THERMAL OXIDATION SOP

Furnace 1

August 2012

Initial conditions:

• The furnace sit idle at a temperature of 600°C.
• The flow rate will be set at 1L/min.
• The wafer boat is stored inside the oxidation tube furnace.

Special instructions before starting:

• Increase the flow rate to 2.5L/min.
• Never place wafer boat on the metal rack.
• Only place u-shaped boat holder on the ceramic plates and never place on the metal rack.
• Only RCA cleaned wafers may be placed in the oxidation tube furnace.
• You may only use RCA cleaned, plastic tipped tweezers. **DO NOT** use metal tipped tweezers for handling wafers.
• Metals, photoresist and Polyimide are not allowed in oxidation tube furnace.

1. Prepare the quartz bubbler:

   a. If the water level in the quartz bubbler is below 1/3 of the capacity of the bubbler it will need to be refilled. This can be done by the MNTC staff or by removing the side fill cap, clamp and disconnecting the inlet line and outlet lines. Be very careful while disconnecting the stainless steel from the quartz lines. Empty and refill the water bubbler to 1/2 full with fresh DI water from the goose neck spouts available at one of the wet benches. Also, fill the thermo well for the thermometer with water to complete heat transfer.

   b. Turn on the Thermolyne bubbler controller, Figure 1, to the designated line for the bubbler temperature to achieve a temperature between 90°C and 100°C. Do not exceed 100°C.

   ![Figure 1. The Thermolyne bubbler controller](Image)
c. Turn the heat tape controller to level 2, Figure 2, or the designated line. This prevents steam from condensing before it reaches the tube furnace. Let the water temperature stabilize between 90°C and 100°C. Do not exceed 100°C before wet oxidation.

![Figure 2. The heat tape controller](image)

2. Loading Wafers

a. Using the white thermal gloves on the metal rack remove the end cap from the tube furnace and place onto the ceramic plates.

b. Remove the oxidation rod from rod tube 1 on the lower section of the metal rack. Take care to not touch the rod past the line etched in the rod for this will help keep contamination from entering the tube furnace.

c. Using the U-shape boat holder remove the wafer boat and place it onto the ceramic plates. Replace rod back into the rod tube 1 making sure to place the hooked end into the tube first.

d. Allow the boat five minutes to cool before loading wafers followed by placing your wafers into the boat.

e. Retrieve the oxidation rod from rod tube 1.

f. Raise the boat holder to the mount of the tube furnace and push quartz boat into the mouth of the furnace. Wait five minutes. This allows the wafers to adjust to the furnace environment.

g. After five minutes, use the rod to push the boat into the center of the tube slowly at the rate of approximately 1" per 5 seconds (12" per minute). Exceeding this rate can cause the wafers to warp. Push the boat to the scribe line on the rod.

h. Replace rod into rod tube 1 making sure to place the hooked end into the tube first.

i. Place the end cap loosely onto the end of the tube furnace and do not push it on all of the way. These tubes and caps have a design error where the cap can become stuck due to heating and cooling of the both components.

3. Program your thermal cycle with a ramp rate, dwell temperature, dwell time, and ramp down.

a. Open the small access door below the first row of buttons.

b. Press both the up and down arrows simultaneously to end any program, which may still be in operation from the last process.
c. Press and hold the far right (P) button to enter program mode.
d. Press (P) again to enter 'Program 1' and press (P) to enter each step of the program. Use the up and down arrow keys to change your desired values.
e. Pr1 = ramp rate in °C/minute. This number should be 20 for a 20°C/minute ramp rate. Do not exceed 20°C/minute.
f. Pl1 = dwell temperature in °C. This number is typically 1000°C and do not exceed 1050°C.
g. Pd1 = dwell time (or soak time) of the furnace in hours.
h. Pr2 = ramp rate to the next temperature for either ramping up or down. Do not exceed 20°C/minute.
i. Pl2 = end dwell temperature or the idle state temperature for the furnace. This number should be kept at 600°C.
j. Pd2 = "END" time. Hold the down arrow key until END is displayed. This will end the program.
k. Once the program is entered wait for the controller to exit program mode.
l. Wait for bubbler to reach between 90°C and 100°C. Do not exceed 100°C.
m. Press the RUN/HOLD key to start the program running.
n. Press the scroll key to display the amount of time left in the ramp program or the existing step in action.

