

FURNACE OPERATION

LAB EQUIPMENT AND MATERIALS

All personnel will wear the blue labcoats, latex gloves, and eye protection while in the cleanroom. **Full battle gear is required for the RCA cleaning step and BHF etch step.** High Temperature Gloves needed for handling the hot quartz furnace tube cap.

Immediately before any wafers go into a furnace, they must be given an RCA clean!

Safety Notes:

1. The furnaces are hot and require appropriate care to avoid severe burns
2. You may be handling an HCL solution at eye level in a small working area. Be careful!
3. Keep the bubbler and HCL bottle away from the end of the furnace tube as they can be damaged by heat.
4. The quartz boat retains heat for a long time.
5. Wafers are to be transferred to the oxidation boat and the transport vehicle (called a Pig or Elephant) to minimize exposure to the lesser quality environment in the open areas of the lab. These items may be hot.

Chemicals Required (varies depending on your process):

Deionized Water (DI) (Resistivity > 12 MΩ)

Hydrochloric Acid (HCL)

Oxygen

Nitrogen

Advice:

To save time in this procedure, you should merge it with the RCA Clean. When you come into the lab start all the heaters at once, furnace, steam generator (if needed), RCA baths. Also start the appropriate gas flow into the furnace tube. By the time you've finished the RCA clean, the furnace and steam generator will be at temperature, ready for you wafers.

Check the posted furnace profile for the location of the "flat zone". When inserting your wafers, be sure that the boat lands in the middle of flat zone.

The part of the push rod inserted into the furnace will be very hot, while the end that remains out of the furnace will remain cool to the touch. Watch out for the hot end!

Do not touch any of the quartz-ware with your bare hands!! If you do, it must be cleaned with HF, and everybody hates HF!

OVERVIEW:

1. Set the furnace to the appropriate temperature.
2. Open the oxygen tank.
3. If doing a wet oxidation, add HCL solution to the steam generator, if needed, and turn on its temperature controller.
4. Program the control computer with your oxidation steps. Start the appropriate gas flow and allow 30 to 40 minutes to establish the proper environment inside the furnace tube.
5. Transfer the wafers from the cassette (after the RCA clean) to the oxidation boat.
6. Insert the oxidation boat containing the wafers into the Pig.

7. Transport the Pig containing the wafers to the Furnaces.
8. Transfer the oxidation boat containing the wafers into the appropriate furnace.
9. Oxidize the wafers.
10. Transfer the oxidation boat containing the wafers from the furnace back into the Pig.
11. Let the wafers cool at the furnaces station (at least 20 min.).
12. Transport the Pig containing the wafers to the MOS Cleaning station.
13. Close the Oxygen at the tank, turn off the steam generator, and reset the furnace to the standby temperature.
14. Transfer the wafers from the oxidation boat to cassette after the wafers have cooled.
- 15. Place the boat back in the mouth of the furnace.**

DETAILED PROCEDURE:

