Chapter 5.13

_Tystar 13 Non-MOS POCl3 Doping Furnace (4” and 6”)_(tystar13 - 386)

1.0 **Title**
Tystar13 Non-MOS Clean POCl3 Doping Furnace (4” and 6”)

2.0 **Purpose**
Tystar13 is an atmospheric pressure, non-MOS furnace that uses POCl3 vapor as phosphorus source to dope process wafers. It can also be used for anneal and dry oxidation processes, only as a back up to non-MOS clean furnaces. This furnace accommodates fifty 4” and twenty 6” wafers in one run. The furnace is non-MOS clean.

3.0 **Scope**
This chapter covers the general furnace description for Tystar13, process recipe loading, operation procedure, which includes wafer loading/unloading, process status monitor, user level problem diagnosis, and wafer cleaning requirements.

4.0 **Applicable Documents**

_Revision History_

4.1 Tytan Diffusion Furnace System Instruction Manual (copy in Office).
4.2 Tycom 9900 Microprocessor Control System Instruction Manual (copy in Office)
4.3 Material Safety Data Sheets for POCl3 (phosphorus tetrachloride), Oxygen, and Nitrogen (copy in Lobby).

5.0 **Definitions & Process Terminology**

5.1 **MOS Furnace**: This kind of furnace is used to fabricate MOS devices (IC), whose performance can be greatly impacted by trace contaminants. Wafers processed in MOS furnaces should be MOS compatible. Absolutely no metal films in any MOS Furnace, except the MOS sintering furnace, which allows only Al and certain refractory metal films (see process staff).

5.2 **Non-MOS Furnace**: This kind of furnace is used for non-MOS processes such as MEMS or similar application. Wafers processed in non-MOS furnaces may contain materials that are not compatible with MOS processes and are not allowed in any MOS furnace. Wafers with metal films can be processed in some non-MOS furnaces, as per defined in Chapter 1.7 (Material and Process Compatibility Policy) or with special permission from Nanolab Management.

5.3 **Phosphorus (P) Doping**: A high temperature process that diffuses phosphorus atoms into the silicon wafer (dopes the substrate). A P atom provides an extra electron for a Si atom, which makes the Si substrate more conductive.

5.4 **Annealing**: A high temperature process that uses N2 to keep wafers in an inert atmosphere. Major applications include dopant diffusion and activation, LTO/PSG/BSG/BPSG densification, film stress release, etc. PSG/BSG/BPSG are different types of doped silicate glass (SiO2 glass).

6.0 **Safety**
Follow general safety guidelines in the lab as well as the specific safety rules, as per follow:
6.1 **Electric Shock Hazard:** Tystar furnaces utilize **high electric power** (high amperages) to generate heat. Do not open the side panels or touch the high power electrical parts in the furnace cabinet.

6.2 **Chemical Hazard:** POCl₃ (phosphorus tetrachloride) is highly toxic substance can pose serious health problems or could be fatal. For more information, please refer to the MSDS form posted in the blue binders at the lobby.

6.3 **Burn Hazard.** Cantilevers, boats, and wafers, which are coming out of the furnace, are very hot. Wear face shield when loading/unloading wafers. Proceed with caution. Avoid touching of any furnace quartz ware to prevent burning of your hands and contamination of the furnace. No flammable chemical, especially organic solvents are allowed in the load station, when the tube is open.

6.4 **New Recipe check/Qualification:** process staff must check out all new recipes, before they can be used on any Tystar furnaces. Customized recipes should be stored on the user’s diskette, not on the standard diskettes.

7.0 **Statistical/Process Data**

7.1 Recipe 13POCL3A temperature, sheet resistance, oxide thickness process parameters

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>No Anneal (sheet resistance, Ω/□; oxide thickness, Å)</th>
<th>1 Hour Anneal</th>
<th>2 Hour Anneal</th>
</tr>
</thead>
<tbody>
<tr>
<td>950</td>
<td></td>
<td>4.65; 1378</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>3.55; 1677</td>
<td>2.58; 1788</td>
<td>2.29; 1873</td>
</tr>
<tr>
<td>1050</td>
<td></td>
<td>1.59; 2349</td>
<td></td>
</tr>
</tbody>
</table>

8.0 **Available Process, Gases, Process Notes**

8.1 **Available Processes**

8.2 **13POCL3A:** P+ doping process which includes both doping and drive-in steps.

