NEMO Name: Tube-LPCVD-Poly, Tube-LPCVD-DopedPoly, Tube-LPCVD-Nitride

Location: L02
Category: LPCVD
Contact: Ben Newcomb, Dennis Ward, Eric Lim

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Figure 1: Multi-Reactor Setup. From top to bottom: Poly, Doped Poly, Nitride.

1 Introduction

The CTR-200 Expertech LPCVD furnaces that are designed to deposit amorphous silicon, polycrystalline silicon, doped poly silicon, and silicon nitride. Multi-step process recipes with specified time and gas flows can be programmed using the Multi Reactor Manager (MRM) process recipe editor. Wafers are loaded in a quartz boat then placed on a cantilevered load arm. Our goal is to keep these furnaces as clean as possible. Discuss with staff so that we can evaluate processing options and the potential contamination effects on other processes. A wet clean must be performed within 24 hours of loading. RCA is preferred and piranha is acceptable. Some metals are allowed, but gold and organics are not permitted.

1.1 Tube-LPCVD-Poly (POLY)

Tube-LPCVD-Poly is a low pressure chemical vapor deposition furnace that flows silane to deposit amorphous silicon or polysilicon. Processes should not exceed eight (8) hours without discussing with staff.

1.2 Tube-LPCVD-DopedPoly (ISD Poly)

A low-pressure chemical vapor deposition (LPCVD) tube furnace for depositing amorphous silicon or polysilicon using silane, with support for in-situ doping and annealing. Capable of achieving n-type or p-type doping through the introduction of phosphine or diborane as dopant gases. Processes should not exceed eight (8) hours without discussing with staff.

1.3 Tube-LPCVD-Nitride (NITRIDE)

Tube-LPCVD-Nitride is a low-pressure chemical vapor deposition (LPCVD) tube furnace for the deposition of silicon nitride films. Processes involve flowing dichlorosilane (DCS) and ammonia gases to form stoichiometric or silicon-rich nitride, depending on the chosen gas ratios. The system is designed for uniform, high-quality nitride coatings. Processes should not exceed eight (8) hours without discussing with staff.

2 Safety

Hazards present in the system are high-temperature parts, possible pinch/crush points, high voltage, and pressurized gases. Parts and samples can be at high temperatures during and after processing. Exercise care when unloading samples from the chamber. Mechanical pinch/crush points exist with the reactor door. Please keep your fingers and other body parts clear when closing the door to the chamber. N_2 can displace oxygen and can cause rapid suffocation. Dichlorosilane (SiH_2Cl_2) is a pyrophoric, toxic gas that reacts with moisture to form hydrochloric acid, causing severe burns and respiratory damage. Silane (SiH_4) is a pyrophoric gas that ignites spontaneously in air, sometimes with delayed and explosive force, and acts as an asphyxiant. Ammonia (NH_3) is a toxic, corrosive gas that causes severe irritation and chemical burns to the eyes, skin, and respiratory tract. Phosphine (PH_3) and Diborane (B_2H_6) are extremely toxic and pyrophoric gases that can cause pulmonary edema, cardiovascular collapse, and death. Under normal operation, the user is protected from these hazards by the system software, tool panels and interlocks, and the Toxic Gas Monitoring System (TGMS). Do not attempt to open or remove any panels or interlocks, as you risk exposing yourself and others to these hazards.

If the tool is behaving dangerously or making loud noises, press the red EMO button, alert the staff, and shut down the system in NEMO. DO NOT attempt to re-energize the tool.