1. If doing a wet oxidation, prepare the steam generator. Open the top Plexiglas doors at the back of the furnaces (this area is called the jungle). The steam generator (sometimes called a bubbler) is the three-headed quartz vessel setting in a heater. The center opening is for gas inlet and outlet, another is for the thermocouple, and the last for adding solution. Be sure that the vessel is more than half full, since if it goes dry there is no safeguard to keep the heater from burning up. There is a labeled squeeze bottle that is convenient for adding solution to the bubbler. Uncap the opening in the quartz vessel used to add the solutions. Add HCl solution into the quartz vessel using the squeeze bottle, and recap the opening. Note: If you need to add a lot of solution it may be easier to remove the top from the squeeze bottle and pour in the solution. If you need to add fresh HCl solution to the squeeze bottle, mix 9 parts water and 1 part HCl (always add acid to water). Close the Plexiglas doors. Turn on the power of the steam generator for the appropriate furnace, located behind the lower Plexiglas doors. The controller will already be set to 95 °C. It will take around 45 minutes to stabilize at 95 °C. **Keep the bubbler and HCl bottle as far as possible from the end of the furnace tube! They can be damaged by the heat!**
2. Turn on the O₂ tank (in the utility area in Room 247) by rotating the valve on top of the Oxygen tank counterclockwise about a quarter of a turn. The high pressure gauge on the right side of the regulator should read above zero if the valve is open. If not rotate the valve another quarter turn. If the gauge still does not read a nonzero value, the tank is empty. Close the valve and contact a TA or Mike Thomas to get a new tank.
3. Activate the furnace control computer (bring it out of screen saver mode). The password is "icfab". Using the drop-down menus for each step, program the desired oxidation steps, but add a first step (duplicating your first timed step) to fill the tube with the appropriate gas. Click the start button. (Note: Your first time doing an RCA clean and oxidation, you'll probably want to wait until the wafers are put into the RCA 2 bath before starting the program).
4. Remove the end caps from the furnace tube and pig, and place the pig on the mouth of the furnace tube. Pull the oxidation boat from the mouth of furnace into the pig. Carefully remove the pig from the furnace tube and replace both end caps. **DO NOT PLACE THE END CAP TIGHTLY INTO THE PIG!!! Leave about 1 cm of the ground-glass joint of the cap showing.** Whenever the pig has been on the furnace tube, it can get hot. If you put the end cap tightly into a hot pig, when the pig cools and contracts it will fuse to the cap. An expensive mistake!
5. On the control panel near the mouth of the tube, locate the temperature control for the appropriate tube. Set the center temperature dial to the desired setting. (This setting does not correspond to degrees C). Push the switch located above the potentiometer from LOW to NORM. It will take about 45 min. for the furnace to reach the setpoint temperature.
6. When the RCA clean of the wafers is done, carry the pig to the cleaning bench and transfer your clean and dry wafers to the boat with the front side of the wafers away from the pushrod loop. Put the wafers

as far from the pushrod loop as possible, leaving a couple of open slots between wafers, if possible. Put the boat back in the pig with the front side of the wafers facing the open end of the pig. Replace the end cap on the pig.

7. Let the furnace come to its equilibrium temperature. When the furnace has reached equilibrium, fill the pig with N₂ using the nitrogen gun located on the MOS cleaning bench, and carry the wafers to the furnace. Remove the end caps from the furnace and the pig, and put the pig on the mouth of the furnace tube being careful to ensure the pig is stable. Leave the wafers in the pig for 2 min. to insure the foreign atmosphere is replaced by the furnace tube atmosphere.
8. Push the boat into the mouth of the furnace and leave the wafers in the mouth for 2 min. Careful, it can be a little tricky to get the boat over the lip of the furnace mouth. Slowly push the boat to the center of the tube. Take about 5 min. to traverse the first 50 cm (the transition zone) from the mouth of the furnace to the “flat zone” of the tube. Refer to the furnace profile to determine the location of the flat zone, and use the provided meter stick to measure the position of the boat in the tube.
9. When the wafers enter the flat zone, click the “Next Step” button to start the second step, which is your first timed step. (This assumes that the program is still in step one, which it will be unless you have been very slow). Take the pig off the tube and recap both the pig and the furnace tube. Put the pig back on the furnace station. **(BE CAREFUL: Never cap the tube or pig too tight or the cap will be unremovable when the quartz cools.)**
10. When the oxidation program is done, remove the end cap and place the pig on the furnace mouth. Pull the boat out of the center of the furnace taking about 5 min. to traverse the first 50 cm from the hot zone to the mouth of the furnace. Leave the boat at the mouth for 2 min. Then leave it in the pig for 2 min.
11. Take the pig off the tube and place on the furnace station (metal shelf at furnace). Recap the tube and the pig. **(BE CAREFUL: Never cap the tube or pig too tight or the cap will be unremovable when the quartz cools.)** Let the pig and wafers cool for 20 minutes before moving the pig to the MOS cleaning hood. Remove the wafers from the boat.
12. Push the switch above the setpoint potentiometer from NORM to LOW. Turn off the oxygen by closing the valve on the top of the O₂ tank. Turn off the steam generator (if used).
- 13. Put the boat back in the mouth of the furnace tube.**

Be sure to fill in your lab notebook. Be complete. Things that you must include are:

Date

Whether solution was added to the steam generator, and how much was used in the procedure.

Time for the various elements of the system to come to the proper temperature.

Color of wafers, oxide thickness, and estimated thickness variation between wafers: