

Thermcraft Tube Furnace – General Use

The Thermcraft furnace is a general use, 3 zone tube furnace capable of reaching temperatures of 1200°C. The large 6” diameter quartz tube is capable of holding up to 4” (100mm) diameter wafers. There are wafer boats or flat sample holders available for this furnace. Process gases include N₂, N₂/H₂ (forming gas), Ar, O₂, and steam-bubbled O₂.

Prerequisites for operating the Thermcraft tube furnace system:

- a) Obtain a NRF ID (if you do not already have one) by completing the [NRF Lab Use Request Form](#) and safety training.
- b) Receive “one on one” training and certification from NRF Staff. Discuss your process with a staff member.

Safety

DANGER! Do not remove the covers of the instrument. Do not modify the instrument.

- **HOT Components** - The User must observe caution when loading/unloading samples from the tube furnace. Samples are very hot when immediately removed from the process tube. Sufficient cooling time must be allowed prior to sample handling.

1.0 Pre-Operation

- 1.1 Tool Reservations may be made via the NRF Reservation Page.
<https://rsc.aux.eng.ufl.edu/resources/default.asp>
- 1.2 Change gloves. WARNING No solvents or liquids are allowed near the machine, change your gloves before operation!!
- 1.3 Log into the tool by using the TUMI computer in this cleanroom bay.



CAUTION

CAUTION

**THE TUBE, SAMPLE HOLDER, AND SAMPLE WILL BE VERY HOT.
USE CAUTION TO NOT TOUCH THE SAMPLE HOLDER OR SAMPLE.
LET THESE COOL COMPLETELY PRIOR TO REMOVAL.**

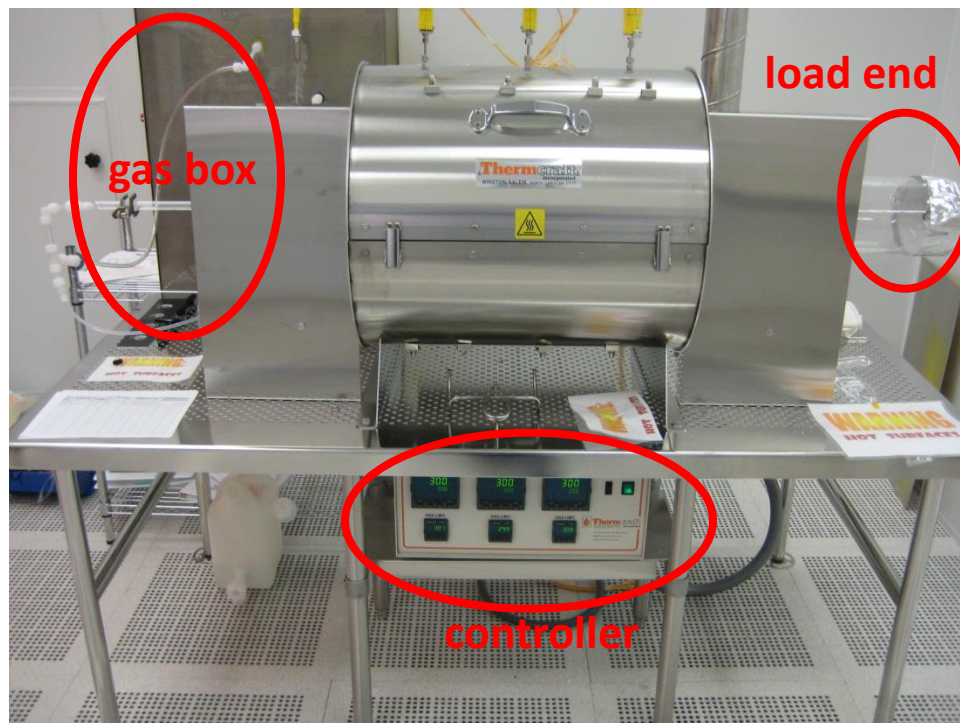
2.0 System overview

The Thermcraft tube furnace system consists of the furnace, temperature controller/power supply, and gas control box.

