Operation procedure of Oxford Plasmalab 100 metal etcher (Oxford-C) for Regular users

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1. Introduction

Oxford-C system is a fully automatic inductively coupled plasma (ICP) etcher. Its vacuum system, plasma power and matching circuits, lower electrode temperature, gas flow and sample transfer are all controlled by a console computer through an onboard programmable logic controller (PLC).

a. Vacuum system and auto pressure controller (APC): Oxford-C has a process chamber and a loadlock, both are pumped by their turbo molecular pumps and backed by rough pumps. The APC controls the process chamber pressure through a throttle valve during etching. The process pressure ranges from 1 mTorr to 100 mTorr.
b. Plasma circuits: Oxford-C has two independent power suppliers. The maximal ICP power is 3000 W and the maximal electrode power (RF) is 300 W, both are 13.6 MHz. It is required to limit the power to 2500 W and 250 W respectively, for this tool

during normal operation. Both power suppliers are auto-matched. **No manual matching is allowed without the permission from the tool manager**.

c. Lower electrode temperature: The temperature of the lower electrode, where the sample sits, can be set between -150 ^{o}C and 400 ^{o}C. The heat exchange is implemented by blowing helium to the sample/sample carrier from the backside.

d. Gas flow: Oxford-C has 12 gas lines (Cl_2, BCl_3, $SiCl_4$, HBr, CH_4, H_2, N_2, Ar, O_2, CF_4, SF_6 and C_4F_8) whose gas flows are controlled by their mass flow controllers (MFCs) individually and are pre-mixed in the gas pod box before fed into the plasma chamber. The maximal flow for each MFC is 100 sccm.

e. Sample transfer: The tool has a robot arm transferring samples between the loadlock and the process chamber. In the process chamber there is a mechanical clamp holding the sample on the lower electrode. The clamp is typically for 4" wafer. A 3" wafer clamp is also available on request. For small piece samples, a carrier wafer is needed to hold it. Consult tool manager for the right material of your carrier wafer.

2. Operation flow
   a. On arrival, log in the log station.
   b. Turn on liquid nitrogen valve.
   c. Log in Oxford-C console computer.
   d. Load your sample(s) and pump down the loadlock until the vacuum reaches the base pressure. **(5 x 10-3 transfer Pirani , 1 x 10-5 Process Gas)**
   e. Load, modify or create a recipe
   f. Run the recipe
   g. Vent the loadlock and unload the sample
   h. Load a blank wafer and run a cleaning recipe according to your etching recipe. Consult the tool manager regarding the right cleaning recipe.
   i. Log off Oxford-C console computer.
   j. Log off the log station.
   k. Turn off the liquid nitrogen valve.
3. Operation procedures

