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Purpose
This document outlines the standard operation for the Trion Plasma Enhanced Chemical Vapour Deposition (PECVD) device located in the AMPEL clean room. It is written with respect to typical usage and does not attempt to describe every operation available. It also describes basic failure mechanisms that may occur during operation. Only qualified users and superusers are allowed to operate this equipment.

Relevant Literature

- TRION User's manual.
- J. Micromech. Microeng. 14 (2004) 317–323
- Journal of Non-Crystalline Solids 338–340 (2004) 76–8
- Materials Letters 54 (2002) 102–107
- Robin Farnworth and Michael Musson, *Optimization of Nanoporous Via-Hole Membranes for Micro-Electro-Mechanical Systems (MEMS)*, Engineering Physics 479 project number 0460 under the supervision of M. Beaudoin. (Available at www.ampel.ubc.ca/nanofab).

Procedure

Foreword

- Be familiar with the reactants and products of the process by consulting the MSDS.
- Be familiar with safety warnings and alarms should a serious malfunction occur (i.e. major gas leak).
- In addition to the literature, consult a user who's familiar with the process intended. If none exist, consult a superuser should he have any concerns.
- In the event of a system crash where the 'Manual Recovery Panel' appears, refer to the end of this SOP on recovery.

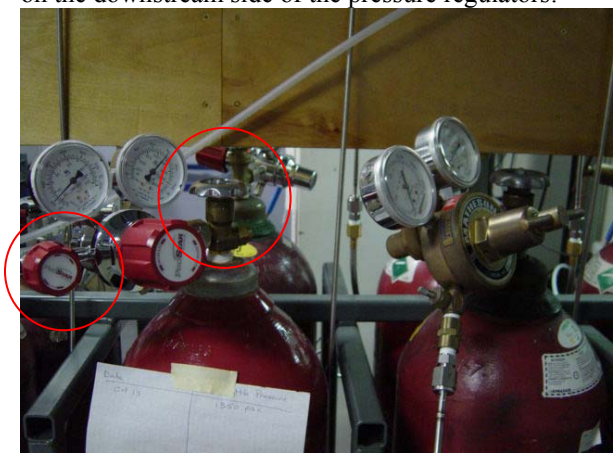
- The PECVD uses a combination touch screen and keyboard interface. Most operations are conducted with the touch screen and any occurrence of operation in this guide will be in reference to the touch screen unless otherwise noted.

Start Up

1. Before entering the clean room, the gasses used for an intended process must be turned on from the master valves located in the cleanroom chase area. Access from room 444. All of the gasses, except ammonia, are in large cylinders located against the clean room wall adjacent to the PECVD:

Ammonia is stored in the vented gas cabinet next to the cylinders:

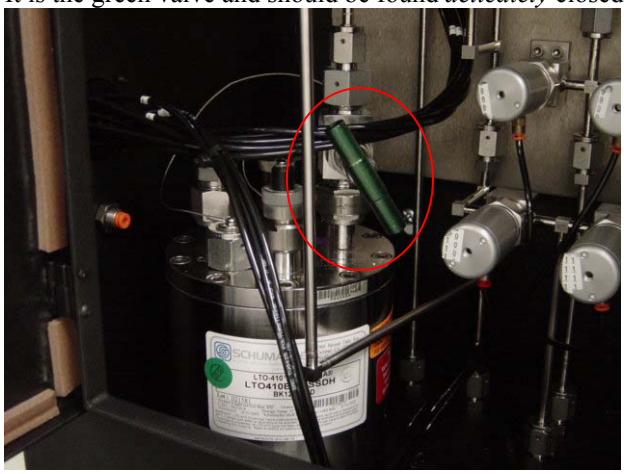
Each gas is turned on from either a main valve (metallic knob) on the cylinder itself and/or from exit valves on the downstream side of the pressure regulators:



Carbon Tetrafluoride (CF_4), Oxygen (O_2), Nitrogen (N_2) and Nitrous Oxide (N_2O) are accessed in this manner. Nitrogen should always be on for any process. Ammonia (NH_3) can be turned on inside the vented cabinet with its own main valve.

2. The DES is opened inside the cleanroom in the black gas distribution cabinet in back of the unit.

It is the green valve and should be found *delicately* closed.

