Chapter 5.6

Tystar6 POCl₃ N-Type Liquid Doping Atmospheric Furnace (6” and 8”)
(Non-MOS)
(tystar - 386)

1.0 Title
Tystar6 Non-MOS POCl₃ N-Type Liquid Doping Atmospheric Furnace (6” and 8”)

2.0 Purpose
Provide specific operation and process information for Tystar6 atmospheric POCl₃ n-type doping furnace that is capable of processing both 6” and 8” wafers. This tube is specifically assigned to n-type doping of Si using the POCl₃ process.

3.0 Scope
This chapter covers the general furnace description for Tystar6 and furnace operation procedures, which includes recipe loading, wafer loading/unloading, process status monitoring, problem diagnosis, and wafer cleaning requirements.

4.0 Applicable Documents
Revision History
4.1 Tystar Diffusion Furnace System Instruction Manual (copy in Office).
4.2 Material Safety Data Sheets for POCl₃, O₂ and N₂ (copies in the lobby).

5.0 Definitions & Process Terminology
5.1 FCS-10: touchscreen control terminal
5.2 POCl₃ Liquid Dopant Diffusion: POCl₃ oxidizes at normal process temperatures with O₂ to form P₂O₅. This material is reduced by reaction with the exposed Si at the wafer surface to form P and SiO₂. P then diffuses into the Si at a rate determined by the temperature of the furnace. Diffusion depth is found using the diffusivity of P at the furnace temperature.
5.3 Annealing: A high temperature process that uses N₂ to keep wafers in an inert atmosphere.
5.4 Furnace Flat Zone: An area inside the furnace with the least temperature variation across it (consequently the best place to process wafers).

6.0 Safety
Follow general safety guidelines in the lab as well as the specific safety rules, listed below:
6.1 Electric Shock Hazard: Tystar furnaces utilize high electric power (high current) 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 is used as a liquid P source for diffusion of n-type regions into Si substrates. POCl₃ is not flammable. However it does pose a serious health hazard if inhaled or ingested. Please refer to the MSDS for first aid information.
6.3 Burn Hazard: Cantilevers, boats, and wafers coming out of the furnace are very hot. Always wear protective gloves when handling hot tools and/or wafers. Beware of burns. Avoid touching hot materials with bare skin.
flammable chemicals, especially organic solvents, are allowed at the load station when the tube is open.

6.4 New recipes are not permitted without the express consent of process staff.

7.0 Statistical/Process Data

7.1 Check the Problem and Comment section under the equipment menu of Mercury.

7.2 Check the message upon enabling for Tystar6.

8.0 Available Process, Gases, Process Notes

8.1 Wafer Cleaning Requirements, before loading them into Tystar furnaces.

8.1.1 Non-metalized wafers to be processed in Tystar6 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 Tystar6. 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

8.1.2 No cleaning steps are necessary when transferring wafers directly from one MOS furnace to another MOS furnace. Similarly, no cleaning is required when directly transferring wafers from one non-MOS furnace to another non-MOS furnace.

8.2 No metals are allowed in Tystar6.

Available Processes

8.3 Non-MOS POCl₃ n-type doping of 6” and 8” wafers.

Available Gases

8.4 Nitrogen (N₂): Used to purge tube of atmospheric gases and keep tube in an inert/clean environment when idle.

8.5 Oxygen (O₂): Used for the oxidation of POCl₃.

8.6 Nitrogen Carrier (N₂CARR): Used to carry POCl₃ vapor to the process tube.

Special Process Notes

8.7 Tystar6 should be used for n-type POCl₃ doping of Si only. In the event that Tystar6 is down, you may request staff to review your process to see if it is suitable for Tystar13. If staff deems your process is OK, Tystar13 may be used as a backup to Tystar6 for 6” wafers. There is currently no 8” wafer backup.

9.0 Overall Furnace Operation

9.1 General Tystar Furnace Operational Guidelines

Tystar6 is a three-zone atmospheric pressure furnace. It operates as a stand-alone unit that is comprised of three modules: wafer load/unload, furnace/process tube, and gas control. It has its own computer, FCS10, whose display panel and keypad are located on the left side of the wafer load/unload module. The furnace operation is controlled using a stylus to press function keys and a series of menu commands. Furnace temperature is controlled by the TCU computer board, which utilizes a proprietary PID algorithm. The temperatures of all 3 furnace zones; i.e. Load,
mass flow system and has five hardware interlocks to ensure safe operation of the tool.