8.3 **13N2ANLA:** Annealing recipe with 3 SLM nitrogen flow (same as old N2ANNEAL).

8.4 **13HIANLA:** Annealing recipe with 9 SLM nitrogen flow (same as old HIN2ANNL).

8.5 **13DRYOXA:** Dry oxidation process.

8.5 **Available Gases**

8.6 **N2CARR (N₂, 1000 sccm):** Used to carry POCl₃ vapor from the reservoir to the process tube.

8.7 **N2 (N₂, 9999 sccm):** Used to purge out room air and keep the process tube in an inert atmosphere.

8.8 **O2HI (O₂: 5000 sccm):** Used for pre-clean and post-purge steps in the POCL₃ process. It is also used in the dry oxidation process.

8.8 **O2LO (O₂: 500 sccm):** Used in the doping step of the POCL₃ process to convert POCl₃ vapor into P₂O₅.
Process Notes

8.9 The POCL3 doping process consists of the following three steps:

8.8.1 POCl₃ vapor reacts with Oxygen to form P₂O₅.
8.8.2 P₂O₅ oxidizes the Silicon substrate to form silicon oxide with P dopant in it.
8.8.3 P dopants diffuse into Si substrate during doping step and drive-in process, which is performed next.

8.10 After the POCL3 process, the wafers will have a layer of silicon oxide film, which can be removed with 5:1 BHF in MSINK8.

8.11 TYSTAR13 can be used as a backup non-MOS furnace for annealing and dry oxidation. However, wafers with metal films should not be processed in this furnace.

9.0 Furnace Operation

9.1 Wafer Cleaning Requirements Before Loading Into Tystar13 Furnace

9.1.1 Non-metalized wafers to be processed in Tystar13 must go through the standard pre-furnace cleaning procedure. This entails a 10 minute piranha dip in Msink8 and Msink6, and an ensuing one minute HF dip for oxide removal if desired. Photoresist coated non-metalized wafers must initially have their photoresist processed in the Matrix Asher or stripped at Msink1 (PRS-3000 bath). This is required for both MOS and non-MOS wafers. The wafers must then be cleaned in Msink8 and Msink6. Msink6 is the pre-furnace clean step prior to wafer introduction into Tystar13. This means photoresist removal from non-metalized wafers requires an additional cleaning at Msink8 regardless of whether the process is MOS or non-MOS. For a complete description of pre-furnace wafer cleaning please see Section 1.3 in Chapter 5.00, Tystar Furnaces Overview.

9.1.2 New wafers fresh out of the vendor box can skip the Msink8 clean step in Section 9.1.1.

9.1.3 Wafers may be directly unloaded from any MOS furnace and directly loaded into Tystar13 without further cleaning. Wafers directly unloaded from a non-MOS furnace may be loaded into another non-MOS furnace without further cleaning. Wafers processed in a non-MOS furnace or wafers which have gone through any non-MOS processes, cannot be loaded into MOS furnaces. There is ABSOLUTELY NO EXCEPTION to this rule.

9.2 Processing a Run

(Refer to the Section 12.0, for detail information on TYCOM and ROP)

Loading a Recipe

9.2.1 Enable the Tystar furnace.

9.2.2 Check that no recipe is running in the furnace and ROP displays READY. Also, check that the LVLALM, TMPALM, and N2PRSAL are OFF.

9.2.3 Insert the recipe diskette for the furnace into floppy drive #2, right hand side, of TYCOM CPU. Every furnace has its own standard recipe diskette.

9.2.4 If you are not sure of the recipe name, enter DI DI at TYCOM Terminal to display the recipe directory.

9.2.5 Enter LO recipe-name 13, then press the [enter] key.

9.2.6 Enter the process parameters when prompted. You can use the numeric keypad on the keyboard. But not the [enter] key on the right end of the numeric keypad. TYCOM does not recognize this key, and will not load the recipe.