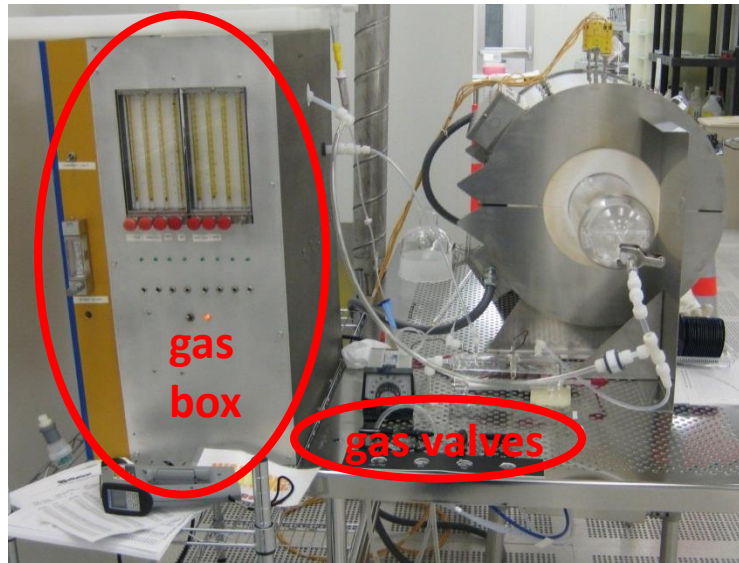
The furnace is a 3 zone system with the 2 end zones being 3" long and the center zone being 12" long. The tube temperature is monitored and controlled via thermocouples in contact with the quartz tube. **The temperature at the wafer center will be different from this controlled reading, usually lower, depending on the thermal mass of your sample and gas flow of the process. It is the user's responsibility to characterize their process and temperatures for any process dependent offset in temperature that may occur.**

The furnace temperature is controlled by 3 Eurotherm 2404/CP controllers, one for each zone. The furnace is kept at an idle temperature of 200°C to maintain tube cleanliness. The maximum useful temperature is 1100°C for uniformity. The end zones may not be able to achieve this maximum temperature due to gas flow.

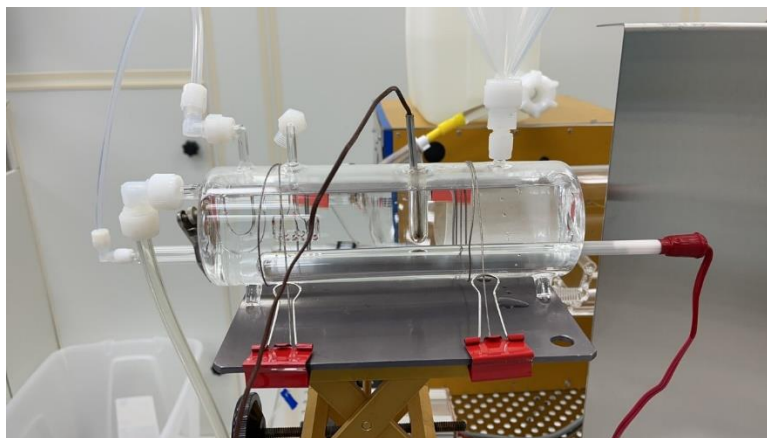
The gas supply is controlled by the custom made gas box. The individual gases are selected by ON/OFF switches (on gas box) and gas supply valves (on the stainless steel table), and the flows are controlled by the Matheson flow meters with 602 and 603 flow tubes. Gas flow settings are controlled by setting the level of the ball to a prescribed level according to the gas type, pressure and the tabulated tube values. These tables are printed and available at the furnace system.



Front view of Thermcraft tube furnace system



End view of Thermcraft tube furnace system



Optional O₂ bubbled steam addition system

3.0 Pre – Operation Considerations

The user should determine if the sample push (moving the samples from the loading area into the heated zone) needs to be achieved at the idle temperature of 200°C or at the user's desired process temperature above 200°C. All sample pushes should be performed with an inert atmosphere flowing in the tube, preferably N₂.

Samples should be clean and photoresist free. If wet processing is required prior to furnace use, the samples must be completely dry prior to loading into the tube furnace.

The furnace is available for metal annealing, forming gas annealing, diffusion, and dry oxidation. With prior staff notice, wet oxidation can also become available through O₂ bubbled through an optional steam addition system. Oxidation push-in is accomplished with O₂ running.

If the user's process may lead to tube contamination, the user's PI will be asked to provide a separate tube for this processing. The NRF can store the tube and will exchange the tube for the user prior to the thermal processing. Sufficient notice must be provided to NRF staff for tube exchange.

4.0 Operation

Prior to any furnace runs, the user must fill out a new furnace run sheet located in the notebook located near the furnace. This is to record the furnace use, materials processed, and any issues associated with the processing. An example of this run sheet can be found at the back of this SOP.

1. Log onto the Thermcraft furnace system with the TUMI computer located in this bay. This will enable the gas box.
2. Using the temperature calibration book, set the furnace to the desired sample push temperature. The 2 end zones should be set to the same temperature as the center zone.
3. Using the high temperature gloves provide, remove the tube endcap. Caution, this endcap is hot and fragile. Place endcap on the stainless table. If the endcap is not easily removable, please call NRF staff.