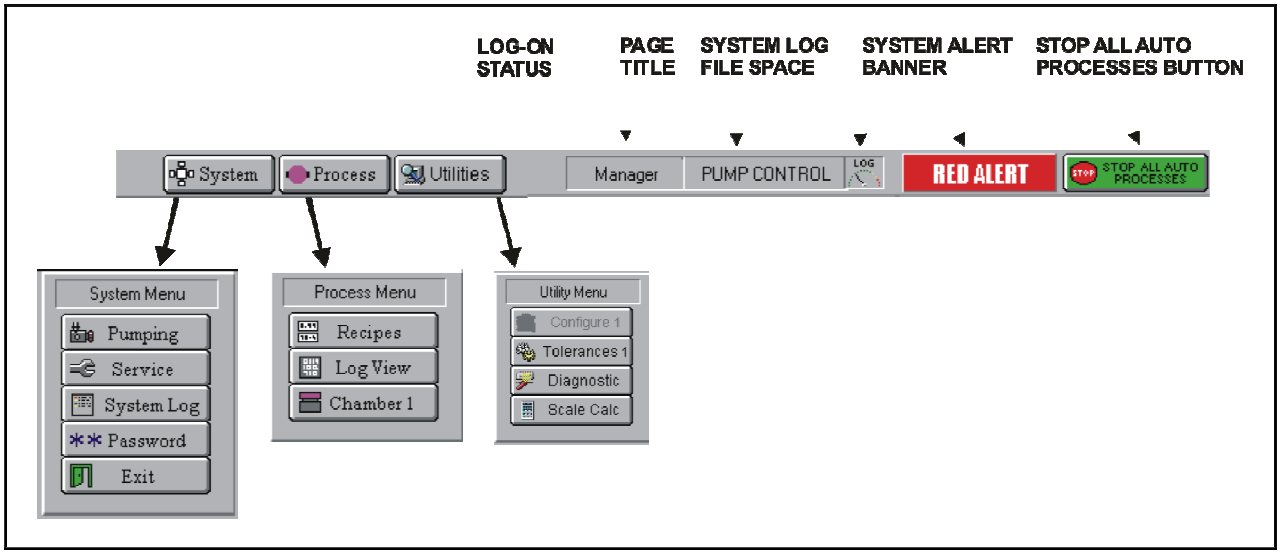

Fig. 1 Manu bar

a. PC 2000 software
The control software of Oxford-C system is called PC2000. This software is running 24/7 and is not allowed to quit normally by the regular users. The PC2000 facilities are accessed from the menu bar at the top of the screen as shown in Fig. 1. For regular users, only "System->Pumping", "System->Password" and the items in "Process" menu are accessible. The current user account name and the current page name are shown in the middle of the menu bar. The "Stop" icon at the right end of the menu bar is a software EMO (Emergency Mains Off) button. Once clicked, the running process will be stopped and the machine will be reset. Only the tool manager can unlock the tool after an EMO is initiated.

b. Log in and log off

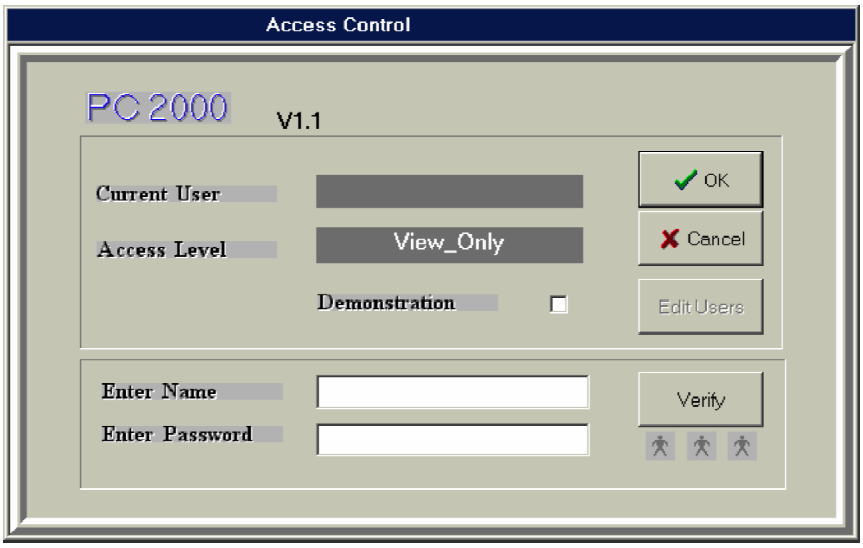

Fig. 2 Access Control window

i. Log in and log off operation can be performed in "Access Control" window (Fig.2), which pops-up after "System->Password" is selected or the "LOG-ON STATUS" area is clicked (see Fig.1 for the location).
ii. To log in, enter user name (CFNUSER) and password (will be released to trained users after training) and click "Verify" button.
iii. To log off, leave user name and password blank and click "Verify" button.

c. Load and unload samples
i. The tool automatically loads and unloads the wafer between the loadlock and the process chamber. All that users need to do is loading and unloading the process wafer to and from the loadlock.
ii. The loadlock is typically under vacuum with a blank wafer sitting on the robot arm. This wafer is generally used for chamber cleaning process.
iii. To load a wafer
1. Switch current page to "Chamber 1" by selecting the menu item "Process -> Chamber 1". Ensure that "No wafer" shows in a cycle under the menu bar and the text box under the "Process Control" panel (upper left corner of the page) shows "No Recipe Running", as shown

in Fig. 3. If the cycle is solid green, it means a wafer is left in the process chamber. Contact the tool manager for help.