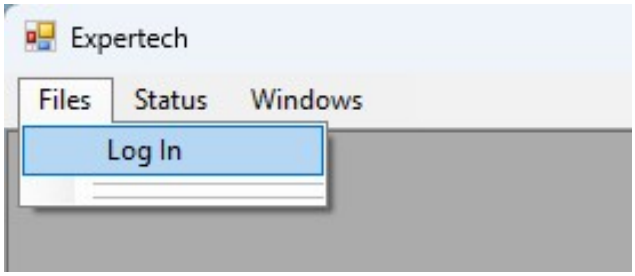
3 User Qualifications and Responsibilities

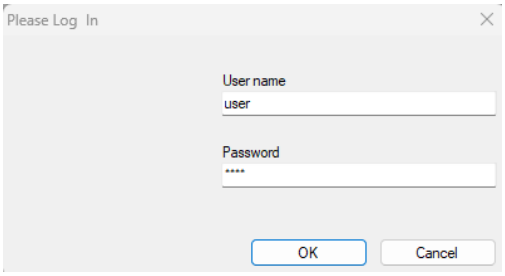
During training, you will learn to load samples and run recipes. To be considered qualified, you need to be trained by the staff in charge, be up to date with your safety trainings, and have a PTC-approved process. Ideally, samples will have an RCA clean directly prior to loading. If your samples cannot withstand RCA or piranha, contact the tool owners for possible alternative cleaning methods. Photoresist is not allowed in the system and organics are prohibited. Circumventing these restrictions or running processes/materials that have not been approved by the PTC can lead to disqualification from the tool.

Users are expected to remove their samples from the reactor, completely close the door, set the tool to IDLE (chamber door closed, pressure below 500 mtorr, flowing 200 sccm N_2, with all temperature zones 450° C), and log out of the operator account when they finish their process. If you encounter any problems or notice anything unusual while operating the machine, report the issue in NEMO so the staff can promptly address it.

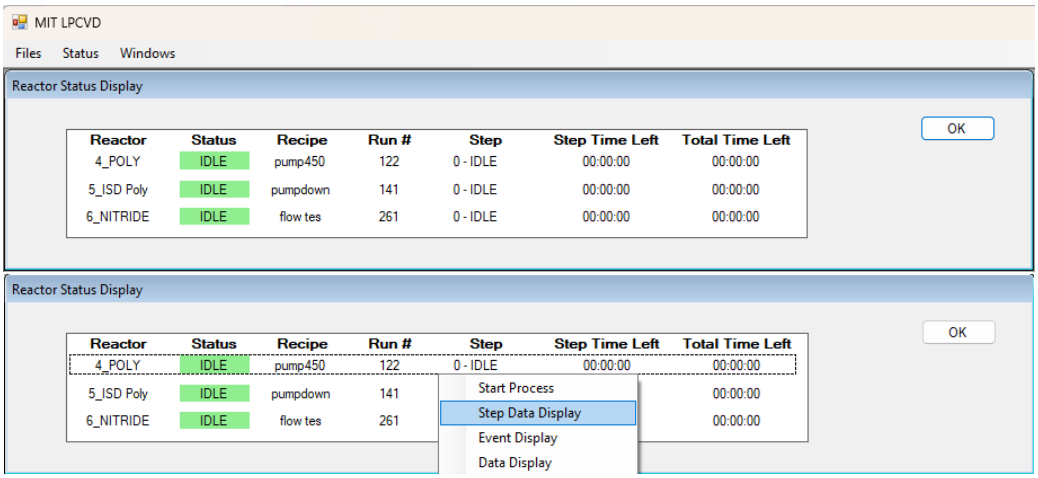
4 Procedure

1. Clean your substrate with respect to your approved process. Check reservations in NEMO to ensure you have reserved the correct tool at the correct time. Engage the tool in NEMO.
2. On the computer, open the MRM (Multi Reactor Manager). In the top left corner of the screen click **Files** then click **Log In**. The operator username is **user** and the password is also **user**.

