



Chapter 5.5

Tystar5 MOS Oxidation Atmospheric Furnace (4", 6", 8")

(tystar5 - 386)

1.0 Equipment Purpose

Tystar5 is a MOS Oxidation Atmospheric Furnace (chips to 8"). This tube is specifically assigned to MOS wet and dry oxidation processes. The tube can be operated up to 1200°C.

2.0 Material Controls & Compatibility

2.1 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.

2.2 No metals are allowed in Tystar5.

2.3 Process run times exceeding 12 hours must be pre-approved by staff

3.0 Training Procedure & Applicable Documents

3.1 Exam Tool - this tool requires an online exam before qualification. Timeline (estimated time to completion: 1 week)

3.1.1 Get trained by any qualified member.

3.1.2 Take the online test in the Nanolab office (open 8A-12P, 1P-5P).

3.1.3 Arrange a qualification session with a superuser or staff to show competency on the tool.

3.2 Tylan Diffusion Furnace System Instruction Manual (copy in Office).

3.3 TYCOM 9900 Microprocessor Control System Instruction Manual (copy in Office)

3.4 Oxide Growth Chart, Semiconductor Technology Handbook (in the binder stored under TYCOM terminal)

3.5 Material Safety Data Sheets for TRANS-LC (trans 1, 2-Dichloroethene), Oxygen, Nitrogen, Argon and Forming Gas H₂/N₂ (copies in the lobby).

4.0 Definitions & Process Terminology

4.1 FCS-10: touchscreen control terminal

4.2 **MOS Furnace:** This furnace is used to fabricate MOS devices (IC), the performance of which can be greatly impacted by trace contaminants. Wafers processed in this MOS furnace must be MOS compatible. Absolutely no metal films in any MOS furnace, except the MOS sintering furnace, which allows only Al film.

4.3 **Dry/Wet Oxidation:** A high temperature (dry O₂ or steam) process that oxidizes the underlying Si to form SiO₂. Dry oxidation uses O₂ for better process control. Wet oxidation uses both DI water and O₂ for faster reaction rate.

- 4.4 **Gate Oxidation:** A special dry oxidation (O_2) process that produces high quality silicon oxide film (well controlled thickness and density).
- 4.5 **Annealing:** A high temperature process that uses N_2 to keep wafers in an inert atmosphere.
- 4.6 **TLC Cleaning:** A high temperature process that uses trans 1, 2-Dichloroethene and oxygen to clean the furnace quartz tube by removing possible metallic contaminants.
- 4.7 **Furnace Flat Zone:** An area inside the furnace with the least temperature variation across it (consequently the best place to process wafers).

5.0 Safety

Follow general safety guidelines in the lab as well as the specific safety rules, listed below:

- 5.1 **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.
- 5.2 **Chemical Hazard:** TLC (trans 1, 2-Dichloroethene) is used for in-situ cleaning of quartz wares. TLC poses moderate health and fire hazards. Please refer to the MSDS for first aid information.
- 5.3 **Burn Hazard:** Cantilevers, boats, and wafers coming out of the furnace are very hot. Always wear a face shield when loading/unloading wafers. Proceed with caution. Avoid touching any furnace quartz ware to prevent burning your hands and/or contaminating the furnace. No 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.**

6.0 Statistical/Process Data

- 6.1 Process monitoring data can be found in the problem and comment section, under the equipment menu of Mercury Client and in the enable message for each Tystar furnace.

7.0 Available Process, Gases, Process Notes

7.1 **Wafer Cleaning Requirements, before loading them into Tystar furnaces.**

- 7.1.1 Non-metalized wafers to be processed in Tystar5 must go through the standard pre-furnace cleaning procedure. This entails a 10 minute piranha dip in Msink8 and Msink6, and an ensuing 30 second HF dip for oxide removal if desired. Photoresist coated non-metalized wafers must initially have their photoresist stripped in the Matrix Asher or stripped at Msink1 (PRS-3000 bath) prior to cleaning in msink8. This is required for both MOS and non-MOS wafers. Msink6 is the pre-furnace clean step prior to wafer introduction into Tystar5. For a complete description of pre-furnace wafer cleaning please see Section 1.3 in Chapter 5.00, Tystar Furnaces Overview.
- 7.1.2 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.

7.2 **No metals are allowed in Tystar5.**

7.3 Available Processes

- 7.3.1 MOS furnace dedicated to wet and dry oxidation.
- 7.3.2 TLC clean - as of August 2016 the TLC clean has been put on hold.

7.4 Available Gases

- 7.4.1 **Nitrogen (N₂):** Used to purge tube of atmospheric gases and keep tube in an inert/clean environment during non-oxidation steps.
- 7.4.2 **Oxygen (O₂):** Used for the dry/wet oxidation process.
- 7.4.3 **DI Water Vapor (H₂O VAP):** Used for wet oxidation.
- 7.4.4 **Argon (Ar):** Available inert gas

NOTE: Forming gas H₂/N₂ and Argon share a line that is controlled by a hand -operated valve in the back of the tool. Currently Argon is the default gas for this line. Contact process staff if your recipe requires Forming Gas.

- 7.4.5 **TLC (C₂H₂Cl₂):** Used for in-situ process tube cleaning. As of August 2016, TLC cleaning is on hold.
- 7.4.6 **Nitrogen Carrier (N₂CARR):** Used to carry TLC vapor to the process tube.

7.5 Special Process Notes

- 7.5.1 Tystar5 should be used for dry and wet oxidation. There is an Anneal recipe also available. In the event that Tystar5 is down, Tystar1 may be used as backup for 4" and 6" wafers. There is currently no 8" wafer backup.
- 7.5.2 Absolutely no wafers with metal on them are allowed in Tystar5.
- 7.5.3 After a TLC process please check the MFS460 alarm. If you do not know where it is located, ask staff for help. If the MFS460 is alarming, no process gas except N₂ can flow for your process.
- 7.5.4 Tystar 5 can operate up to 1200C.

8.0 Equipment Operation

8.1 **General Tystar Furnace Operational Guidelines**

Tystar5 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, Center and Source can be independently set. The process gases are controlled by the MFS460 mass flow system and the five hardware interlocks it contains to ensure safe operation of the tool.

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 alphanumeric 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 alphanumeric 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.

8.2 Computer Terminal (**loading recipes and looking at status of run in progress**)

The Computer Terminal controls and monitors all user accessible Tystar5 Furnace operations.

Commands:

The computer terminal only recognizes CAPITAL letters. You can also use the special function buttons. However, it is suggested that you learn the commands manually as well.

Summary of Commands and Functions.

Commands	Function
DR	Displays available recipes. Use arrows and double enter to view recipe steps. Top of the window gives instructions on how to view steps in detail. Press the shortcut labeled NEXT PAGE to display the next page of steps/sub-steps.
RL	Loads process recipes. You will be prompted to use the Arrow Keys to select a recipe. Afterward, press the ENTER button twice. The computer will prompt you to enter process parameters, if/when needed.
DS	Displays current process status of Tystar5. Includes current step, time to go, and parameters status.
DH	Displays the process history from the last time the RUN button was pressed to present time.
GS	Changes the Display to graphic mode. It shows large characters with only selected process information. Use the CMD button to select process parameters to be displayed.

8.3 Available Recipes

VARDRY.005: Gate Oxidation. Variables are temperature, oxidation time, and anneal time.

WETOXYA.005: Wet Oxidation. Variables are temperature, wet oxidation time, and H2O vapor flow.

TLCA.005: TLC cleaning.

8.4 Processing a Run (**Loading Recipe and Wafers**)

Loading a Recipe

Enable Tystar5 on Mercury.

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

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

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

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

Put on the face shield.

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.

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

Load your wafers using the MOS clean vacuum wand with red 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.

Do not wear poly gloves over nitrile gloves when loading/unloading wafers. The poly gloves are usually too big and slippery for proper dexterity, and the tips of the poly gloves may melt, causing contamination and burns.

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

Unload wafers after process ends

No alarm will sound when your recipe is finished running. You are in charge of checking the status of your run of your own accord. Both VARDRY.005 and WETOXYA.005 are programmed to hold your wafers in an inert environment until you are ready to unload.

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 MOS vacuum wand to unload into the cooling rack next to the furnace (Tystar5 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.

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

Disable Tystar5 on Mercury and be sure to report any problems.

9.0 Troubleshooting Guidelines

9.1 Computer Terminal is blank.

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

9.2 Door won't open/Boat loader stuck

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

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

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

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

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.

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

9.4 The tube is at special hold (step SHLD)

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.

10.0 **Study Guide**

10.1 Maximum temperature.

10.2 MOS vs. non-MOS rule.

10.3 Loading a recipe.

10.4 TLC cleaning: when, why and how.

10.5 Troubleshooting the Computer Terminal.

10.6 Cleaning wafers before they go into the furnace.

10.7 Loading wafers.

10.8 Displaying the status of a process.

10.9 Unloading wafers and closing the tube.

10.10 Which vacuum wand to use.

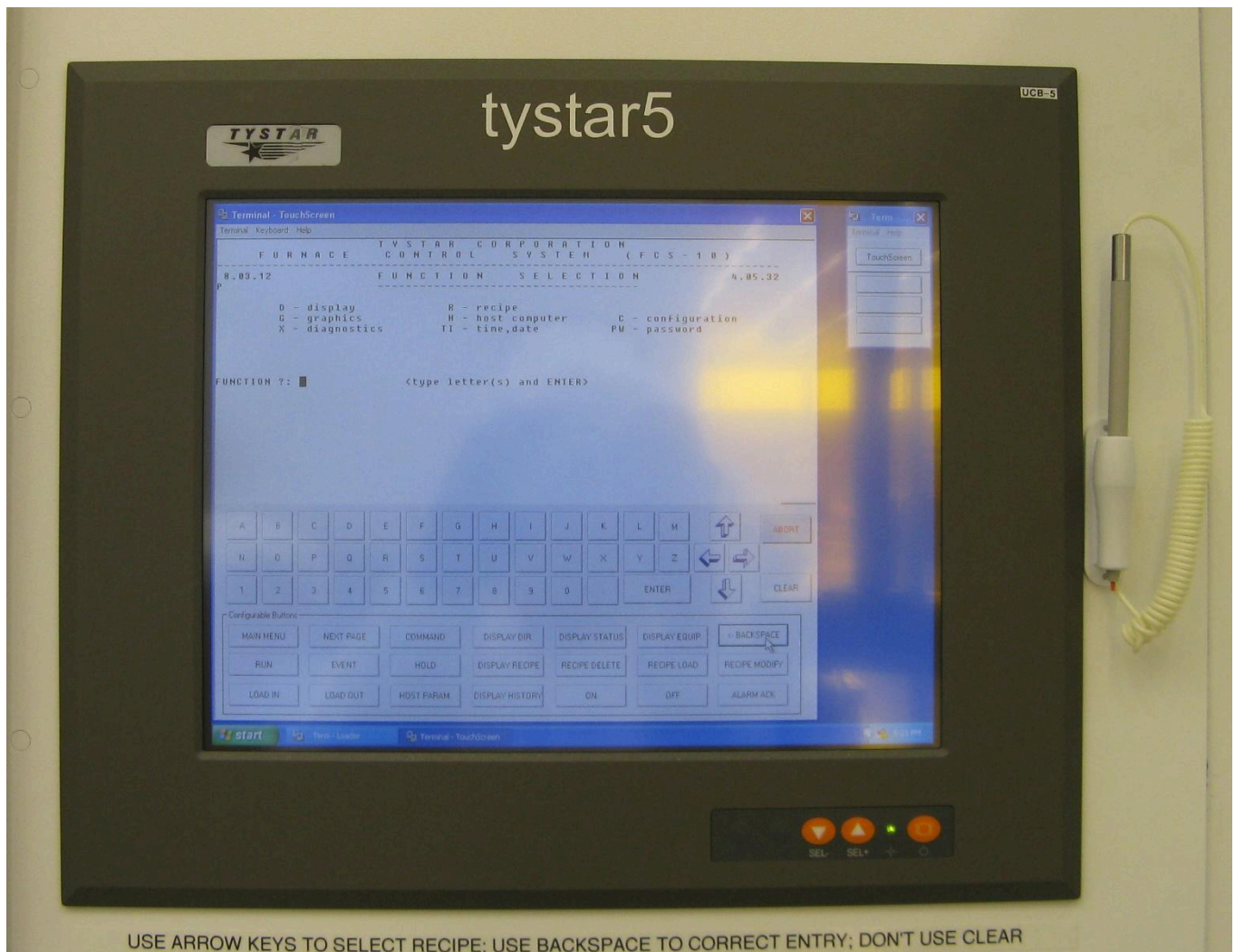
10.11 Alarms and what to do when you hear them.

10.12 Positioning wafers in boats: why and how.

10.13 Which gases are used by tystar5.

11.0 Appendices, Figures & Schematics

11.1 Figure 1 – Tystar5 computer terminal Display



11.2 Appendix

FCS10 Furnace Computer Manu 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.

11.3 Standard Recipes***Standard 1kÅ Wet Oxide Recipe***

Recipe= WETOX.005, Temperature 1000°C, time 10minutes (ultraMEMS online calculator, yields 1002 Å)

Standard 10kÅ Wet Oxide Recipe

Recipe = WETOXYA.005, Temperature = 1050°C, time = 3 hours, 5 minutes and 48 sec