Chapter 5.18

**Tystar 18**

*MOS Al Sintering Atmospheric Furnace*

*(4” and 6”)*

(tystar18 - 386)

1.0 **Title**

Tystar18 MOS Aluminum Sintering Atmospheric Furnace

2.0 **Purpose**

Tystar18 is a MOS clean atmospheric furnace for Sintering/Alloying. It can also be used for annealing in nitrogen ambient at temperatures not exceeding 600°C.

3.0 **Scope**

This document provides operational procedures for Tystar18 furnace, recipe loading from the FCS10 furnace computer, and guidelines for user level troubleshooting.

4.0 **Applicable Documents**

Revision History

4.1 Chapter 5.0 of the lab manual (Tystar Furnaces - Overview).

4.2 TYTAN Diffusion Furnace System Manual, includes FCS10, TCU, MFS460 (Copy in Office)

4.3 The Material Safety Data Sheets (MSDS), which explains the safety concerns for the specific gases used in Tystar18.

5.0 **Definitions & Process Terminology**

5.1 **MOS Furnace**: This kind of furnace is used for processing MOS devices (IC), whose performance can be greatly impacted by trace contaminants. Wafers processed in MOS clean furnaces should absolutely be MOS compatible (IC device). Absolutely no metal films are allowed in any MOS Furnace, except the MOS sintering furnace, Tystar18, which allows Al and refractory metals such as W.

5.2 **Non-MOS Furnace**: This kind of furnace is used for processing non-MOS devices (non-IC) such as MEMS devices. Any wafer that has been processed in a non-MOS furnace is not allowed in any MOS furnace.

5.3 **Atmospheric furnace**: This type of furnace is at standard pressure and does not have a vacuum pump connected to it. The process gas is fed into the quartz tube from the backend (source), and flows toward the frontend (load) of the furnace.

6.0 **Safety**

Follow general safety guidelines in the lab and the specific safety rules as per follows:

6.1 Tystar18 utilizes **high electric power** (high current) heating elements. Do not touch high power electrical parts inside the panels of the furnace.

6.2 Special care must be taken when your process aborts. In the event your process goes into SPECIAL HOLD, immediately inform process staff to assess the problem. There may be
hazardous gases still present in the tube. Process staff will decide whether to continue the process and what actions to take to remedy the situation.

**DO NOT ATTEMPT TO OPEN THE TUBE, WHEN IT IS IN SPECIAL HOLD.**

6.3 All new recipes have to be approved by the process staff, before they can be used on any Tystar furnaces.

6.4 **Burn Hazard.** Furnace cantilevers, boats, and wafers come out of the furnace are very hot. Wear face shield when loading/unloading wafers. Proceed with caution.

7.0 *Statistical/Process Data*

7.1 Problem and Comment fields under the Equipment section of Mercury.

7.2 Enable message for Tystar18.

8.0 *Available Process, Gases, Process Notes*

8.1 Only MOS wafers can be processed in this furnace. Non-metalized wafers to be processed in Tystar18 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. Metalized wafers which can be attacked by piranha should never be processed at Msink8 or Msink6. A clean heated metal bath is available at Msink1 for cleaning metalized wafers prior to entering Tystar18. 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 any furnace. This means photoresist removal from non-metalized wafers requires an additional cleaning at Msink8 regardless of whether the process is MOS or non-MOS. Resist coated metalized wafers will need to get a resist strip, *ash & wet*, plus rinse steps, before going into the Tystar18 furnace. Sometimes the ash strip alone can leave minute particles on the wafer, so a wet strip becomes necessary. For a complete description of pre-furnace wafer cleaning please see Section 1.3 in Chapter 5.00, Tystar Furnaces Overview.

8.2 Wafers coming out of another MOS Tystar furnace, and going straight into Tystar18 without delay, will not require a cleaning step in between.

8.3 Metal wafers - only wafers with Al/2%Si film or other type of metal films that do not melt below 1500°C (refractory metals) can be processed in this furnace.