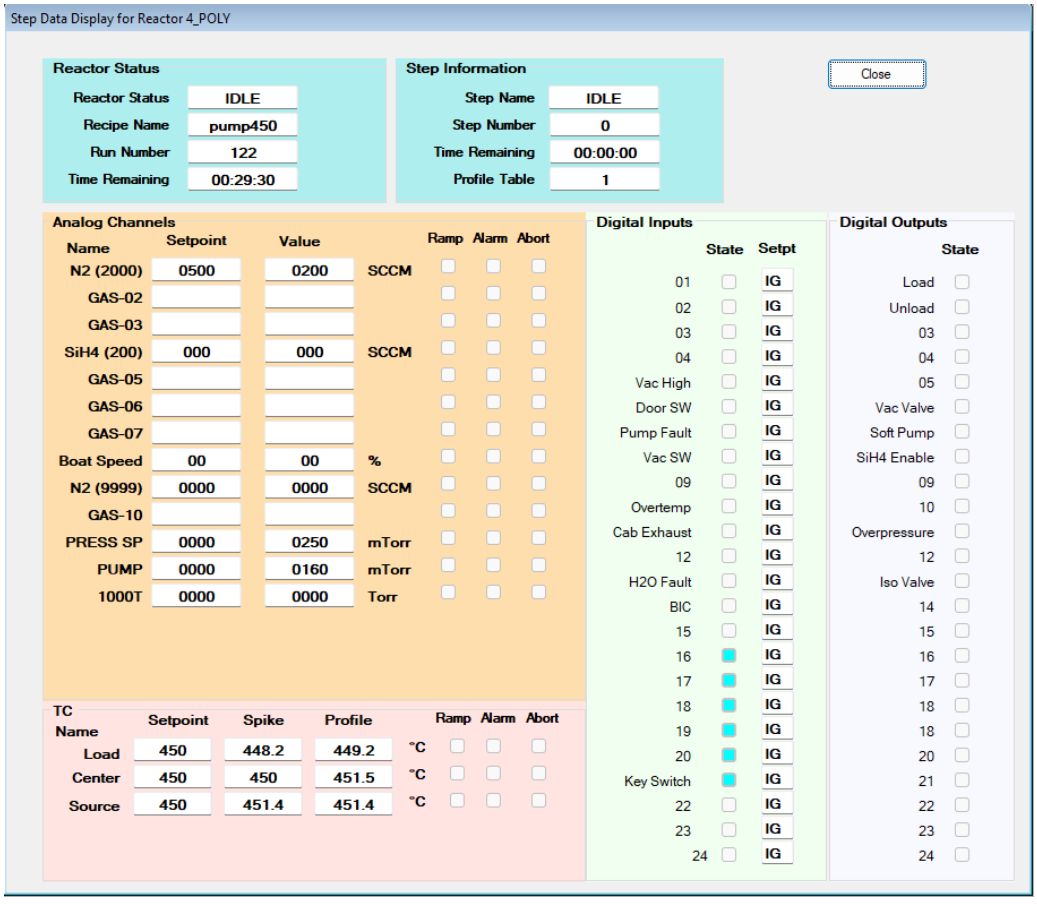




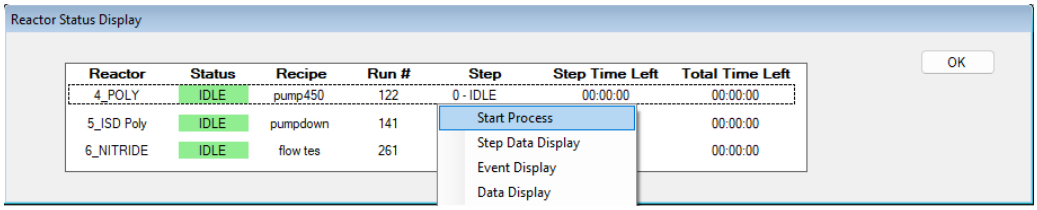
3. Click **Status** on the top toolbar to see information about each reactor. Right click the reactor that you are running your process on and click **Step Data Display** to open the **PCE Process Start** window.