9.2.7 TYCOM Terminal displays RECIPE LOADED SUCCESSFULLY if there is no error in the recipe and parameter entries.
9.2.8 (Do not use TYCOM command RU # to start the process, because someone may be loading/unloading wafers on another furnace of the same bank. Besides, it is recommended that you check the ROP to make sure the recipe is loaded into the furnace.)

**Load Wafers and Run a Process Recipe**

9.2.9 Go to the front of the load station module of the Tystar furnace. Press [7/Status] button on the ROP to make sure the furnace is at READY state and the recipe name is correct.

9.2.10 Put on the face shield. Then press [Recipe/Run] button. The furnace door will open and the wafer boats come out. The door will close automatically after 20 minutes. If the boats start moving in and you need more time loading wafers, press [Alarm Ack] button on the ROP before the door closes, the boats will move out again and you have another 20 minutes.

9.2.11 Transfer your wafers from MSink6 to the furnace in a black wafer box. Do not use the Msink6 teflon cassette to avoid contamination. See Section 9.1 for wafer cleaning requirement.

9.2.12 Load MOS clean wafers using the MOS vacuum wand with red tubing. Load non-MOS wafers using the non-MOS vacuum wand with black tubing. All the wafers should be loaded with flat up for better wafer support and consistent run-to-run results.

9.2.13 Do not wear poly gloves over clean room gloves when loading/unloading wafers. The poly gloves usually are too big and slippery. The tips of the poly glove may melt on the hot quartzware and cause contamination, which is hard to notice, because it is colorless and transparent. The poly gloves should be used at sinks and other room temperature operations only.

9.2.14 After loading wafers, press [Alarm Ack] button on the ROP. The boat will start moving into the furnace. If you want to add/remove or reposition wafers before the door closes, press [Alarm Ack] once, the boat will move out again.

9.2.15 After the door closes completely, check DNTLK on the TYCOM Terminal. If DNTLK is OFF, the process will continue automatically. You can also monitor the status of the process run remotely (Section 12.6).

9.2.16 If the DNTLK keeps ON, the process will abort after a few minutes. Press [Alarm Ack] button to silence the alarm. Check that the track and cable of the boat loader is cleared of any obstacle. Press [Recipe/Run] button again. If problem continues, report on Mercury for boat loader problem.

9.2.17 You should monitor the process frequently during your run. You can use either the TYCOM terminal (Section 12.4) or remotely log into the WAND (Section 12.6) to do so.

**Unload Wafers After Process Ends**

9.2.18 When the process reaches the last step, the ROP displays END and the alarm beeps. Press [Alarm Ack] button to silence the alarm and reset the furnace to READY state.

9.2.19 To unload your wafers, press [Recipe/Run] button again, and the boats will move out. When the boats stop moving, wait a few minutes for wafers to cool down. Then use the appropriate vacuum wand to unload your wafers to the quartz boat on the cooling rack next to the furnace. The wafers may still be too hot for the plastic wafer box.

9.2.20 Press [Alarm Ack] button to move in the boats. After the door closes completely, press [Abort] button, then [Alarm Ack], and the furnace returns to READY state. If you press [Abort] before the door closes, the boats will stop moving and the door left open. Press and hold the in button to close the door manually.
9.2.21 Disable the Tystar furnace on Mercury. Unload wafers from the cooling rack into wafer a box.

10.0 Troubleshooting Guidelines

TYCOM Terminal Problems

10.1 TYCOM Terminal is blank.
- **Cause:** The terminal is in sleep mode.
- **Solution:** Press [Enter] key to activate the terminal.
- **Cause:** The terminal needs reset.
- **Solution:** Turn the terminal off, then on. Adjust brightness/contrast if needed.
- **Cause:** The power is off.
- **Solution:** Make sure the terminal is turned on and the power cord in the back of the terminal is properly connected.

10.2 TYCOM Terminal displays the status of a tube continuously, and does not respond to the keyboard input.
- **Cause:** The previous user set the display to the continuous mode.
- **Solution:** Press [ctrl] and [c] keys at the same time to kill the continuous mode.