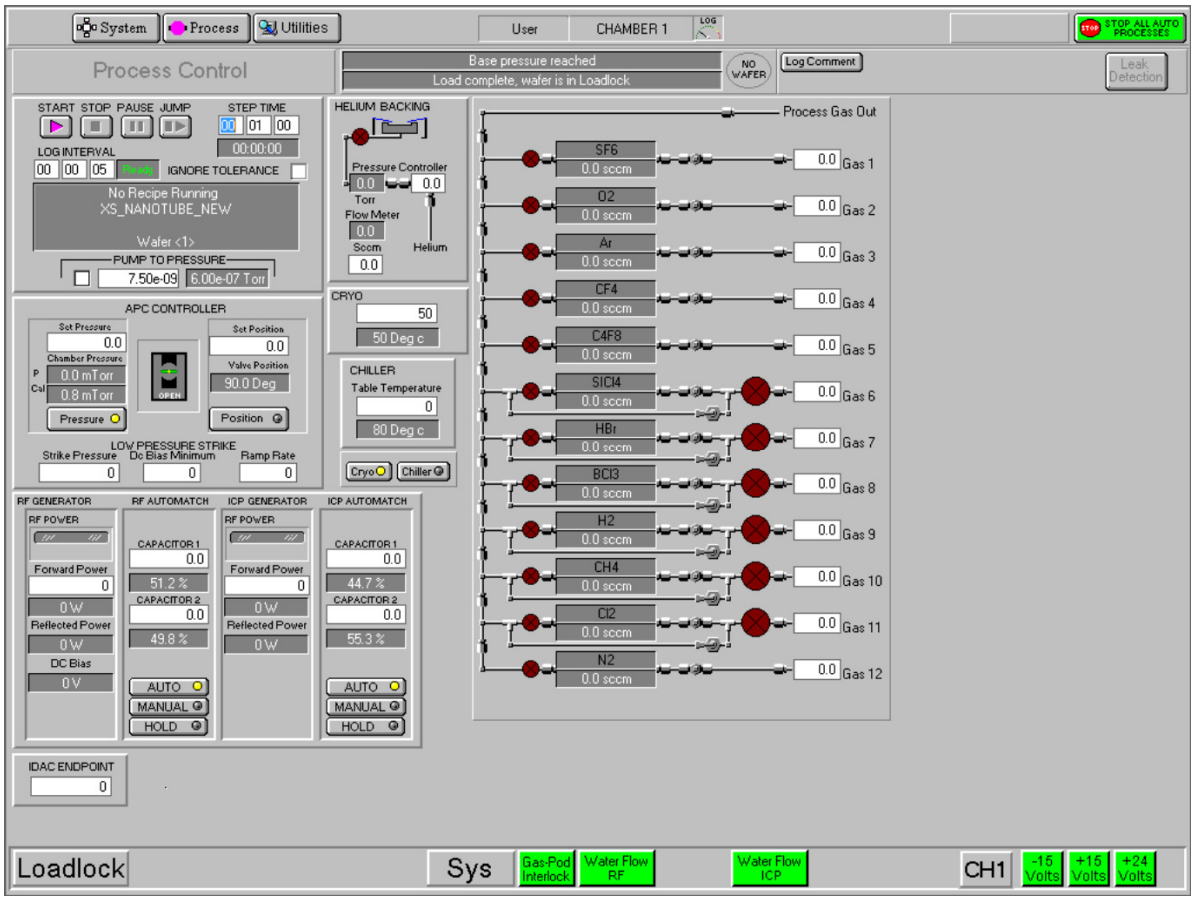

Fig. 3. Chamber 1 page

2. Switch current page to “Pump Control” by selecting menu item “System->Pumping”. The “Pump Control” page is shown in Fig. 4.
3. In the “Loadlock status” panel at lower left part of the page, click “STOP” then “VENT”. Wait until “Vent Time Left” shows 0 secs.
4. Open the loadlock lid, put in a wafer. Push the wafer all way left to the alignment cylinders. Don’t leave gap.
5. In the “Loadlock status” panel, click “STOP” then “EVACUATE”. A window will pop-up and ask for the wafer name. Input a unique name for this sample. This name will be used to identify all the log data related to the processes on this sample. Wait until the “Ready for transfer” indicators at the upper left corners of both the process chamber and the loadlock chamber turn to green, which means the vacuum is ready for the plasma process.