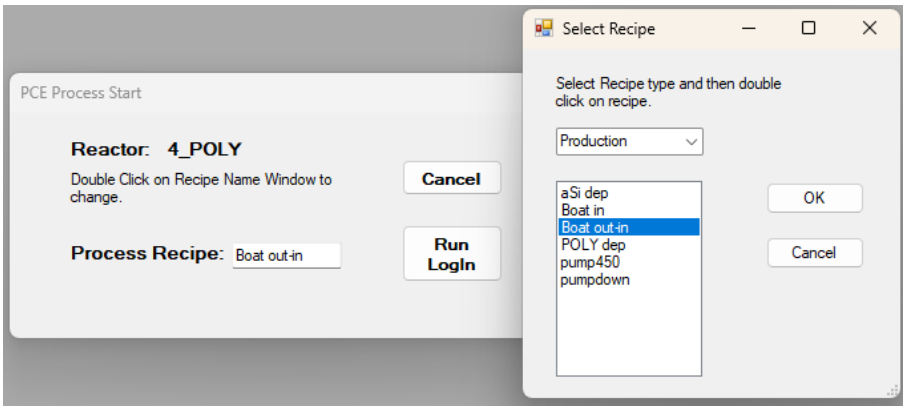
4. It is important to check the gas flow, pressure, and temperature setpoints before starting a new run or unloading reactor. The display below shows that the reactor is flowing 200 sccm of nitrogen (and no other gases), the pressure is below 500 mTorr (PRESS SP Value) and is steadily at the idle temperature of 450° C. If something on the data display looks unusual, stop and contact a staff member for help before proceeding. A N_2 setpoint of 500 or 200 sccm are both acceptable.



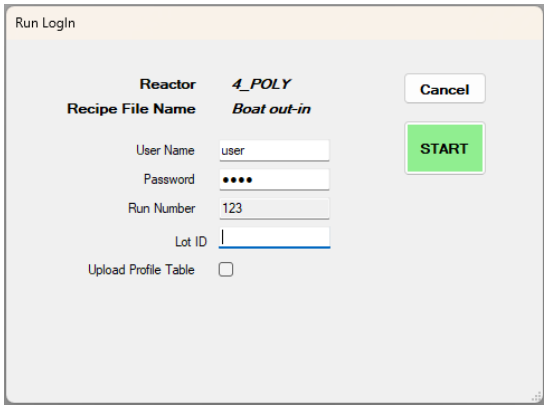
5. In the **Status** window, right click the reactor that you are running your process on and click **Start Process** to open the **PCE Process Start** window. If under the **Step** column in the **Status** window for the reactor you want to use says **59 - Maintenan.**, stop and contact a staff member for assistance.



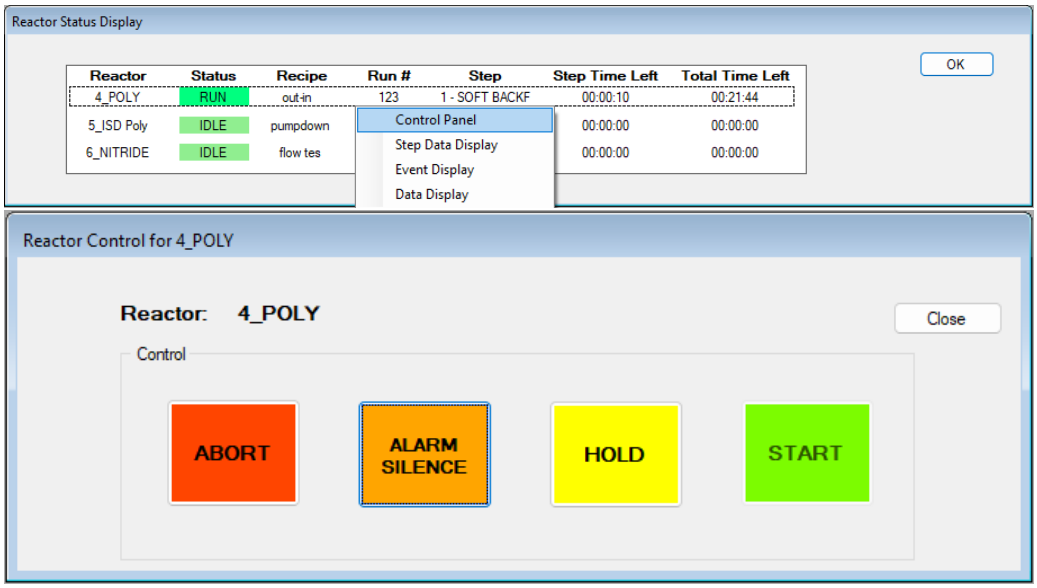
6. In the **PCE Process Start** window, double click the box to the right of **Process Recipe:** to open the **Select Recipe** window. Under the **Production** recipes select **Boat out-in** from the menu. Click **OK** in the **Select Recipe** window, then **Run LogIn** in the **PCE Process Start** window.



