Chapter 5.15

**Tystar15**

*LPCVD Furnace (4” and 6”)*

(tystar15 - 386)

1.0 **Title**

Tystar15 — non-MOS LPCVD Polycrystalline Silicon Carbide

2.0 **Purpose**

Tystar15 is used to deposit polycrystalline silicon carbide (poly-SiC) films, doped with nitrogen or undoped. It can process both 4” and 6” wafers.

**Materials Policy:**

The following materials or film stack may be processed in this equipment:

- Silicon, silicon dioxide (SiO₂), silicon nitride (Si₃N₄), low temperature oxide (Furnace LTO), metals with melting points above 1500°C (i.e. titanium, tungsten, nickel).

Follow the furnace pre-cleaning policy and refer to lab manual chapter 1.7, entitled "Materials & Process Compatibility" for more information. If your sample contains Au or materials other than what is approved from the list above, you must review your samples and proposed process with staff before proceeding.

3.0 **Scope**

This chapter covers the general furnace description of TYSTAR 15, TYCOM and furnace operation procedure, which includes process recipe loading, wafer loading/unloading, process status monitor, user level problem diagnosis, and wafer cleaning requirements.

4.0 **Applicable Documents**

**Revision History**

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

4.2 Material Safety Data Sheets for Methylsilane (MS), Dichlorosilane (DCS), Ammonia (NH₃), Hydrogen (H₂) and Nitrogen (N₂) (copies in Lobby).

4.3 Specialty gas(es) charge(s) are applied to this equipment.

5.0 **Definitions & Process Terminology**

5.1 **Non-MOS Tube:** Tystar15 is a general/MEMS use type fabrication furnace (non-MOS).

5.2 **Methylsilane (MS; CH₃SiH₃) and Dichlorosilane (DCS, SiH₂Cl₂):** Two gases used in our poly-SiC (doped & undoped) processes.

5.3 **Ammonia (NH₃):** A gas used to dope the polysilicon carbide film.

5.4 **ROP:** Remote-Operation Panel.

5.5 **ALMACK:** Alarm Acknowledge is a button used to proceed to next step in recipe.
5.6 **ABORT**: This key can be used to abort the process. This is commonly used for unloading the wafers, where users invoke the recipe again, after run has been completed and properly vented. The tube will open for the users to unload their wafers followed by abort to load the standby recipe, and before leaving the area.

### Machine Interlock Messages

5.7 **ANTLK**: Above atmosphere interlock, no process gas can flow (including N2).

5.8 **BNTLK**: Below process pressure interlock, no process gas can flow.

5.9 **DNTLK**: Door interlock, door is not closed; no process gas can flow.

5.10 **GNTLK**: Gate valve interlock, gate valve is not open, no process gas can flow.

5.11 **VNTLK**: Vacuum interlock, pump problem, no process gas can flow.

### Safety

6.0 *Safety*

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

6.1 Tystar15 utilizes potentially hazardous gases and high electric power (high amperages to heat its elements). Do not open the front or the back panels, as it can expose you to high power circuitry.

6.2 Special care must be taken when the tube is aborted and while in deposition step. The toxic process gases present will need to be properly vented. This can be accomplished by acknowledging out of **flush & hold** steps of the standard recipes. In an emergency situation (earthquake, fire) the process can be aborted. Make sure toxic gases are properly vented by a series of pump and purges and by running the **15purge** recipe. Ask process staff if you need help or if you have any questions in this regard. Do not alter any of the standard processes and specially do no skip any important purge or vent step in your recipes.

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

6.4 This tube is a dedicated poly-SiC tube, and process temperatures are typically around 800ºC. Do not run the tube at temperatures above 835ºC, as it may crack the tube, which has thick poly-SiC deposited on its walls, under stress. Damage to the door seal may occur also.

### Statistical/Process Data

7.0 *Statistical/Process Data*

Pertinent information can be found on the following sites:

7.1 Process monitoring test section of the Nanolab’s home page.

7.2 Problem and comments section under equipment section of Mercury.

7.3 Enable message for Tystar15.

### Available Processes & Gases

8.0 *Available Processes & Gases*

Tystar15 tube is assigned to standard doped and undoped poly-SiC processing.

8.1 Standard undoped poly-SiC process: For standard undoped poly-SiC films, the variable poly-SiC recipe **15CH6SIA** should be used with the following input conditions: DCS = 15, NH₃ = 0, T = 800, P = 170.

8.2 Standard doped poly-SiC process: For standard doped poly-SiC films, the variable poly-SiC recipe **15CH6SIA**, should be used with the following input conditions: DCS = 15, NH₃ = 1.5, T = 800, P = 170.

8.3 Variable doped Polysilicon carbide process: The variable doped poly-SiC recipe **15CH6SIA**, allows for the user to vary the gas flowrates (DCS and Ammonia) as well as process pressure and deposition temperature.
8.4 To reduce the stress and strain gradient in the film, the DCS flow rate can be increased. However, be aware that this will lead to a Si-richer film. An additional annealing step (10h, 1050°C, Ar) in Tystar4 is also necessary.