10.3 TYCOM Terminal displays the status of a tube at a fixed interval of time repeatedly.
- **Cause:** Other user is checking the status of the tube remotely.
- **Solution:** If too many users are doing so and you cannot perform the routine TYCOM operation, contact staff to kill some of the remote checking.

10.4 TYCOM Terminal does not respond to any keyboard command at all (CPU hangs).
- **Cause:** TYCOM CPU needs reset.
- **Solution:** Follow the steps below to reset TYCOM:
  - Slide the TYCOM CPU out slowly.
  - Check that power cord and all the cables connected to the backside of the CPU are secured.
  - On the backside (up left corner facing the CPU), there is a black square power switch. Toggle the switch off then on.
  - Slide back the CPU slowly.
  - On TYCOM terminal, Enter `ACT PR`, then [Enter].
  - Enter `IN DA dd/mm/yy`; enter `IN TI hh:mm:ss` to set the date/time.

10.5 TYCOM Terminal displays a few lines of system messages every few seconds that interferes with command inputs.
- **Cause:** TYCOM reset was not properly finished
- **Solution:** Enter `ACT PR` when TYCOM is not displaying messages.
  - Check the system date/time by entering `DI DA`.
  - If the date/time is not correct, enter `IN DA dd/mm/yy` and `IN TI hh:mm:ss`.

10.6 TYCOM Terminal displays Tube I/O error message after a command is entered.
- **Cause:** The furnace I/O board needs to be replaced.
- **Solution:** Report on Mercury. Equipment staff will replace the I/O board.

Process/Recipe Problems

10.7 Door will not open and the process ends immediately after you press [RUN] button.
- **Cause:** TMPALM, LVLALM, or N2PRSAL is ON.
Solution: Find which alarm is ON, then report on Mercury.

10.8 The boat will not open or the boat loader stuck in the middle of the track with process still running.
Cause: Something physically blocks the movement of the boat loader.
Solution: Clear the track and the boat loader path, then try again. If the problem repeats, the boat loader needs to be reset. Report on Mercury.

10.9 The process advances to the process-fail-hold step or ends without ramping up the specified doping temperature.
Cause: The door did not close properly and DNTLK is ON.
Solution: Abort the recipe and run it again. Make sure there is nothing on the track to block the door movement. If problem repeat, the door sensor needs to be checked. Report on Mercury.

10.10 The process advances to the process-fail-hold step before the doping step is done.
Cause: One of the process gases, e.g., POCl$_3$, O$_2$, or N$_2$ has been used up.
Solution: Report on Mercury.

10.11 The furnace temperature does not stabilize at the doping temperature one hour after the wafer loading.
Cause: If all 3-temperature inputs are good, it is the electronic noise.
Solution: Press [Alarm Ack], and the process will continue to next step.
Cause: If one of the temperature inputs is 5°C deviate from the set point then the furnace needs be re-calibrated.
Solution: Report on Mercury.

11.0 Figures & Schematics
The Tystar Furnace consists of three basic modules: Load Station Module, Furnace Module, and Source Cabinet Module. Nano lab users can only access to the Load Station Module in the clean room area. The other two are in the Tylan service chase. Only Nano lab staff with proper training has access to these two modules due to potential hazards.

The Load Station Module houses a laminar flow unit with HEPA filter for clean air distribution. A Boat Loader Unit opens/closes the furnace door and pulls-out/pushes-in the cantilevers with wafer boats sitting on top. The operation can be automatically controlled by a process recipe, or manually using the ROP (see Section 12.8).

The Furnace Module consists of a quartz process tube, thermal couples, and heating elements. It is divided into three zones: Load, Center, and Source. The temperature is controlled through a PID electronic board. All the control parameters can be set in the process recipe. The volume of the quartz tube is approximately 45 liters. The process gas flows into the tube from the Source end and vented through the holes on the Load end.

The Source Cabinet Module contains several Mass Flow Controllers (MFC) that regulate the process gas flows, the DI water vapor generator, and the TLC bubbler. An electronic gas control system MFS 460 coordinates all the MFC and interlocks for safe operation.