7. Enter the username (user) and password (user) into the **Run LogIn** window then click **START**.

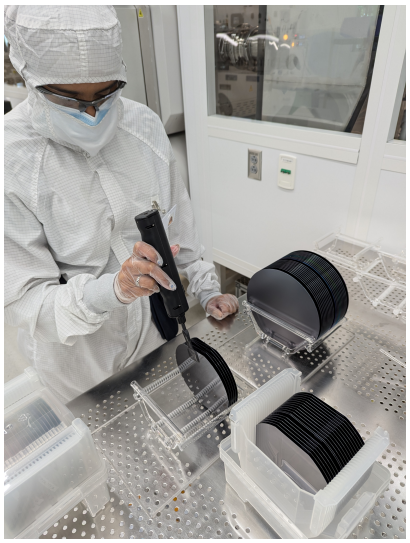


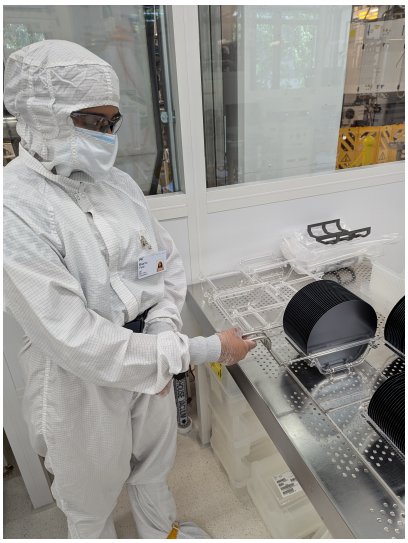
8. Wait patiently as the tube is vented to atmospheric pressure and the cantilever door slowly moves out of the tube until it is completely extended. The hold step alarm will trigger and the reactor will wait for user input to proceed further. To silence the alarm, right click the reactor you are running in the **Status** toolbar, then select **Reactor Control**. In the **Reactor Control** window, click **ALARM SILENCE**. While the boat is open, you are required to be present in the bay.



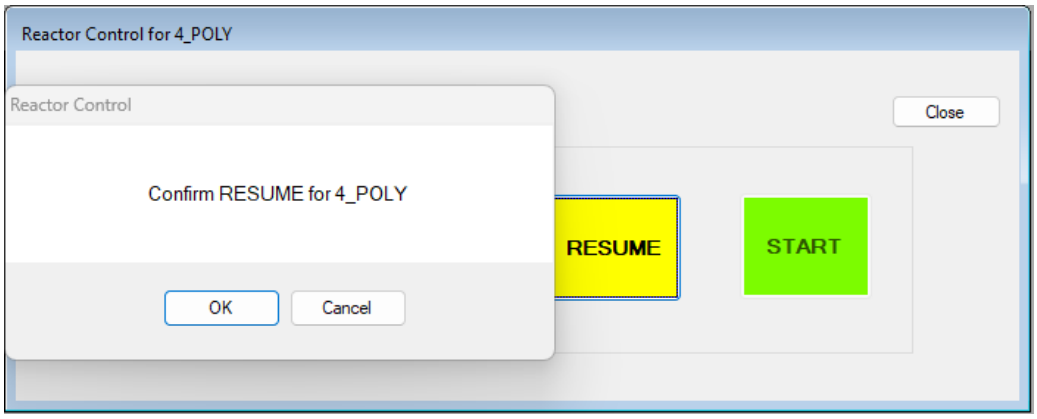
9. Using a quartz tipped metal fork, remove the quartz boat from the cantilever and place it on a quartz plate on the metal table. Wait five minutes for the wafers to cool down. Using a vacuum wand, replace some of the center wafers with your process wafers and take note of which slots you used. All of the available wafer slots in the boat should be filled because the reactor's temperature profiles were calibrated in this condition. Return the boat to the cantilever using the quartz tipped loading fork. For most processes, the process side of the wafer should face the reactor door.







