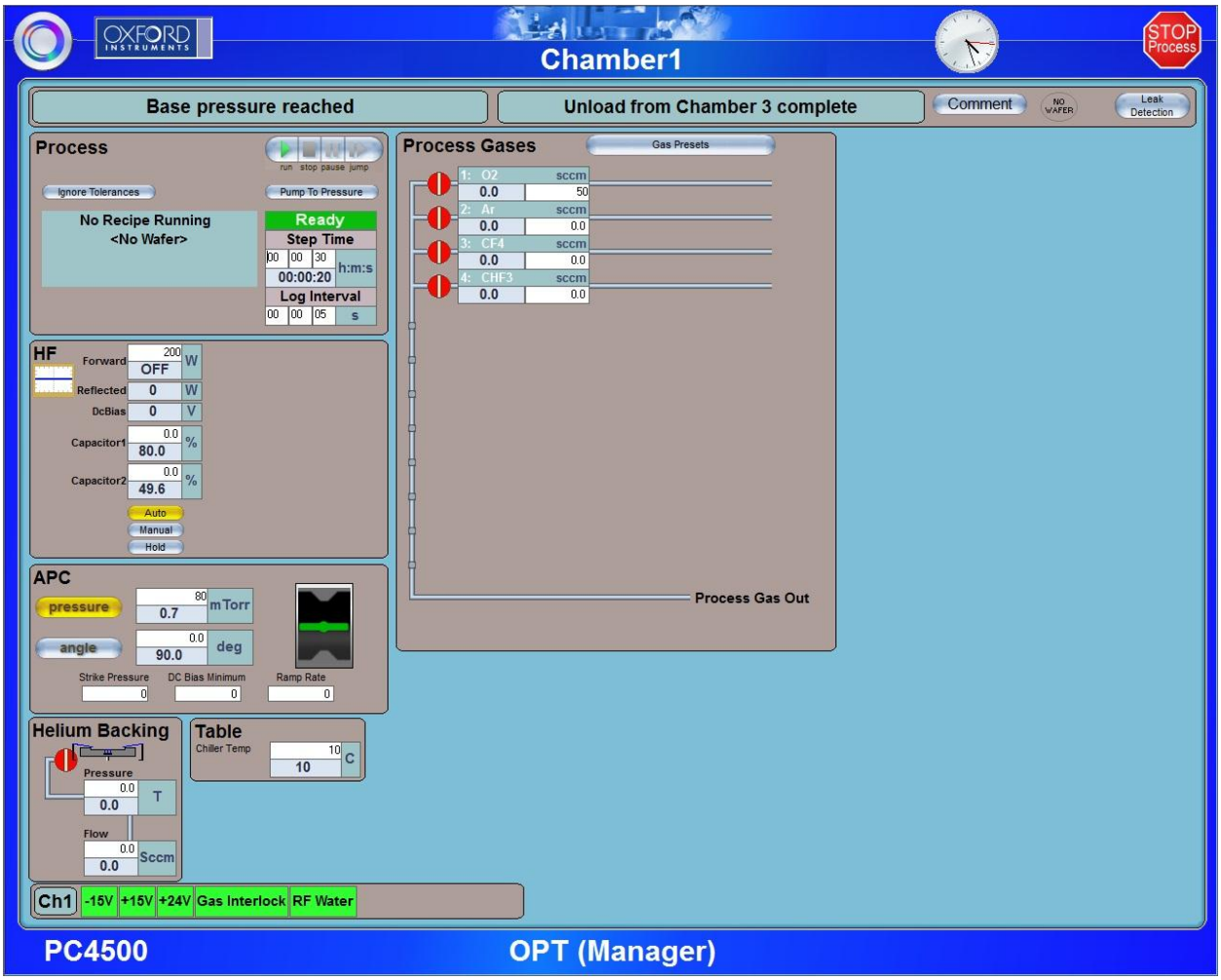

Figure 10 Process setup interface for Chamber 1

3.8 Chamber Cleaning Process

After the completion of the process, users are required to conduct a 10-minute chamber cleaning, regardless of whether it's a chlorine or non-chlorine process. Remember to manually insert the dummy wafer into the reaction chamber and then initiate the cleaning process.