4. Gas controls

Dry Oxidation
a. At 1000°C close or flip down the N₂ valve on the gas distribution panel, Figure 3b.
b. Close or flip down the Dry Oxidation Valve after the bubbler, Figure 3a.
c. Open or flip up the valve above the oxygen flow rate meter and rotate the 3-way valve to the down position between both flow rate meters, Figure 3b.

d. Open the O₂ green valve on the gas distribution rack. Oxygen should be flowing at a rate of 1L/min or a setting of 30 on the flow meter.
e. Perform dry oxidation for 0.1 hours, which will be followed by wet oxidation (next section).

**Wet Oxidation**

a. After dry oxidation is complete open or flip up the Dry Oxidation Valve after the bubbler, Figure 4a. Close or flip down the valve above the oxygen flow rate meter and rotate the 3-way valve to the up position between both flow rate meters, Figure 4b.

![Figure 4a](image1.png)  
![Figure 4b](image2.png)

**Figure 4. Gas Flow Diagram for wet oxidation**

b. You should start to see oxygen bubbling through the bubbler and follow the wet oxidation for your desired duration.

c. Make sure that the Thermowell does not become dry during your program by refilling it frequently with DI water in the provided bottle.

**After Wet Oxidation & Turning off Oxygen**

a. After your wet oxidation is complete perform dry oxidation for 0.1 hours.

b. Turn off O₂ green valve on gas distribution rack and open or flip up on N₂ valve, Figure 3b.

4. Unloading wafers

a. After the oxidation program is complete turn off the bubbler heat controller and heat tape.

b. Using the white thermal gloves on the metal rack remove the end cap from the oxidation tube furnace and place onto the ceramic plates.

c. Remove the oxidation rod from rod tube 1 on the lower section of the metal rack. Take care to not touch the rod past the line etched in the rod for this will help keep contamination from entering the tube furnace.

d. Pull out boat at 700°C slowly at the rate of 1" per 5 seconds. Allow the wafers to cool at the end of the oxidation tube furnace for five minutes before removing the quartz wafer boat from the furnace using the u-shaped wafer boat holder.

e. At the end of the 5 minutes cool-down period, remove the wafer boat using the u-shaped boat holder and push rod. Place the wafer boat only on the ceramic plates.

f. Replace rod back into the rod tube 1 making sure to place the hooked end into the tube first.
g. Allow the wafer(s) to cool for 5 minutes and use only RCA cleaned/plastic tipped tweezers to remove the oxidized wafers from the boat.

h. Retrieve the rod from the rod tube 1 and return the boat to the entrance mouth of the tube furnace. Replace the tube furnace end cap loosely and decrease the level to 1L/min.

Remarks:

To modify a program while it is running:

a. Press the HOLD key. A dot should be blinking next to the value.

b. Go into the program mode and change the value to be modified using the up and down arrow keys.

c. When finished modifying the program, press the HOLD key again.

d. Allow the program to exit and return to the normal operating mode.

5. Inspection and Rework Procedure:

1. A visual color inspection will give a reasonable check on the oxide uniformity and thickness. However, use of the Filmetrics Spectral Resonance System, Figure 5, will give a more accurate assessment. Refer to the Filmetrics SOP for operation of the system.

![Figure 5. The Filmetrics Spectral Resonance system used to determine oxide film thicknesses](image)

2. Check the color of the wafer by holding the wafer perpendicular to white lights or fluorescent fixtures in the cleanroom. Check the oxide thickness from color charts listed below. This should match well with the calculated oxide thickness from graphs of silicon dioxide growth.

3. If you are not satisfied with your result you can rework the wafer by strip off the oxide using the Silicon Dioxide Etch SOP, perform an RCA WAFER CLEAN and repeat the OXIDATION.

NOTE: Improper oxide thickness could be due to an incorrect oxygen flow rate, incorrect position in the tube furnace, or an incorrect water and/or furnace temperature. Recheck all of these variables before reworking.