10. In the **Reactor Control** window opened in step 6, click **Resume** and confirm in the pop-up to release the hold. The cantilever will retract into the tube until the door is closed. The tube will pump back down to vacuum and perform a leak check. Wait for the recipe to finish and the reactor status to say **IDLE**.



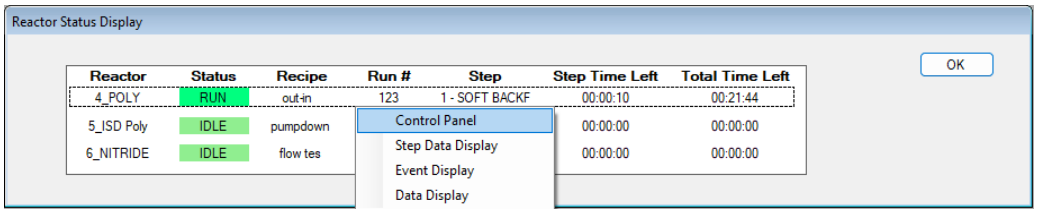
11. Repeat steps 3-7 to start a process, but this time select your desired process recipe from the **Production** tab in the **Select Recipe** window. Review Appendix 5.2 if you need to modify process variables. **For any recipe with process variables, make sure to check the process variable table before every run.** If your process aborts before the deposition gases turn on, you may contact staff, reset, and retry. If the process aborts during or after this step, or you are not sure, contact staff to fix the issue.
12. Once your process is complete, repeat steps 3-10 but this time remove your processed wafers from the boat and replace them with the dummy wafers that were removed in step 7. Wait for the recipe to finish and the reactor status to say **IDLE**.
13. Log out of the MRM software by selecting **File** on the top toolbar followed by **Log Out**.
14. Disengage the appropriate reactor in NEMO.

5 Appendix

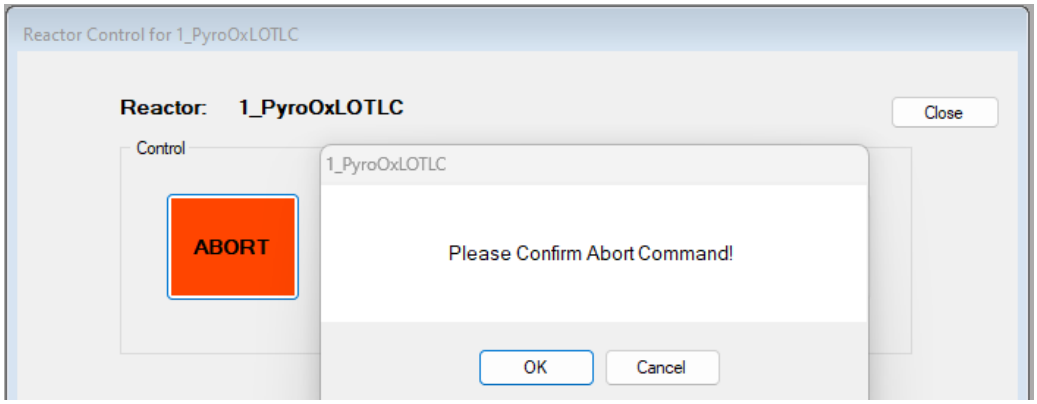
5.1 Aborting a Process

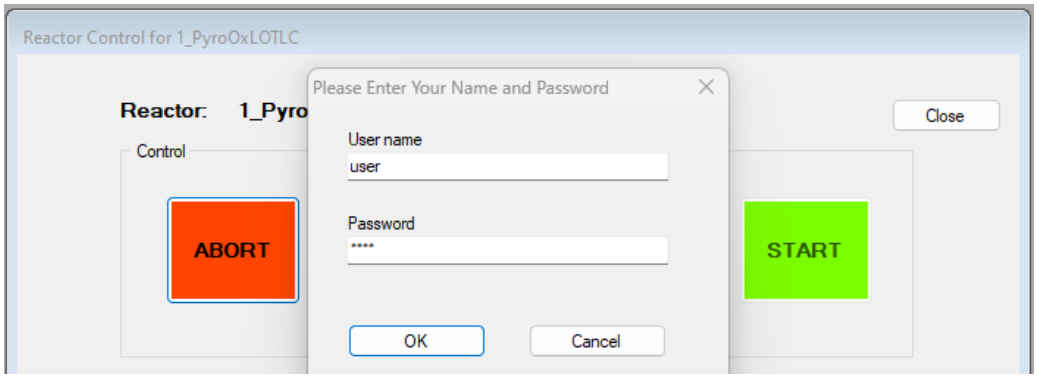
If there is an issue with the reactor, let a staff person know before proceeding. If the tool is behaving dangerously, press the red EMO button to the left of the reactor door, alert the staff, and shut down the system in NEMO.