**USER EXTREME CARE WHEN HANDLING THE ENDCAP,
SAMPLE BOAT AND PUSH/PULL ROD.
THESE ARE QUARTZ AND VERY EXPENSIVE.**

4. Start the flow of N₂ for the push. A recommended flow for the push is 3.5 SLPM.



**TO BEGIN GAS FLOWS, THE FOLLOWING PROCEDURE
MUST BE FOLLOWED.**

Failure to follow this procedure will result in the quartz endcap blowing off the end of the process tube and breaking on the floor.

- a. Place the gas valve in the OFF position.
- b. Turn the flow meter to OFF (fully clockwise).
- c. Turn the gas switch to ON.
- d. Open the gas supply valve.
- e. Adjust the gas flow meter to 3.5 SLPM.

5. Load wafer(s) into the sample boat.
6. Using the load tray place the boat into the mouth of the tube.
7. Using the push rod, slowly push the sample boat into the tube. Use caution, the end of the push rod will become very hot and should not be touched. It is recommended that the travel time from mouth of the tube to the center of the hot zone take at least five (5) minutes.

Push the sample boat into the estimated center of the heated zone. A properly centered boat can be checked by counting the number of heating element lines from each end zone. Place the push rod onto the stainless table so it may cool. The ends of the push rod are very hot, please avoid contact.



CAUTION

CAUTION

**THE ENDCAP, PUSH ROD AND SAMPLE BOAT ARE VERY HOT.
USE CAUTION WHEN HANDLING.
WEAR PROPER HEAT RESISTANT GLOVES.**

8. Replace the endcap onto the process tube. The endcap should fit tightly onto the tube end without pushing hard.
9. Allow the inert purge for 5 minutes to ensure the tube is clear of atmosphere.
10. Start the process run by:
 - i. Beginning the flow of the desired process gas



CAUTION

CAUTION

To begin gas flows: the following procedure must be followed. Failure to follow this procedure will result in the quartz endcap blowing off of the process tube and breaking on the floor.

- a. Place the gas valve in the OFF position.
- b. Turn the flow meter to OFF (fully clockwise)
- c. Turn the gas switch to ON.
- d. Open the gas supply valve
- e. Adjust the gas flow meter to 5 SLPM

To remove the inert purge gas:

- a. Turn the gas supply valve to OFF.
- b. Reduce the flow meter for the inert gas (fully clockwise)
- c. Turn the gas switch to OFF.

- ii. Ramping the temperature to the desired value.
Change the controller from "RUN" to "HOLD" and use the UP or DOWN arrows on the temperature controller to change the temperature to the desired value. Change the controller back to "RUN" to set the new temperature setting.

Do not change any other setting on the temperature controller without NRF staff approval.

The user will have to track the process time manually. Check the rate of rise graph for approximate time.

11. Once the process has finished, switch the process gas back to the inert (N₂) for the sample pull (removal). Carefully follow the above procedures for adding and removing gases from the tube furnace.
12. For sample removal, remove the tube endcap and carefully and slowly pull the sample boat to the loading end. Be careful to avoid the ends of the pull rod, it is very hot. The sample boat may be pulled onto the sample boat tray for easier sample removal. Replace the endcap when finished.

5.0 System shutdown

Once the samples are removed and endcap replaced:

1. Reset the furnace temperature to 200°C for idle.
2. Turn off the flow gas:
 - a. Turn the gas supply valve to OFF.
 - b. Reduce the flow meter for the inert gas (fully clockwise)
 - c. Turn the gas switch to OFF.
3. Log out of the furnace via the TUMI computer, leave notes if necessary.
4. Record any final notes on the Thermcraft Run sheet.
5. Place the heat resistant gloves, push/pull rod, sample boat tray, and sample boats on the stainless-steel table for the next user.

Thermcraft Process Run Checksheet

Date (mm/dd/yy) _____

Name _____

PI _____

- If wafer was previously patterned, has ALL photoresist been removed?
Yes _____
No _____ **STOP!** Do not run in furnace!

- If wafer has or previously had metal on it, record metals below....

Si OXIDATION

- Temperature for process _____
- Process time _____
- Gases used/flows _____

- Oxide thickness _____
- Wafer orientation (Circle one)
111 110 100
Other (specify) _____
- Wafer grade (Circle one)
Prime Test Reclaim
- Wafer Type and Dopant:
Si _____ n _____ p _____

ANNEALING

- Temperature for process _____
- Process time _____
- Gases used/flows _____

- Sample material