12.2 Tycom Terminal
The Tycom Terminal controls/monitors all the Tystar Furnace operations. It consists of a CPU with two floppy disk drives, a CRT monitor and a keyboard. Disk drive #2, on the right side, is used for viewing and loading of recipes. The auxiliary drive is used for copying diskettes. The standard recipes for an individual furnace are stored on a floppy diskette labeled with the furnace name, e.g. TYSTAR1 STANDARD RECIPES. The floppy disk used has a special format. Please ask staff if you need one to store your customized recipes.

### 12.3 TYCOM Commands – TYCOM CPU only recognizes CAPITAL letters.

<table>
<thead>
<tr>
<th>Commands</th>
<th>Function</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI DI</td>
<td>Displays the recipe directory of the diskette in Drive #2</td>
<td></td>
</tr>
<tr>
<td>DI RE recipe name</td>
<td>Displays the content of a recipe on the diskette in Drive #2</td>
<td>DI RE 1SWETOXA</td>
</tr>
<tr>
<td>LO recipe name #</td>
<td>Load a recipe to a Tystar furnace</td>
<td>LO 2SDRYOXA 2</td>
</tr>
<tr>
<td>DI ST #</td>
<td>Displays current status of a Tystar furnace (see Section 9.2.2)</td>
<td>DI ST 3</td>
</tr>
<tr>
<td>DI DE #</td>
<td>Displays the system configuration of a Tystar furnace</td>
<td>DI DE 3</td>
</tr>
<tr>
<td>DI AL #</td>
<td>Displays previous process alarms of a Tystar furnace</td>
<td>DI AL 4</td>
</tr>
</tbody>
</table>

### 12.4 Display Furnace Status

When you use DI ST commands, the CRT monitor displays the status of the Tystar furnace. This information is very important, especially for equipment diagnosis. The following example is used to explain the information users should know. The furnace status to be displayed is Tystar13 with recipe 13POCL3A loaded but not running (Idle state).

<table>
<thead>
<tr>
<th>TUBE STATUS</th>
<th>PROCID</th>
<th>ET</th>
<th>STEP</th>
<th>TIME-TO-GO</th>
<th>STEP ET</th>
</tr>
</thead>
<tbody>
<tr>
<td>013</td>
<td>READY</td>
<td>2SWETOXA</td>
<td>00:00:00</td>
<td>0000</td>
<td>00:00:00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OUTPUTS</th>
<th>RELAYOUT</th>
<th>RELAYIN</th>
<th>INPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>N2CARR = 0.0</td>
<td>N2CARR = ON</td>
<td>DNTLK = OFF</td>
<td>TEMPL = H 752.3</td>
</tr>
</tbody>
</table>

N2 = 3000.0, N2 = ON, CCIN2 = OFF, TEMPC = G 751.0, 0840
O2HI = .0, O2HI = OFF, CCIN3 = OFF, TEMPS = L 747.2, 1031
O2LO = .0, O2LO = OFF, CCIN4 = OFF, CALIBL = 752.1
ANA05 = .0, CCOUT5 = OFF, CCIN5 = OFF, CALIBC = 750.9
ANA06 = .0, CCOUT6 = OFF, BPIN = ON, CALIBS = 747.3
SPEED = .0, CCOUT7 = OFF, BPOUT = OFF
The following sections explain the above display in details.

### 12.4.1 Display Header (first 4 rows)

The first row shows the current Data and Time stored in Tycom CPU. The second row indicates that any INPUT or OUTPUT followed by an * on the display is disabled. None of the INPUT and OUTPUT of Tystar 13 is disabled.

On the third and fourth lines:

<table>
<thead>
<tr>
<th>TUBE</th>
<th>Tystar furnace #.</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATUS</td>
<td>READY (idle, recipe loaded but not running)</td>
</tr>
<tr>
<td></td>
<td>RUN (recipe running)</td>
</tr>
<tr>
<td></td>
<td>HOLD (recipe hold at certain step)</td>
</tr>
<tr>
<td></td>
<td>STNBY (no recipe loaded, indicate power failure)</td>
</tr>
<tr>
<td>PROCID</td>
<td>Recipe ID, stated in the first line of the recipe.</td>
</tr>
<tr>
<td>ET</td>
<td>Total time elapsed since the process starts.</td>
</tr>
<tr>
<td>STEP</td>
<td>Current recipe step.</td>
</tr>
<tr>
<td>TIME-TO-GO</td>
<td>Time left to run in the current step.</td>
</tr>
<tr>
<td>STEP ET</td>
<td>Time elapsed in the current step.</td>
</tr>
</tbody>
</table>
12.4.2 OUTPUTS – Process parameter settings sent from TYCOM CPU to a Tystar furnace.