To abort a process gracefully, right click the reactor you are working on in the **Reactor Status Display**, then select **Control Panel**. The images show the atmospheric tube names, but the procedure is identical.



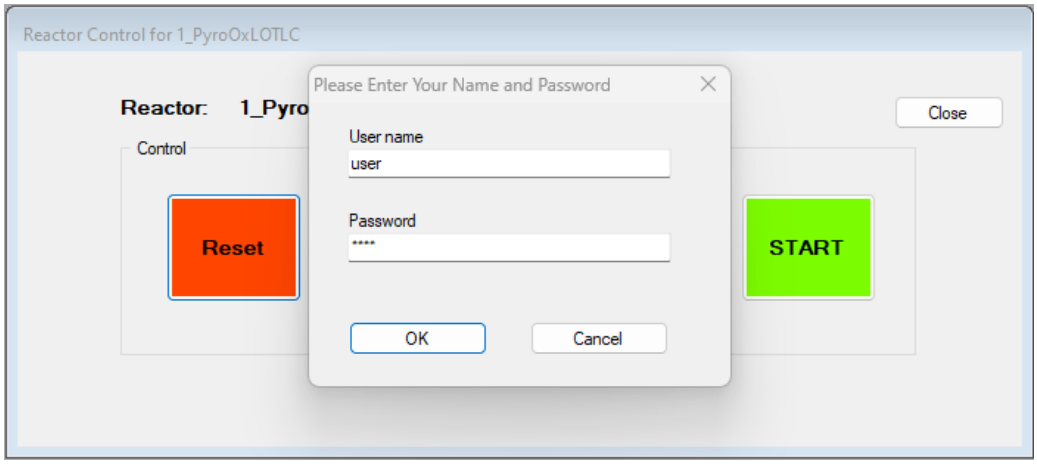
Once the reactor's **Control Panel** is displayed, click the red **ABORT** button. Click **OK** on the confirmation pop-up. Enter the username (user) and password (user) into the dialogue box, then click **OK**.

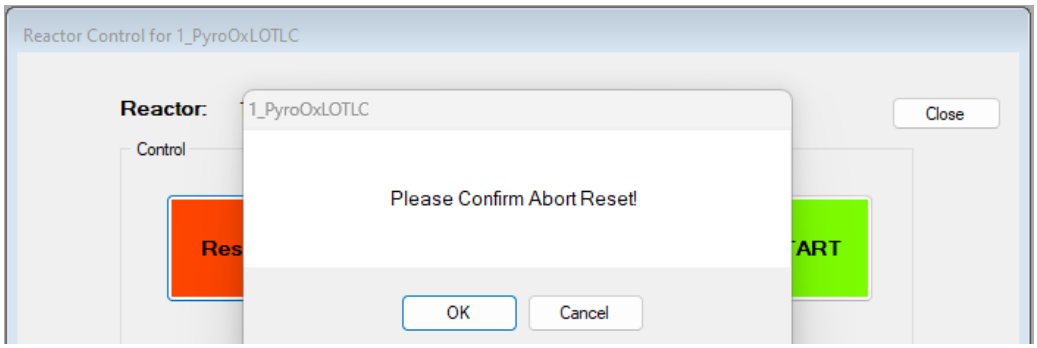




On the **Control Panel**, click **ALARM SILENCE** then proceed to reset the abort to return the reactor to **IDLE** status. Click the red **Reset** button that should have taken the place of the **ABORT** button on the **Control Panel**.