Available Processes

8.4 H2SINT4A.018: Regular forming gas (10% H2, 90% N2) sintering at 400°C.

8.5 H2SINT6A.018: Regular forming gas (10% H2, 90% N2) sintering at 600°C.

8.6 H2SINTVT.018: Regular forming gas (10% H2, 90% N2) sintering at a variable temperature (<=600°C).

8.7 LTANNL.018: Regular forming gas (10% H2, 90% N2) and/or N2 annealing at a variable temperature (<=600°C).

8.8 LTN2ANL.018: N2 annealing at a variable temperature (<=600°C).

8.9 LTO2ANL.018: O2 flow in the furnace at a variable temperature (<=600°C).

8.10 Please contact process staff for any customized processes you may need.

Available Gases

8.11 Hydrogen/Nitrogen (10%H2, 90%N2): Forming gas is used because many metal films are sensitive to oxygen at elevated temperatures. The hydrogen is responsible for passivating and deactivating the interface traps.

8.12 Deuterium/Nitrogen (10%D2, 90%N2): Not available at present.
8.13 **Nitrogen (N₂):** Used for annealing and to maintain the process tube in a clean, inert environment.

8.14 **Oxygen (O₂):** Available.

8.15 **Argon (Ar):** Not connected.

**Process Notes**

8.16 The maximum temperature for Tystar18 is 600°C. Any attempt to go above this temperature will damage the heating system of the furnace.

8.17 Please load and unload wafers as quickly as possible with safety in mind. Avoid opening the tube for more than 5 minutes. This may cause the tube temperature to drop significantly, and the process temperature may not reach the set point, as the process sintering time is relatively short (20 minutes, or so).

8.18 The sintering recipes are optimized when the starting temperature is at the set point for all five heater zones. Please leave at least 30 minutes between two consecutive runs for temperature to recover.

8.19 If your process temperature is different from the previous run, you should load your recipe and wait until the temperature stabilizes before running the process.

8.20 All Tystar18 recipes use 4-letter step ID’s, instead of 4-digit numbers used in the past. The commonly used ID’s are noted below:

| IDLE   | IDLE state   | STRT   | process StaRT   |
| LOAD   | LOAD/unload wafers | BTIN   | BoaT moves into the tube |
| CKDR   | Check Door interlock | STEQ   | Sintering Temp Equilibrium |
| SINT   | SINTERing step   | GOFF   | process gas turn OFF. |
| BTOU   | BoaR OUT automatically | UNLD   | UNLoaD wafer |
| CLDR   | Close Door | PEND   | Process END |
| ABRT   | ABORt sequence | SHLD   | Special HoLD |

**9.0 Overall Furnace Operation**

**9.1 General Information and Menu Keypad Explanation**

Tystar18 is a five-zone atmospheric pressure furnace. It operates as a stand-alone unit with three modules: wafer load/unload module, furnace/process tube module, and gas control module. 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 through special 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 5 furnace zones; i.e. Load, Load/Center, Center, Source/Center, and Source can be independently set. The process gases are controlled by the MFS460 controller and five hardware interlocks contained within to insure safe operation of the tool.

**9.1.1 Front Panel Special Function Buttons and Keypad Description** (see Section 11.1 for the picture of the front keypad)

**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 process/evacuating toxic gases from the furnace. This action requires a password as well.

**MENU**

Display 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 to reboot it.
CMD
Used for certain special functions. (Mostly used with GS commands, Section 9.1.2)

Arrow Keys
Used when prompted to select a recipe. Do not use these keys as a DEL/BACKSPACE key when entering alphanumerical inputs. If you do, the computer will freeze and you'll need a member of the process staff to reboot it.

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

ENTER
Used to enter the menu command or alphanumerical inputs.

CLEAR
Used to clear the error on the alphanumerical key input.

RUN
Run the recipe loaded in the 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 instance, after you've finished loading your wafers and want to close the furnace door. Note that some process recipe steps cannot shortened or skipped by pressing the EVENT key.

BOAT IN/OUT
Press these switches to move the boats in and out of the process tube manually, independent of the recipe. These are toggle switches. Push them once to turn on and the second time to turn off. If both are ON at the same time, the boat will 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 the Mercury Client.

9.1.2 Commonly Used MENU Commands (press MENU button, then enter the two letter commands):

DS
Displays the status of the furnace. An example is shown in Section 11.2.

DH
Displays the process history from the last time the RUN button was pressed to present time.

DR
Displays the contents of the selected recipe.

GS
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.

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 the process parameters, if needed.

9.1.3 Process Gas Flow Interlocks

DNTLK
Door interlock. When ON, it indicates that the tube door is not properly closed. As a result, no process gas, except N₂, will flow.