8.5 This tube is calibrated in the temperature range of 650ºC – 835ºC. Do not attempt to run any processes outside of this temperature range. Process temperatures above 835ºC are not allowed. This could crack the tube and damage the door seal.

8.6 Available gases on this tube are DCS, NH$_3$, MS, H$_2$, N$_2$, VAC, and N$_2$PRG.

8.7 Please note that there is a specialty gas charge for Methylsilane. This gas is very expensive; thus, gas charges are calculated based on the amount of gas used during deposition. Methylsilane is 4 cents/cc. This translates into $72 for a 1 hour run at 30 sccm for Methylsilane (30cc/min x 60 min x 0.04 $/cc).

9.0 Furnace Operation

9.1 Control Key Description

Many of the operational commands can be executed from ROP. Function keys such as Recipe, Run, Hold, Clock, Status, and more are also available. Appendix 1, at the end of this chapter, displays all these function keys. There are two ALMACK keys available on the ROP. The one on the far right side just above the ABORT key is the main one to use.

9.2 Operational Procedure/Guidelines

Recipes can be loaded from the TYSTAR15 recipe diskette and Tycom terminal. Run your process. Take your wafers out after your process is completed. Note: You will need to wait for the boat to completely go back in before you can load the standby recipe. This means, once you find your run completed, ALMACK twice out of the flush & hold step, then run the recipe again, get your wafers out (this takes about 12 minutes). Then, ALMACK through the unload step to send the boat in and make sure the door is completely closed, before you ABORT the process. Finally, load the standby recipe. Note: Aborting the tube before the boat-loading step is completed, stops the boat loader in its track with the door open.

9.2.1 Recipes

Tystar15 recipes are on a dedicated diskette marked as Tystar15. These recipes have a standard format with three pump and purge cycles before and after the deposition step. This is designed to better control the film particles by keeping the tube cleaner. There is a variable doped poly-SiC recipe available on Tystar15 disk, as well as standby, vent and purge recipes. The vent and purge recipes are designed to speed up any recovery process.

See Appendix 2 for more details on the available recipes.

15CH6SIA Recipe: Methilsilane + Dichlorsilane SiC recipe
15STNBYA Recipe: Standby recipe to be used, post poly-SiC deposition.
15PURGE Recipe: Additional recipe available to purge and vent the tube.*
15VENT Recipe: Additional recipe available to vent the tube.*

* Note: The vent and purge recipes can be used for quick vent or pump/purge cycles. The abort takes the recipe back to its first step. It may take a long time for the tube to vent. This is because the initial step bleeds only about one liter of N$_2$ into the tube. Venting the tube can be accomplished much faster by loading one of the two recipes noted above. However, take extreme care and make sure that you do not use the vent recipe when harmful gases are present (abort
at deposition step). Load the purge recipe instead. This can come in handy when the abort has occurred, while still in deposition step or if the origin of the abort sequence is not known (did it abort at the deposition step?).

9.2.2 Recipe Modification and New Recipe Generation
As always, modification to standard recipes is not allowed. There is the 15CH6SIA recipe available on the TYSTAR15 diskette for users to vary the process parameters. Talk to process staff if you need to develop other recipes.

9.2.3 Recipe Loading
Type LO followed by recipe name and 15 to load the recipe onto the tube from Tycom terminal. E.g. LO 15CH6SIA 15.

9.2.4 Running Recipe
Once the recipe is loaded you can type RU followed by tube number (15) or simply press run button on the ROP terminal.

9.2.5 Wafer Loading
Once the boat is out, replace dummy wafers with your work wafers. There is a 20 minutes window available for this task. Once the 20 minutes elapses, the boat loader will automatically go in. Do not worry, simply ALMACK through to cycle back to boat unload step and wait for the boat to come out. You have another 20 minutes to load your wafers.

9.2.6 Unloading Wafers
Once the process is completed the furnace will wait in flush & hold step. You will need to ALMACK twice out of this step to vent the tube. You will need to run the recipe again so that the boat loader will bring the tube out. You will then need to press the ALMACK button to send the boat in and wait for the door to completely close. You can then abort the process and load the standby recipe, before signing off.

9.2.7 Standby Recipe (finishing up)
Once your run is completed and your work wafers are out, you will need to load & run the standby recipe, 15STNBYA

10.0 Troubleshooting Guidelines

10.1 Failed Leak Check
10.1.1 Check the machine status screen on the Tycom terminal (type in DI ST 15).
   10.1.1.1 If GNTLK or VNTLK is ON, stop and report it as fault.
   10.1.1.2 If DNTLK is ON, vent the tube. Run the process again. Do this a couple of times, if necessary. Report as a fault, if it still fails. There may be door sensor problems.
   10.1.1.3 If no interlock is ON, vent the tube, wipe the door and the o-ring. Run the process again, and if it still fails, report it as a fault.