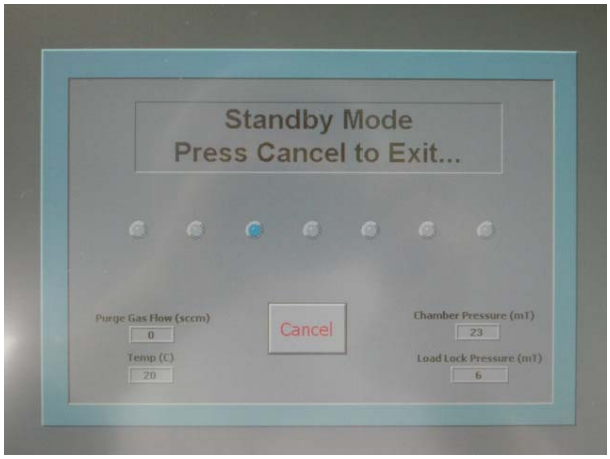


Open it *COUNTER CLOCKWISE*.

3. If CF_4 is being used for your process, check that the release valve is closed and the toggle valve is open. They should be located behind the PECVD and are a pair of brass valves connecting white 1/4" tubes.

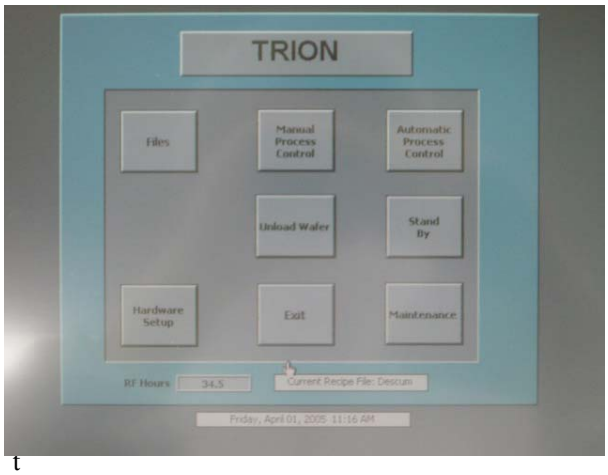
These valves are normally left in this configuration.

4. Upon entering the clean room and accessing the PECVD, the user should note that it's currently on Stand-By mode.



Press 'Cancel' to exit Stand-By mode. The PECVD will go through its own start-up process.

5. Once the PECVD has finished its start-up process, an operational main menu should appear with eight buttons and a blank space for a 9th to the middle-left.



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he carbon disc should still be in the growth chamber and the arm retracted in the load-lock – verify by looking through the glass port of the lid to the load-lock. The centre button should display 'Unload Wafer'. This button will disappear and a 'Load Wafer' button will appear in the middle-left when the carbon disc is in the load-lock. From left-to-right, top-to-bottom, the buttons are as follows: Files, Manual Process Control, Automatic Process Control; *Load Wafer*, *Unload Wafer*, Stand-By; Hardware Setup, Exit, Maintenance. *Should the disc be on the arm and the 'Load Wafer' button be present rather than the 'Unload Wafer', it implies a previous user did not shut down the system properly and is unnecessarily putting stress on the robotic arm. Your process may continue as normal although the first few steps in processing will not be applicable.*

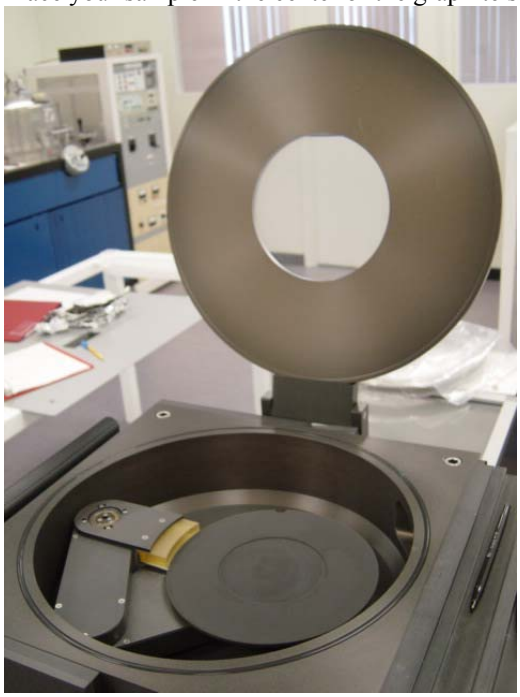
Processing

1. Press the 'Files' button to open a menu for selecting the desired recipe.

   It is important to load the correct settings first to allow the PECVD to equilibrate the temperature as soon as possible. Once the desired process is loaded, it should appear in the top right of the display under “Current Recipe”. Should you wish to create a new process file, refer to step 5 before proceeding to step 2.