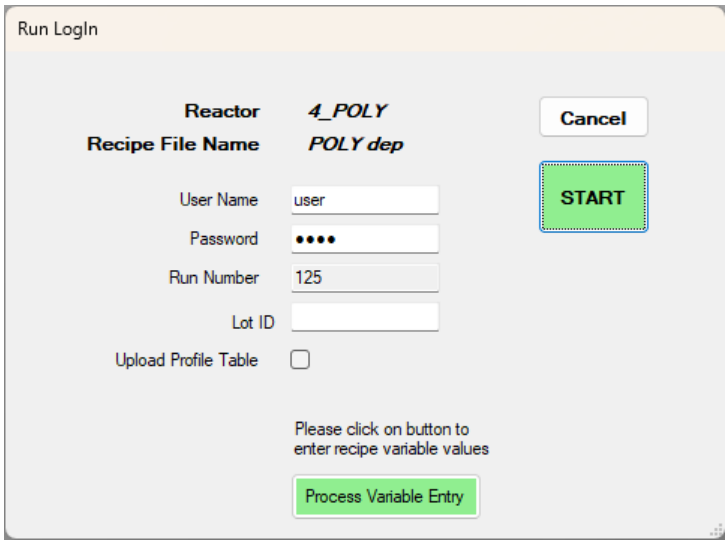
Enter the username (user) and password (user) into the dialogue box, then click **OK**. Click **OK** on the confirmation pop-up.



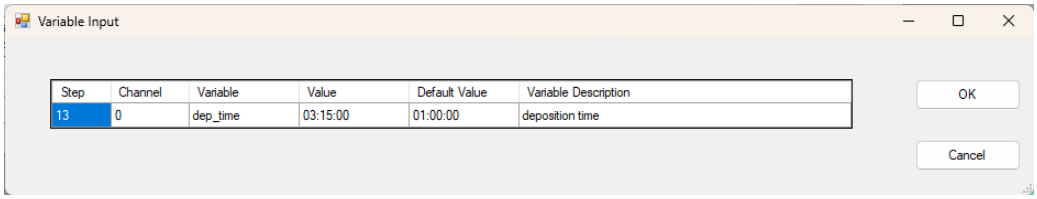


5.2 Editing Process Variables

In some recipes, process variables need to be adjusted to execute your process properly. For example, in the *POLY dep* recipe, it is possible to change the deposition time. When starting a process, input the username (user) and password (user) into the **Run LogIn** window, then click another input box such as Lot ID. A new green **Process Variable Entry** button will become available.



Click on **Process Variable Entry** to open the **Variable Input** table for the run. As shown in the figure below, there is an adjustable variable, *dep_time*, with a current value of 03:15:00 (hh:mm:ss). To run for a different time, click "03:15:00" in the Value column, in the top row (not the greyed out rows). Type in a new time in hh:mm:ss, then hit **Enter** on the keyboard. Ignore the Default Value column.



After checking that all variables are correct, proceed by hitting **OK** and starting the process.

5.3 Troubleshooting

5.3.1 Difficulty Closing Door

In the **Production** tab of the **Select Recipe** window, all reactors should have a process labeled **Boat-In**. Abort the current process if necessary, then run the **Boat-In** process. If you have further difficulty, contact staff for assistance.

5.3.2 IDLE State

Always leave the reactor with the door completely closed, reactor pressure below 500 mTorr, and flowing 200 (500 sccm also acceptable) sccm N_2, with all temperature zones 450° C2 L/min before disengaging in NEMO. You can run the **Pumpdown** recipe to recover this state if the reactor door is closed and hazardous gas has been purged from the system already.

5.3.3 Nonsensical Values in Step-Data Display

Sometimes in the **IDLE** state, the **Step Data Display** may give nonsensical values (ex. random numbers for all gas flows). To correct this, run the **Pumpdown** recipe in the **Production** tab of the **Select Recipe** window. If you have further difficulty, contact staff for assistance.

5.3.4 Windows Login

The Windows username is **user** and the password is also **user**.