- **N2CARR, N2, O2HI, O2LO**: Process gas flow settings
- **SPEED**: Boat pull-out/push-in speed settings.
- **TEMPL, TEMPC, TEMPS**: Temperature settings for Load, Center, and Source Zone
- **ANA05, ANA06, ANA08**: Available for future use.

12.4.3 RELAYOUT – Commands sent from TYCOM to a Tystar furnace to turn on/off Contact Closure Switches.

- **N2CARR, N2, O2HI, O2LO**: Turn on/off the NUPRO valves of individual process gas. If off, no process gas flows regardless of what the flow setting is.
- **POCL3**: When ON, the N2CARR is forced to bubble through the POCl3 reservoir and carries the POCl3 vapor into the process tube. When OFF, the N2CARR bypass the reservoir and flow into the process tube directly.
- **CCOUT6, CCOUT6-13**: Available for future use.
- **DTCENA**: Turns on the DTC board for furnace temperature control. Every recipe must have DTCENA=ON statement in step 0001.
- **LOAD/UNLOAD**: LOAD=ON pulls the boat cantilever out, UNLOAD=ON pushes it back into the furnace. LOAD and UNLOAD should not be on the same time. The boat speed is controlled by the SPEED under OUTPUT (Section 12.4.2).

12.4.4 RELAYIN – Contact Closure Sensor inputs from a Tystar furnace to TYCOM CPU. When a process is running after the furnace door closes, only BPIN (and H2ORDY and TAPERDY for wet oxidation) should be ON. All other RELAYIN should be OFF.

- **DNTLK**: Door Interlock. When ON, indicates the furnace door is not properly closed.
- **LVLALM**: When ON, indicates the POCl3 level in the reservoir is too low.
- **TMPALM**: When ON, indicates the POCl3 reservoir is not at the set point.
- **CCIN2, CCIN5**: Available for future use.
- **BPIN/BPOUT**: Boat cantilever at IN and OUT position.
- **N2PRSAL**: Low Nitrogen Pressure Alarm. When ON, all NUPRO valves close (except N2) and no process gas will flow. **Check N2PRSAL before running any process.**

12.4.5 INPUTS – Actual Temperature and Gas Flow readings from furnace thermal couples and mass flow controllers.

- **TEMPL, TEMPC, TEMPS**: Actual temperature readings of Load, Center, and Source zones. A letter (H, G, L) in front of the temperature reading indicates whether the temperature is in the tolerance band set in the recipe. The 4-digits number, follows the temperature reading, represents electric power sent to each zone. The maximum power is 4095.
- **CALIBL, CALIBC, CALIBS**: Calibrated temperature readings. If these readings differ from TEMPL, TEMPC, TEMPS by 2ºC, the process...
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- Temperature may not stabilize. Report the problem on Mercury.

  *N2CARR, N2, O2HI, O2LO* Actual process gas flows. A letter (H, G, L) in front of the flow reading indicates whether the flow is in the tolerance band set in the recipe. If no tolerance is set, it is assumed that the tolerance is infinite, and the letter G appears all the time.

12.5 Display Process Alarms – There is no special abort sequence for the Tystar Atmospheric Furnace. To make sure that your process completes without any problem, the user should check the process run history by enter **DI AL #** command at Tycom terminal.

12.6 WAND/TYCOM Interface – Some TYCOM commands can be executed remotely using your UNIX account.

  12.6.1 Type wand at the UNIX prompt. Under WAND main menu, select **E** (Equipment Communication). Then press the space bar to select **t** (Tylan furnace interface). The TYCOM COMMUNICATION sub-menu will be displayed.

  12.6.2 Under the TYCOM COMMUNICATION sub-menu, press **d** (Display Status) to display Tystar furnace status. Same as **DI ST #** command on TYCOM terminal.