2. Press 'Unload Wafer'. This should bring up the 'Wafer Unload Sequence' and describe the unloading process as it occurs. The unloading process will finish with nitrogen venting the load-lock to bring it to atmosphere. The LCD screen should display when the exchange chamber reaches atmosphere and it should be accompanied with a hissing sound from the lid. Open the lid at this point and hit OK. When the main menu reappears, this button will disappear and a 'Load Wafer' button will appear.

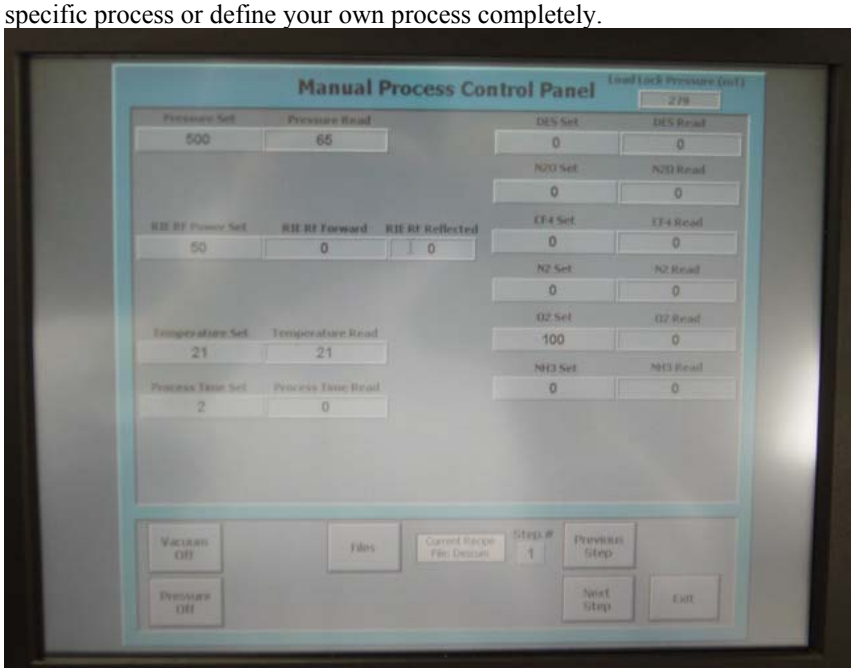
3. Place your sample in the center of the graphite susceptor.



   The susceptor is designed for 100 mm wafers, if your sample is much smaller, a good trick is to use the

cleaved 100 mm wafers available in the cleanroom shelf and specifically marked for PECVD use. Ensure that the disk is flush with the back of the arm. Check that the large O-ring seal is still seated properly. If you are concerned about the vacuum, discuss the appropriate application of vacuum grease with a superuser. Close the lid.

4. Press 'Load Wafer'. This should bring up the 'Wafer Load Sequence' and describe the loading process as it occurs. Be aware of any irregular sounds that might indicate an improper seal on the lid. Press 'Cancel' on the process should any reverberating sound occurs that might indicate an overtaxed pumping motor. Check the seating and lubrication of the O-ring and the action of the lid and repeat this step. Should problems persist, contact a superuser. Under normal operating conditions, the load-lock should reach 750 mTorr in less than a minute.
5. Press 'Manual Process Control' to bring up the process control menu. Do not use 'Automatic Process Control' as there are bugs that affect the process. In this control menu, you can change parameters to tailor to your specific process or define your own process completely.