Chamber 1(RIE) Cleaning Parameters

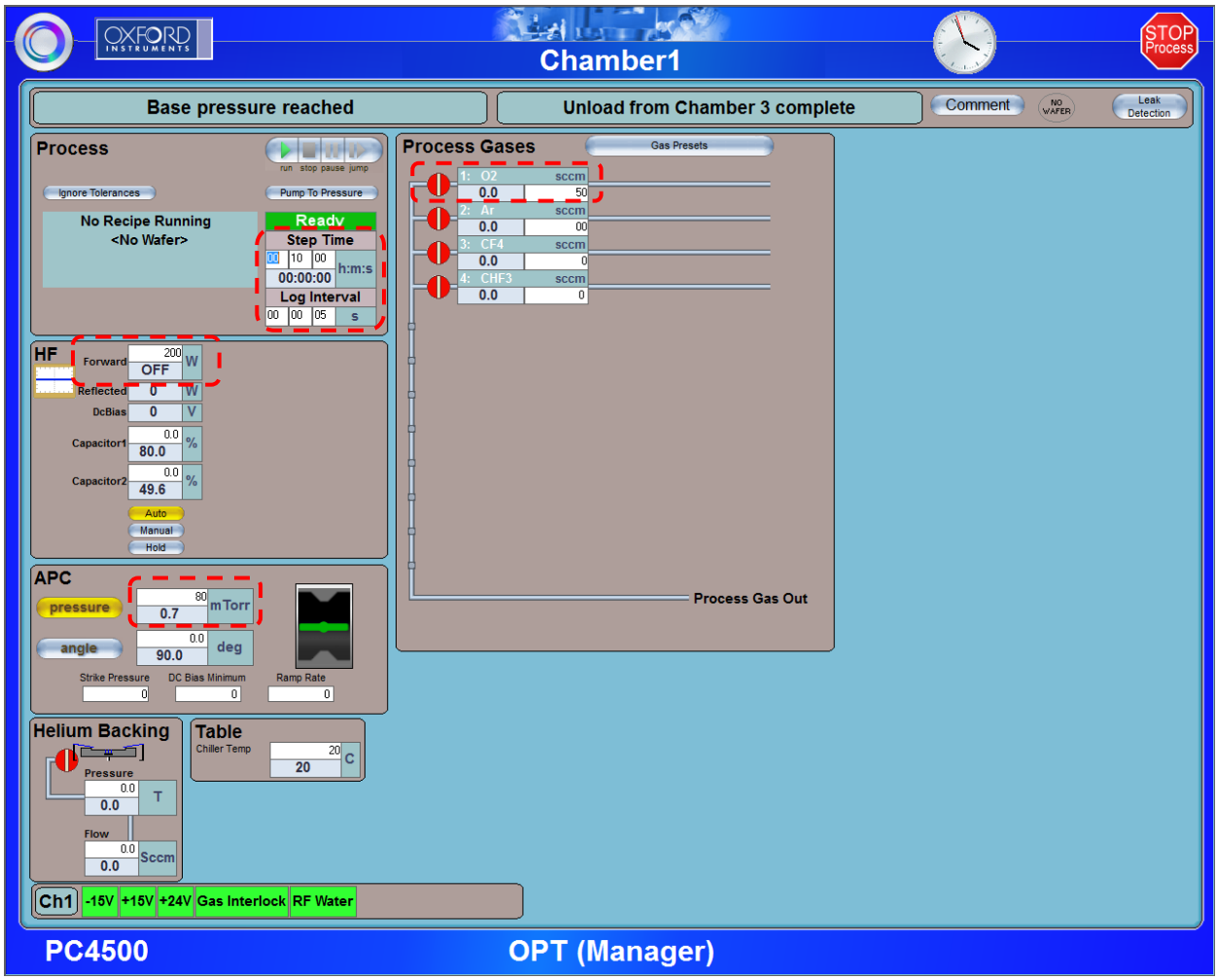

Figure 11 Chamber 1 Cleaning Parameters

Step time: 10 mins
Log interval: 5 s
HF Power: 200W
APC pressure: 80 mTorr
O_2: 50 sccm