  12.6.3 Under the TYCOM COMMUNICATION sub-menu, press **D** (Display Definition Table) to display Tystar furnace configuration. Same as **DI DE #** command on TYCOM terminal.

  12.6.4 Under the TYCOM COMMUNICATION sub-menu, press **R** (Recipes) for some recipe related commands.

    - Press **c** to copy a recipe (must be on the diskette currently in TYCOM CPU disk drive #2) to the root directory of your Nanolab root directory.

    - Press **d** to display the directory of the diskette currently in TYCOM CPU disk drive #2. Same as **DI DI** command on TYCOM terminal.

    - Press **l** to display a recipe content on the diskette currently in TYCOM CPU disk drive #2. Same as **DI RE recipe-name** command on the TYCOM terminal.

12.7 Other TYCOM Commands

There are several commands such as: RU, HO, CO, AC, and AB that should be executed at the ROP for safety reasons. Please refer to Section 12.8.6 for the details of these commands.

12.8 Remote Operating Panel (ROP)

Every Tystar furnace has a Remote Operating Panel (ROP) that is located next to its Load Station Module. The ROP is used to perform all the process operation after recipe loading at TYCOM terminal. It consists of a schematics, a LED display panel, several LED lights, and buttons. Their functions are explained in the following sections.

**Furnace Schematics** – On the left up corner of the ROP. It shows the process gas plumbing of the furnace.

  12.8.1 **Furnace Zone LED** – Below the schematics. There are three LED for three zones of the furnace. One flash on the LED means one electric current pulse flows through the heating element of the furnace zone.

  12.8.2 **Boat Control** – Under the furnace zone LED, there are six square buttons for manual boat in/out control. Use this manual control only when the furnace is idle (the LED Display Panel reads **READY**). The following sub-sections describe how to pull-out/push-in furnace door and boat cantilevers.

12.8.3 **Hardware Alarm** – To the right of the Boat Control Buttons, there are two Alarm Cause LED, OT and SCR. Both of them are hardware temperature control alarms. If either one is on, press the [Alarm Ack] button below them to silence the alarm, then contact staff immediately. During non-office hours, abort process, then report problem on Mercury.

12.8.4 **LED Display Panel and Numerical Pad** – On the right center of the panel, there is a LED display panel and a Numerical pad. The LED Display Panel cycles through the following furnace information when the [7/Status] button on the numerical pad is pressed.

**Process Status:**

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>READY</td>
<td>Idle status, recipe loaded but not running (holding at step 0001 of the recipe)</td>
</tr>
<tr>
<td>STNBY</td>
<td>Standby status, recipe lost due to power failure or furnace computer reset. A recipe needs to be loaded, otherwise the furnace cools down with all gases shut off.</td>
</tr>
</tbody>
</table>

**Recipe Name:** The Process ID that appears on the first line of the recipe. Usually the same as the recipe file name.

**STEP:** The current step number of the running recipe.

**Time:** Time to go in current process step (HH:MM:SS)

**Temperature:** Average temperature of the three furnace zones.

Do not press other numeric buttons, which are designed, for the industrial manufacturing use. If press by mistake, the LED display panel may not function properly. Press [Clear], then [7/Status] button to clear this problem.

12.8.5 **Process Operation Buttons** – There are four buttons, on the right side of the ROP, for process control. Their function and corresponding TYCOM commands are listed in the following table.

<table>
<thead>
<tr>
<th>ROP button</th>
<th>TYCOM command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recipe/Run</td>
<td>RU #</td>
<td>Run the loaded recipe</td>
</tr>
<tr>
<td>Hold/Clock</td>
<td>HO #</td>
<td>Hold the process at current recipe step</td>
</tr>
<tr>
<td>Alarm/Ack</td>
<td>AC #</td>
<td>Silence the <strong>process end</strong> alarm, returns the furnace to READY. Skip to next process step (works only IF ALMACK=ON GOTO #### is in the current process step)</td>
</tr>
<tr>
<td>Abort</td>
<td>AB #</td>
<td>Abort the current process, the furnace skip to <strong>END</strong> state</td>
</tr>
</tbody>
</table>