iv. To unload a wafer

1. Make sure the wafer to be unloaded is sitting on the robot arm in the loadlock.

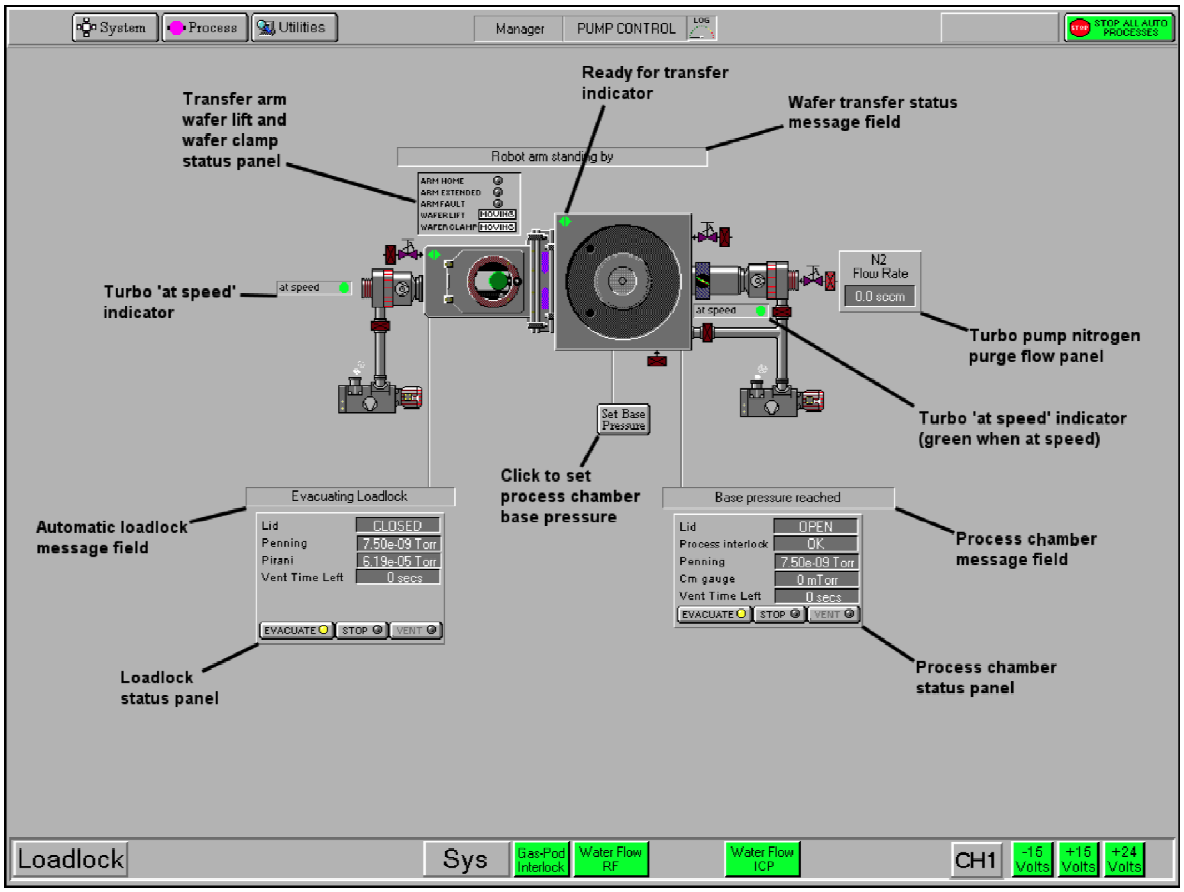

Fig.4. Pump Control page

2. Switch current page to “Chamber 1” by selecting the menu item “Process -> Chamber 1”.
3. Make sure the readings in all the MFC icons (under the name of each process gas) are **ZERO**.
4. Switch current page to “Pump Control” by selecting menu item “System->Pumping”.
5. In the “Loadlock status” panel at lower left part of the page, click “STOP” then “VENT”. Wait until “Vent Time Left” shows 0 secs.
6. Open the loadlock lid and take out the wafer.

d. Load a recipe
   i. Switch current page to “Recipes” by selecting the menu item “Process -> Recipes”, as shown in Fig. 5.
   ii. Click “Load” button in the upper middle part of the page. Select your recipe in the pop-up window.