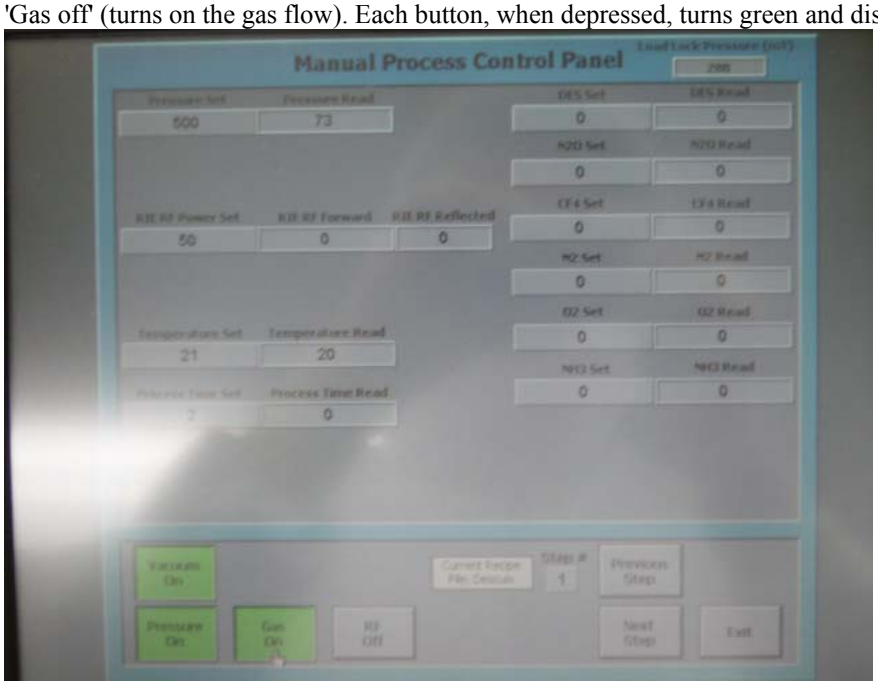


For each parameter, there are two displayed numbers: a parameter set and a parameter read. The parameter set displays the current value which the system is trying to achieve; the parameter read is the current measured value of the parameter. To change any setting, press the desired parameter set and enter in new values. The next step and previous step buttons at the bottom right of the screen allow you to cycle through steps and define the values for each parameter per step. You can save the file under a new name in the 'Files' menu accessed from the bottom of the screen. You can also retrieve other recipe files from the 'Files' menu.

6. Record your parameters and sample information in the logbook as necessary.

Refer to previous entries as a guide.

7. Once you are satisfied with the parameters, let the system equilibrate to those parameters. First, allow the chuck to reach the temperature specified. The time for this can vary from about an hour when heating up the chuck, to hours for cool down. NB: the temperature read is that of the chuck, the graphite susceptor itself will require some time to reach the same temperature. Once the temperature reaches the desired level, press 'Vacuum off' (opens the valve to the pump), 'Pressure off' (turns on regulation of the butterfly valve), and 'Gas off' (turns on the gas flow). Each button, when depressed, turns green and displays 'on' instead of 'off'.



Let the gas come to the desired pressure.

8. Once the gas flow is regulated, press 'RF off' to ignite the plasma. Note the step time counter. Press “RF on” to turn it off once the timer reaches the desired time. Press 'Gas on' to turn off the gas flow. Let the chamber evacuate until the pressure reaches equilibrium and press 'Next Step' if required. Repeat this step as needed.
9. Once all steps have been processed, press “Pressure on' and 'Vacuum on'. Press 'Exit' to return the to the 'Main Menu'.
10. Once exited, you are returned to the 'Main Menu'. Let the chuck cool down as necessary. Press 'Unload Wafer' to remove your sample. The unloading step is very similar to step 2. Remove your sample once the load-lock reaches atmosphere. Repeat the process steps as many times as needed.

Note: it is possible and is not unlikely with a small sample that during the loading and unloading stages, the sample will flip onto its other side. Again, the superuser suggests using a cleaved 100 mm wafer to create a small sample holding cavity to alleviate this problem.

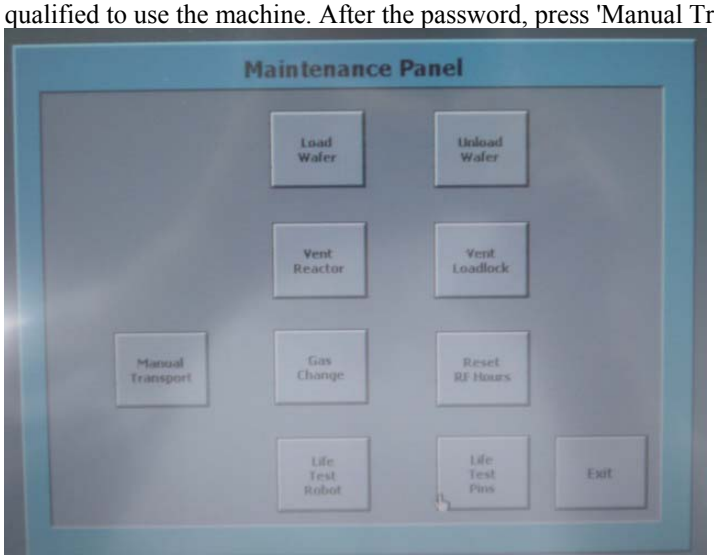
Shut Down

1. Make sure that the susceptor is flush with the loading fork guide.
2. Close the DES valve if you used it; please close *DELICATELY!* It closes *CLOCKWISE*.
3. Press 'Load Wafer'. The wafer is left inside the growth chamber to reduce the load on the robotic arm. It also helps if the next user wishes to preheat the susceptor before his/her growth/etch.
4. Press 'Stand-By'.
5. Make sure that the system properly makes it through its purge/vent sequence.
6. Exit the clean room, enter the chase and turn off the gases used. Typically, Nitrogen is always left on as many other processes in the clean room use it.