9.1.1 Front Panel Special Function Buttons and Keypad Description (see Section 11.1 for the schematics of the front panel)

**ABORT: ***USE ONLY IN EMERGENCY***,** e.g. fire, toxic gas leak. DO NOT use this key to abort a recipe in progress. If you must stop a recipe, please contact a super-user or process staff. They know the proper procedure for stopping a process or evacuating toxic gases from the furnace. This action requires a password.

**MAIN MENU:** Displays the main menu (See the Appendix for the description of all menu commands)

**NEXT PAGE:** Used to display more information/instructions on the display. Use when prompted, otherwise the computer will freeze and you will need to find a process staff member to reboot it.

**CMD:** Used for certain special functions. (Mostly used with GS commands)

**Arrow Keys:** Used when prompted to select a recipe. Do not use the arrow keys for **DEL/BACKSPACE** when entering alphanumerical inputs. The computer will freeze and you will need to find a process staff to reboot it.

**Alpha-Numeric Keys:** Used to enter process parameters, e.g. gas flows, pressure, deposition time, and etc.

**ENTER:** Used to enter the menu command or alphanumerical inputs.

**CLEAR:** DO NOT USE ON THIS FURNACE. This will freeze the computer.

**BACKSPACE:** Used for correcting alphanumeric inputs.

**RUN:** Run the recipe loaded in computer memory.

**HOLD:** Hold a recipe step at its present process condition. Press the RUN key to resume the process.

**EVENT:** Acknowledge the process to go to the next step of the recipe when the current step time has not finished yet. For example, after you finish loading the wafers and want to close the furnace door before your 20 minute time limit is up. Note that some process recipe steps do not respond to the EVENT key.

**BOAT IN/OUT:** Move the boats in/out of the process tube manually, independent of the recipe. These are toggle switches, i.e. push once to turn on and the second time to turn off. If both are ON at the same time, then the boats stop moving.

**ALARM ACK:** Silences an alarm, but does not correct the alarm condition. Alarm conditions are displayed on the bottom line of the screen. In most cases, the computer will clear the alarm conditions by itself. If not, report the problem on Mercury.

9.2 Computer Terminal (loading recipes and looking at status of run in progress)
Summary of Commands and Functions.

<table>
<thead>
<tr>
<th>Commands</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR</td>
<td>Displays available recipes. Use arrows and double enter to view recipe steps. Top of window gives instructions on how to view steps in detail. Press shortcut labeled <strong>NEXT PAGE</strong> to display next page of steps/sub-steps.</td>
</tr>
<tr>
<td>RL</td>
<td>Loads process recipes. You will be prompted to use the Arrow Keys to select a recipe. Afterward, press ENTER button twice. The computer will prompt you to enter process parameters, if/when needed.</td>
</tr>
<tr>
<td>DS</td>
<td>Displays current process status of Tystar6. Includes current step, time to go, and parameters status.</td>
</tr>
<tr>
<td>DH</td>
<td>Displays the process history from the last time the RUN button was pressed to present time.</td>
</tr>
<tr>
<td>GS</td>
<td>Changes the Display to graphic mode. It shows large characters with only selected process information. Use CMD button to select process parameters to be displayed.</td>
</tr>
</tbody>
</table>

9.3 Available Recipes

9.3.1 PCLO2.006: POCl₃ n-type doping. Variables are ramp and POCl₃ deposit temperatures, N₂ and N₂ carrier flow, O₂ flow, POCl₃ deposition and drive-in times.

9.4 Processing a Run (Loading Recipe and Wafers)

**Loading a Recipe**

9.4.1 Enable Tystar6 on Mercury.

9.4.2 Check that no recipe is already running in the furnace and that the furnace status reads IDLE (status found at center top of **DISPLAY STATUS** sub menu).

9.4.3 Go to **MAIN MENU** and type RL (Recipe Load) to display available recipes.

9.4.4 Select desired recipe using arrow keys and press **ENTER** twice to begin.

9.4.5 Enter desired process parameters when prompted and press **MAIN MENU**, as instructed by the computer, upon variable entry completion. The furnace status should still read IDLE in Display Status.

**Load wafers and run a process recipe**

9.4.6 Put on the face shield.

9.4.7 Press **RUN**. The furnace door will open and wafer boats will come out. Be aware that the furnace door will automatically close after 20 minutes.