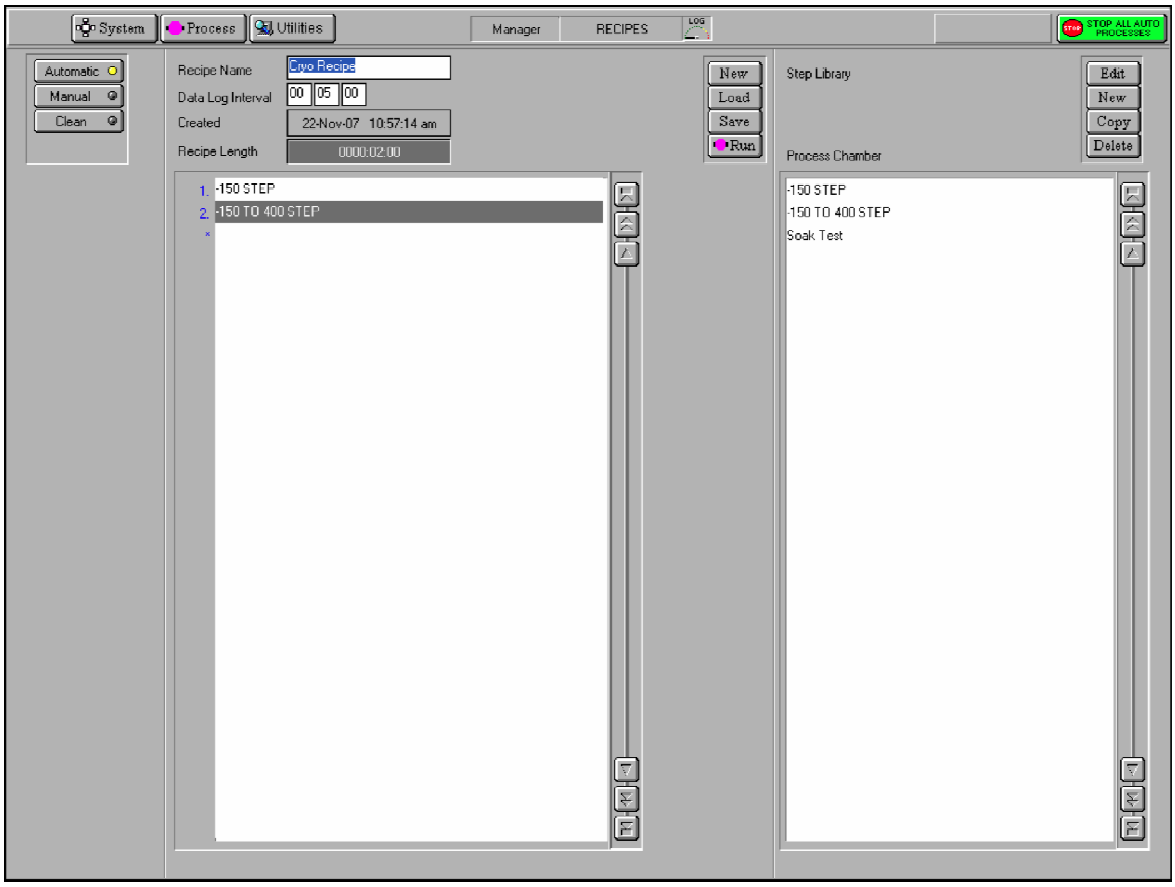

Fig. 5. Recipes Page

e. Create or edit a recipe
   i. Switch current page to “Recipes” by selecting the menu item “Process -> Recipes”.
   ii. As shown in Fig. 4, in the “Recipes” page, there are two white list boxes. The right one is the Step Library list, which is to store “step” templates. A “step” refers to a step of certain time duration when the set points for all the recipe parameters (such as power, pressure, gas flows, temperature, etc.) are fixed. The popular step templates are stored in this list box and can be pulled and dropped into the recipe box at left to save editing time. A recipe is composed of multiple steps. Typically one or several etch steps sandwiched by two “Pump to pressure” steps. The “Pump to pressure” only pumps down the chamber. All the parameters are set to zero except the step time and the temperature.
   iii. To create a new recipe step, use the following procedure:
      1. In the Step Library panel, select the “New” button. The Step Edit page is displayed, which is same as the “Chamber 1” page except the page title is “STEP EDIT” and that there is no parameter readings in all the gray boxes.
      2. Enter the step parameters as required, then click on OK. The step is automatically saved.