10.2 No Process Gas Flow
10.2.1 Check the machine status screen on the Tycom terminal (type in DI ST 15).
   10.2.1.1 If any interlock is ON, report it as a fault.
10.2.1.2 Check the appropriate gas cylinder, if empty report as a fault.

11.0 Figures

11.1 Polysilicon – Tube 15
12.1 Process Recipes

**15CH6SIA**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Initialize</td>
<td>N/A</td>
</tr>
<tr>
<td>05</td>
<td>Boat Out</td>
<td>10 min</td>
</tr>
<tr>
<td>10</td>
<td>Load/ Unload Wafers</td>
<td>20 min</td>
</tr>
<tr>
<td>15</td>
<td>Load boat</td>
<td>10 min</td>
</tr>
<tr>
<td>20</td>
<td>Check dntlk</td>
<td>10 sec</td>
</tr>
<tr>
<td>25</td>
<td>Predep Pump1</td>
<td>2 min</td>
</tr>
<tr>
<td>30</td>
<td>Predep Purge1</td>
<td>2 min</td>
</tr>
<tr>
<td>35</td>
<td>Predep Pump2</td>
<td>2 min</td>
</tr>
<tr>
<td>40</td>
<td>Predep Purge2</td>
<td>2 min</td>
</tr>
<tr>
<td>45</td>
<td>Predep Pump3</td>
<td>2 min</td>
</tr>
<tr>
<td>50</td>
<td>Leak check</td>
<td>1 min</td>
</tr>
<tr>
<td>55</td>
<td>Set temp (variable 700-835°C)</td>
<td>20 min</td>
</tr>
<tr>
<td>60</td>
<td>Temp stabilize</td>
<td>5 min</td>
</tr>
<tr>
<td>65</td>
<td>Check temp profile</td>
<td>5 min</td>
</tr>
<tr>
<td>70</td>
<td>Predep Pump4</td>
<td>2 min</td>
</tr>
<tr>
<td>75</td>
<td>Flow gases (variable gases allowed)</td>
<td>30 sec</td>
</tr>
<tr>
<td>80</td>
<td>Pressure set (variable)</td>
<td>30 sec</td>
</tr>
<tr>
<td>85</td>
<td>Deposition step (Time Var.)</td>
<td>Variable</td>
</tr>
<tr>
<td>90</td>
<td>Reset temp to 450°C</td>
<td>5 sec</td>
</tr>
<tr>
<td>95</td>
<td>Postdep Pump1</td>
<td>2 min</td>
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<td>100</td>
<td>Postdep Purge1</td>
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<tr>
<td>105</td>
<td>Postdep Pump2</td>
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<td>Postdep Purge2</td>
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<td>115</td>
<td>Postdep Pump3</td>
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<tr>
<td>120</td>
<td>Check if process fail</td>
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</tr>
<tr>
<td>125</td>
<td>Postdep standby</td>
<td>0</td>
</tr>
<tr>
<td>130</td>
<td>1st almack branch</td>
<td>5 sec</td>
</tr>
<tr>
<td>135</td>
<td>loop back to standby</td>
<td>5 sec</td>
</tr>
<tr>
<td>140</td>
<td>2nd almack branch</td>
<td>5 sec</td>
</tr>
<tr>
<td>145</td>
<td>Backfill-1</td>
<td>5 min</td>
</tr>
<tr>
<td>150</td>
<td>Backfill-2</td>
<td>7 min</td>
</tr>
<tr>
<td>155</td>
<td>End</td>
<td></td>
</tr>
</tbody>
</table>
12.2 How to check/adjust gas flows for 15CH6SIA recipe:

1. Acceptable gas flow range for each gas used in 15CH6SIA recipe:

   Process Parameter Range: NH₃ (0-10sccm), DCS (0-100sccm), Methylsilane (30 sccm), H₂ (48 sccm), Process temp (800°C), and Pressure (170 mtorr).

2. Before loading the recipe you have to check whether the amount of the gas flow is set at the right value or not and also whether the high pressure is OFF (so low pressure is ON). You should check it at the back side of the tool, so please ask the trainer to show you this during your training session.

   Figure 1 below show how to verify the amount of gases used at this recipe:

![Figure 1](image)

Check the Methylsilane and H₂ set points by first selecting correct channel positions on the channel selector knob located to the left of the controller panel (channel 1 for Methylsilane and channel 2 for H₂), then press and hold the push button shown in Figure 2 to read the value for each gas setting. You should be able to read 30 for methylsilane and 48 for H₂, if different values are displayed, turn the flow adjustment knob shown in Figure 2 (close up in Figure 3), while turning the respective knob to adjust the flow setting to the correct value for each channel.

Channel selector
Methylsilane 1
Hydrogen 2
Also make sure the process pressure is set at 170 mTorr.