Manual Recovery

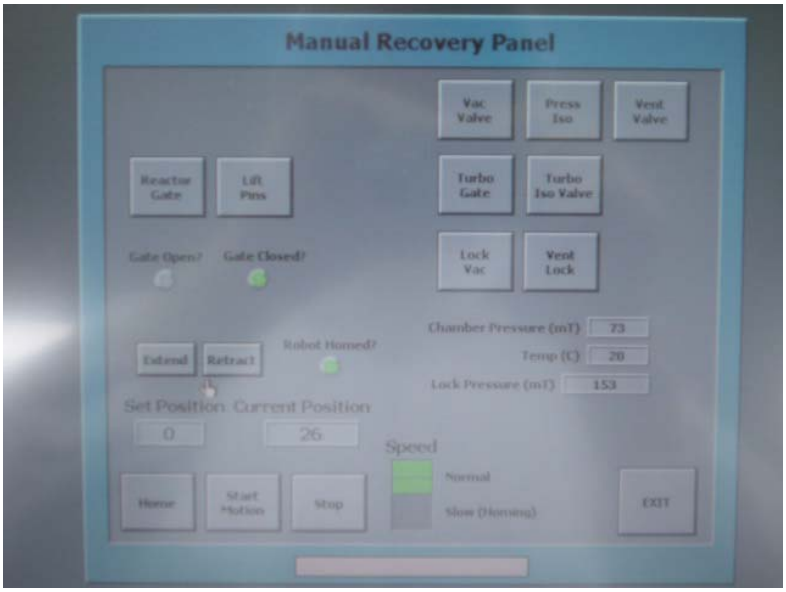
In the event of a mechanical failure, or some other abnormal operation, it may be required to enter the maintenance mode. In this mode, the user can operate many of the individual steps that are normally all handled within a single process-step. The following outlines recovery of the robotic arm specifically in loading and unloading.

1. To open the Manual Recovery Panel directly, press 'Maintenance' in the main menu window. A keypad will pop up, prompting you to enter a password. The superuser should give the password to you when you get qualified to use the machine. After the password, press 'Manual Transport'.



The Manual Recovery Panel will pop up by default if there's a malfunction in the device.

2. There is no set of steps that completely outlines what to do at any point: the machine may have crashed at any number of steps. What's important is to understand the steps the machine goes through, assess its current state and activate the necessary steps for recovery. The following list outlines normal operation with loading and unloading of the chuck:



1. The robotic arm is retracted, with the chuck on the arm and the lid down. The exchange chamber is at atmosphere, the main gate valve is closed and the pins are retracted.
2. Evacuate the exchange chamber by pressing 'load vacuum'.
3. Open the main gate valve. NB: the main gate valve should only be opened if the growth chamber and the load lock are at comparable pressures; for typical operation, the growth chamber is evacuated and the gate valve should only be opened if the load lock pressure is below 700 mTorr (note the m for millitorr).
4. Extend the robotic arm.
5. Lift the pins to lift the susceptor from the loading fork.
6. Retract the robotic arm.
7. Home the robotic arm.
8. Lower the pins to lower the susceptor in position on the growth chamber chuck.
9. Close the main gate valve.
10. *Run processes. (Exit manual transport mode and proceed through main menu)*
11. Raise the pins to raise the susceptor above the chuck. NB, otherwise, the loading arm would collide with the susceptor and push it against the back of the growth chamber; this would force an unwelcomed vent of the growth chamber and could also create damage to the forks, susceptor, chuck or other features in the growth chamber.
12. Make sure the load lock is under vacuum (i.e. 700 mTorr or less).
13. Open the main gate valve.
14. Extend the arm.
15. Lower the pins to lower the susceptor on the loading arm fork.
16. Retract the arm.
17. Home the arm.
18. Close the main gate valve.
19. Bring load-lock to atmosphere by pressing 'vent load'.

It is up to the user to identify in which step the malfunction occurred and to identify the course of action given these normal sequence of steps. Note that manual operation does not change the main menu status. Thus, if the user manually loads the chuck and goes back to the main menu, it will still display 'Load Wafer' and not display 'Unload Wafer'.