NOTE: the detailed information on all the step parameters can be found in Page 5-43 to Page5-46 of the system manual.

iv. To create a step, based on an existing step, use the following procedure:
    1. Select a step from the Step Library list.
    2. Select the "Copy" button. Enter a new step name. Click "Edit" button.
    3. Edit the step parameters as required, then click on OK. The new recipe step is automatically saved.

v. To edit an existing step, use the following procedure:
    1. Select a step from the Step Library list.
    2. In the Step Library panel, click on the Edit button.
    3. Edit the step's process parameters as required, then click on OK. The step is automatically saved.

vi. To create a recipe, use the following procedure:
    1. In the Recipe panel, select the "New" button.
    2. Click on a recipe step in the Step Library list, hold the left mouse button down then drag the mouse pointer to the Step Name field next to the asterisk (*) then release the mouse button. The step name is displayed in the Step Name field.
    3. Repeat 2 as required to add further steps to the recipe.
    4. To remove a step from the list, click on it to highlight it then select the Delete step button from the Step Commands pop-up menu. Any further steps will move up the list by one place.
    5. To add a step before an existing step, click on the existing step then select the Insert step button from Step Commands pop-up menu. The selected step and all those following it will move down the list by one place. You can then drag another step from the Step Library list into the now vacant field.
    6. When all steps have been added, enter a time into the Data Log Interval field, and then enter a name for the recipe in the Recipe Name field. Finally, select the "Save" button.

vii. To edit a recipe, use the following procedure:
    1. Load the recipe to be edited.
    2. Click the step to be edited in the recipe box. A "Step Commands" menu will pop-up, as shown in Fig. 6.

Fig. 6 Step Commands menu

3. In the "Step Commands" pop-up menu, click on the Edit Step button, and then edit the process parameters as required.
4. Other operation is similar to Section 3.e.vi.

f. Run a recipe
   i. Make sure both chambers are ready to transfer (both diamond indicators are green).
   ii. Click "Run" button in the middle of the "Recipes" page. The current page will automatically switch to "Chamber 1" page.
   iii. A cartoon in the "HELLIUM BACKING" panel will show the procedure of wafer transfer between the loadlock and the process chamber. The status icons is illustrated in Fig. 7.

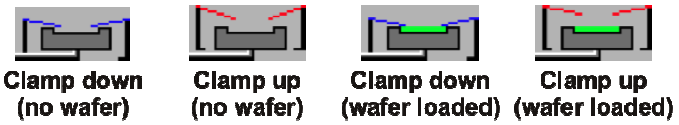

Fig. 7. Wafer transfer status

   iv. Once the wafer is loaded, the tool will automatically run the recipe step by step. Each step starts with pumping down the chamber to base pressure, stabilizing the temperature to the set point, followed by turning on the gases. After the pressure is in the tolerance for 15 seconds, the plasma will be ignited and the timer will count down. Once it is done, the wafer will be automatically unloaded to loadlock.
   v. The user can start, stop, pause the recipe or skip the current step by clicking "START", "STOP", "PAUSE" or "JUMP" button, respectively, at the upper left corner of the "Chamber 1" page. If any parameter set point is updated with new value and the "START" button is clicked, the new value will be in effect. If the parameter reading is not in the tolerance, the machine will freeze the time, turn off the plasma power and wait until everything is in tolerance.
   vi. When "STOP" is clicked, a window will pop-up and ask whether to return the wafer back to loadlock. **PLEASE CLICK YES!** Otherwise the wafer will be stuck in the process chamber. Only tool manager will be able to unload it. Therefore, a good alternative to "STOP" is "JUMP". Unless there are tens or hundreds steps left not run, several clicks of "JUMP" will bring the recipe running to its normal end and unload the wafer automatically.

4. Safety precautions
   i. Contact with toxic gases (Cl_2, HBr, BCl_3, $SiCl_4$) can cause death or serious injury. When any process gas is toxic, do not transfer a wafer from the process chamber to the loadlock until all the process gases have been pumped**. It is REQUIRED to include at least on minute of "Pump to pressure" step at the end of these recipes.** If a recipe of these kinds is stopped using "STOP" button, hold on for at least one minute before confirm the action of returning the wafer back to the loadlock. If a recipe is skipped using "JUMP" button, ensure not to skip the last "pump to pressure" step.
   ii. Do not set the temperature beyond 300 degree C unless an approval is obtained from the tool manager and the quartz clamp is removed. Ensure the

process chamber enclosure is covering the process chamber and do not try to touch any metal surface in the enclosure to avoid burning.

5. Reference

   Plasmalab System100 System Manual (file name: OIPT_100_SM_219983.pdf, location: Desktop folder of the console computer).