9.2 Processing a Run

Load Recipe

9.2.1 Enable TYSTAR18 on the Mercury
9.2.2 Press MENU button, then enter DS. The screen displays the status of the furnace. Make sure the process is in the IDLE state.

9.2.3 Press MENU button, and then enter RL for the screen to show a list of the available recipes. Use the arrow keys to highlight the recipe that you plan to load, then press ENTER twice.

9.2.4 The computer will prompt you to enter the process parameters defined in the recipe. The input values of the previous run will be displayed for your reference. Enter your values in the same format shown on the screen, even if it is exactly the same as what is already displayed on the screen. Press ENTER after typing each process variable value.

9.2.5 Use the CLEAR key if you need to erase a wrong value, entered. **DO NOT USE THE ARROW KEY TO MOVE THE CURSOR!** This will cause the software to crash and all the recipes might be lost. You will have to find a super user or staff to reboot the furnace computer.

9.2.6 Time is entered in the format of HH.MM.SS. Do not enter 00.00.00 since it will hold the process at the associated step indefinitely. If you want to skip the associated step, enter 00.00.01 which is the shortest time for a step. Usually, the process parameters cannot respond within one second, and the process skips to the next step.

9.2.7 Once you have finished entering all of your required values, press MENU, then DS to check that the recipe is loaded properly. Check the temperatures (all 5 zones) are stabilized at the set point.

**Start A Process Recipe**

9.2.8 Press RUN to start the process recipe loaded previously. The tube door will open and boats will come out.

9.2.9 Put on the face shield. After the cantilever with the boats move out completely, load your wafers. The boats will remain out for 20 minutes. If the boats start moving in, and you have not finish loading your wafers, press EVENT before the door closes, and the boats will come out again. You have another 20 minutes to load. (See Process Notes)

9.2.10 Press EVENT, and the boats will start moving into the tube. When the door closes completely, the temperature stabilization step starts. This is normally a five minutes step optimized to recover the temperature gradient caused by opening the door. Afterwards, the sintering/annealing step starts.

9.2.11 Once the anneal process is completed, furnace will advance to a wait state. To obtain your wafers press EVENT. The door will open automatically and your wafers will move out of the furnace. The door will remain open for 20 minutes. You should unload your wafers as soon as possible.

9.2.12 Press EVENT, and boats will start moving into the tube. When the door closes completely, the recipe ends. There is no standby recipe for the furnace.

9.2.13 Disable TYSTAR18 on Mercury.

**10.0 Troubleshooting Guidelines**

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

10.1.1 Cause: One of the process gas flows was out of tolerance due to delivery system malfunction or gas cylinder getting empty.

Solution: Press MENU, then, enter DH. Press ENTER when prompted for input. The whole process history for this run will be displayed. Find the root cause for the abort and report on Mercury.

10.1.2 Cause: You have not enabled the furnace. In this case, find a staff member to restart the process.
10.2 The tube is at special hold (step SHLD)
   10.2.1 Cause: When the process is in SHLD, it indicates a serious system problem has occurred, such as pump failure, tube leakage, while process gases were flowing in the tube.
   Solution: Report on Mercury or find a staff member immediately. Do not attempt to fix the situation yourself (including super-users).

10.3 The door won't open.
   10.3.1 Cause: BOATIN is ON. Someone pressed the button by mistake.
   Solution: Press BOATIN to turn it OFF. Check BOATOUT.
   10.3.2 Cause: System mal-function. The boat loader has a problem.
   Solution: Report on Mercury.
   10.3.3 Cause: No N₂ flow. On the display, the value of N₂ is 0.
   Solution: Report on Mercury.

10.4 The FCS10 computer does not respond to the keypad input (computer crash).
   10.4.1 Cause: Use of the Arrow keys instead of the CLEAR key to erase an error, when entering an alphanumeric value.
   Solution: Report on Mercury.
   10.4.2 Cause: Pressed NEXTPAGE twice when loading a recipe that requires multi-pages of inputs. Usually, this is caused by aging keypads, not by the user.
   Solution: Report on Mercury.

11.0 Figures & Schematics
   11.1 Front Control Panel of the FCS10 Furnace Computer. Schematic view of Front Panel Display is shown below (Menu-Driven or ROP Display)
11.2 Furnace Status Displayed on the FCS10 Front Panel (Idle state of the LTANNA.018 recipe)
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, but are stated for completeness and

to satisfy your curiosity.

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.