9.4.8 Transfer your wafers from Msink6 to the furnace in the designated wafer transfer box. Do not use the Teflon cassette to avoid contamination.

9.4.9 Load your wafers using the non-MOS clean vacuum wand with black tubing. These vacuum wands do work with 8” wafers, no special equipment is necessary. All wafers should be loaded with their flats up for optimal wafer support and consistent gas distribution.
gloves are usually too big and slippery for proper dexterity, and the tips of the poly gloves may melt, causing contamination and burns.

9.4.11 Once wafers are loaded, press EVENT to start the boat moving into the furnace.

Unload wafers after process ends

9.4.12 No alarm will sound when your recipe is finished running. You are in charge of checking the status of your run. PCLO2.006 is programmed to hold your wafers in an inert environment until you are ready to unload.

9.4.13 To unload your wafers, press EVENT. The boats will move out. When the boats stop moving, wait a few minutes for the wafers to cool down. Then use the non-MOS vacuum wand to unload into the cooling rack next to the furnace (Tystar6 quartz boats). Wafers may still be too hot, so you may have to wait for a few more minutes before placing them into your plastic cassettes.

9.4.14 Press EVENT to move the boats back into the furnace. The furnace status will return to IDLE once the door is closed.

9.4.15 Disable Tystar6 on Mercury and be sure to report any problems.

10.0 Troubleshooting Guidelines

10.1 Computer Terminal is blank.

10.1.1 Tap on the far right side of the screen. It should light up.

10.2 Door won’t open/Boat loader stuck

10.2.1 Make sure there is nothing obstructing the movement of the boat loader.

10.2.2 Make sure the cable that pulls the boat loader is not loose. If so, ask staff to adjust the tension on the cable.

10.2.3 If the above steps fail, report the problem on Mercury.

10.3 The tube is at one of the abort sequences (step ABRT) when you come back to unload your wafers.

10.3.1 One of the process gas flows was out of tolerance due to a delivery system malfunction or empty gas cylinder.

Solution: Press MAIN MENU, then enter DH. Press ENTER when prompted for input. The process history for this run will be displayed. Note the last step before the abort sequence and report it on Mercury.

10.3.2 You did not enable the furnace. Find a staff person to restart the process.

10.4 The tube is at special hold (step SHLD)

10.4.1 When the process is in SHLD, an equipment failure has occurred.

Solution: Report as a fault on Mercury. Do not attempt to fix the situation yourself.

11.0 Figures & Schematics
Appendix

FCS10 Furnace Computer Manual Commands

D - Display Sub-Menu
   DE equipment status
   DD file directory - Lists the recipes in memory. (Same as DI DI in Tycom)
   DH process history. In case of recipe abort, error message can be found.
   DR process steps in a recipe file. The system will prompt you to select a specific recipe from
   memory.
   DS process status that is continuously updated.
   DT temperature history
   DE and DT should not be used.

R - Recipe Sub-Menu (password protected except RL)
   RE Allows one to edit recipes. See the Tystar Manual for instructions.
   RL Load a recipe for subsequent use. Usually, this is the only command, which you will need to use
   from this sub-menu.
   RM Modifies current process parameters.
   RR Renames a recipe. Don't use this either...
   RX Deletes a recipe from memory.

G - Graphics Sub-Menu
   GP plumbing diagram
   GE plumbing edit (password protected)
   GS tube status. An abbreviated status summary screen is displayed.

The following sub-menu commands should not be used and are for reference only.

H - Host computer Sub-Menu
   HP host parameters

C - Configuration Sub-Menu
   CC contact closures
   CM MFS460 gases
   CT TCU temperature
   CS station options
   CA alarm selection

X - Diagnostics Sub-Menu
   XM memory utility
   TI (change time, date) and PW (change password) have no submenu. Don't use these commands.

Tystar6 Furnace Study Guide

Be sure to know...

1. Maximum temperature.
2. MOS vs. non-MOS rule.
3. Loading a recipe.
4. Troubleshooting the Computer Terminal.
5. Cleaning wafers before they go into the furnace.
7. Displaying the status of a process.
8. Unloading wafers and closing the tube.
9. Which vacuum wand to use.
10. Alarms and what to do when you hear them.
12. Which gases are used by tystar6.