Chamber 3 (ICP-RIE) Cleaning Parameters

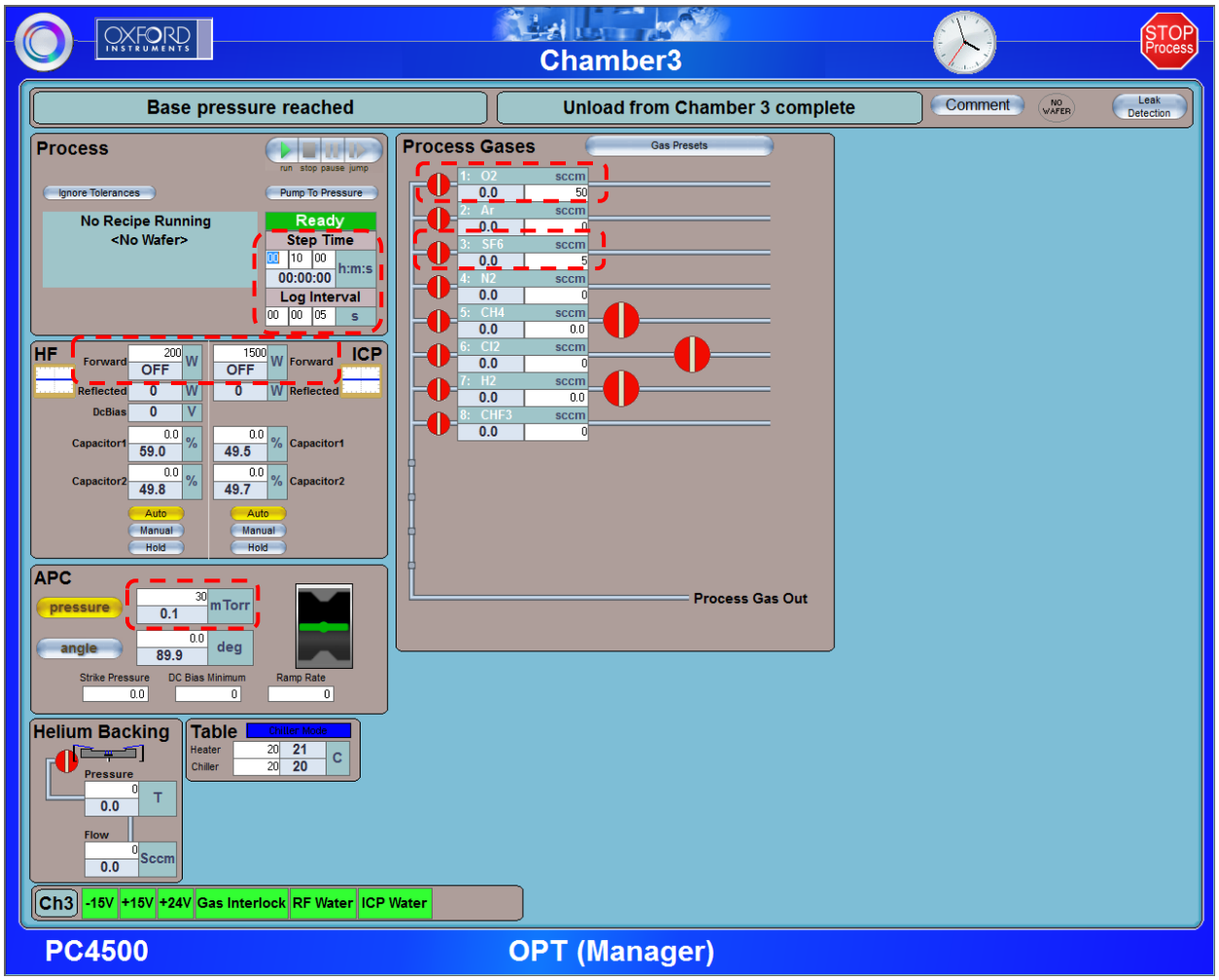

Figure 12 Chamber 3 Cleaning Parameters

Step Time: 10 mins
Log Interval: 5 s
HF Power: 200W
ICP Power: 1500 W
APC pressure: 30 mTorr
O_2: 50 sccm
SF_6: 5 sccm

3.9 Chamber pump down

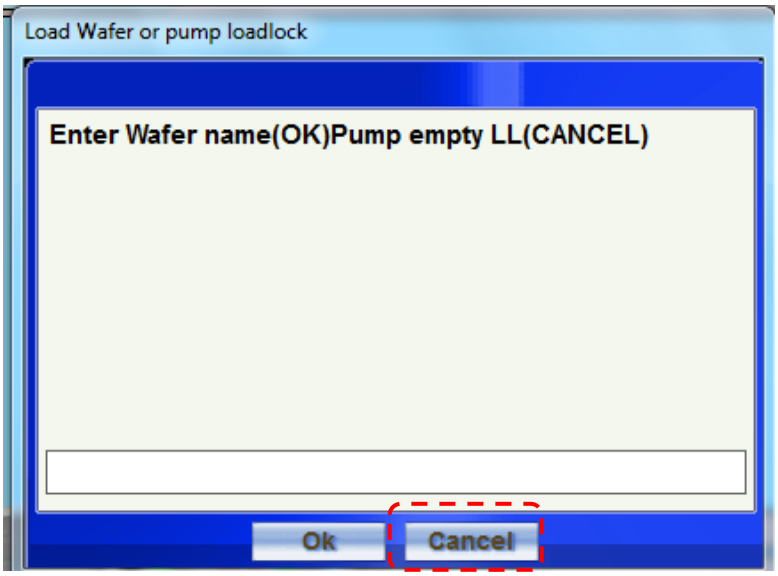

Figure 13 Click Cancel to deactivate the green tray indicator

4 Post-Use Inspection Checklist:

- ☐Ensure all status indicator lights are green
- ☐Arm home & Peg Switch 1 are green
- ☐Check loadlock indicator and pressure $< 7 \times 10^{-2}$ Torr
- ☐Check process chambers indicators and pressure ~10^{-7} Torr
- ☐Check the cleaning process is completed
- ☐Check the green tray indicator light has been cancelled

After everything is set, you can check out.

5 Version History

Version	Time	Author	Note
1.0	April, 2023	Yu-Ta Chen/Jheng-Ru Wu	
1.1	Nov, 2023	Yu-Ta Chen	● Regardless of process gas, a carrier wafer must be used for the cleaning process