

Cory 218 Aluminum Thermal Evaporator

(ATE)

1.0 Title

Aluminum thermal evaporator (ATE) in Cory 218

2.0 Purpose:

This document has specific information about the aluminum thermal evaporator in Cory 218 to help EE143 TAs and students understand its safe and correct operation.

3.0 Scope:

The thermal evaporator is dedicated to EE143 laboratory for Aluminum thermal evaporation. It can accommodate three, 3" wafers at a time.

4.0 Applicable documents:

Description of a basic vacuum system: <http://www-inst.eecs.berkeley.edu/~ee143/f2001/Lab/vacuum.pdf>
Vendor manual.

5.0 Definitions & Process Terminology:

- 5.1 Al: Aluminum, a metal used extensively as contacts for Silicon-based devices. The geometry can be rod, hairpin or folded sheet depending on the topology of the evaporation source. In EE143 lab, we use Al hairpins.
- 5.2 Tungsten Coil: Tungsten coil is used as the evaporation source to heat the Al hairpin.
- 5.3 Thermionic controller: A knob which controls the currents supplied to the coil.
- 5.4 AC meter: Reading of the currents flowing through the coil.
- 5.5 Shutter: to block initial Aluminum evaporation during wetting process.
- 5.6 Ion gauge: Pressure reader at when system is in high-vacuum state (below $5e-4$ torr).
- 5.7 Liquid N₂ (LN): gas phase nitrogen becomes liquid phase nitrogen when cooled down below 77K. A cold trap, more properly known as a Meisner trap reduce the vapor pressure of water and prevents the backstreaming of oil vapor used in the diffusion pump.
- 5.8 Cherry bomb: container or drawer to store liquid nitrogen.

6.0 Safety:

- 6.1 Do not scratch the base plate.

- 6.2 Use IPA to wipe clean the base plate and the sealing rubber of the bell jar before roughing down.
- 6.3 Do not leave the system unattended until you are certain the bell jar is seated correctly and the system is roughing down properly.
- 6.4 Do keep the cold trap filled with LN at all times when the high vacuum valve is open. It will prevent oil vapor “back-streaming” into the system.
- 6.5 Do always wear clean polyethylene (clear plastic) gloves when working inside the bell jar.
- 6.6 Always fill the cold trap with a funnel.
- 6.7 Do cover the cold trap inlet after filling in LN to prevent condensed moisture from entering the cold trap.
- 6.8 Do not turn on ion gauge before the vacuum goes below 5e-4torr.
- 6.9 Turn off the ion gauge during the evaporation.

7.0 Statistical/process data:

12 wafers fall between $\pm 10\%$ thickness variation with the following evaporation condition:

Chamber pressure: 9e-6torr.

Wetting of the Tungsten coil: 40mA for 30seconds.

Thermal evaporation of ONE Al hairpin: 60mA for 30seconds.

Resulting Aluminum thickness for 12 wafers: 1100 angstrom $\pm 10\%$ thickness variation using etching time as the index (assume a constant etching rate).

8.0 Available Processes, Gases, process notes:

ATE is dedicated to thermal evaporation of Aluminum. No other process is available .

Gases: Liquid nitrogen (LN) is stored in a cherry bomb container.

9.0 Equipment Operation:

The system should be in the following status before operation:

Start up/Vent/Pump/Shut down switch: PUMP (remember to fill LN after the operation to make sure there's enough LN for diffusion pump before the next group uses it)

Shutter: CLOSE

Convectron gauge reading: $\sim 7.6 \times 10^{-2}$

Ion gauge reading: off

Thermionic control: 0

Thermionic control power switch: OFF

The procedures for Aluminum thermal evaporation are detailed below:

- 9.1 Turn knob on front of evaporator to "STARTUP". This starts the roughing pump, evacuates the foreline, and starts the diffusion pump. Only the foreline valve should be open in this setting. Add liquid nitrogen to cold trap after the diffusion pump has warmed up for 20 min. The ATE should be left in the PUMP mode throughout the week as long as the LN trap is filled. For the weekend, place the system in VENT to preclude contaminating the belljar should the cold trap run out of LN.
- 9.2 Pour liquid nitrogen from the cherry bomb container to the thermal-isolated transfer bottle.
- 9.3 Place the funnel in the throat of the cold trap. Pour liquid nitrogen from the bottle through the funnel to the cold trap. This requires several separate pouring steps as the LN will boil vigorously in the beginning.
- 9.4 Cover the cold trap inlet by inverting the funnel
- 9.5 Vent the chamber by turning the knob to "VENT". All the valves should be closed and N₂ is vented into the chamber.
- 9.6 After chamber reaches atmospheric pressure 7.6×10^{-2} (760torr), the jar will lift from the steel base plate. (if the belljar boot gaskets sticks, a light, sideways rap with the palm of your hand should free it.
- 9.7 Lift stainless steel wafer holder out of the inner glass cylinder ("chimney") and place it on the table covered with lint-free paper.
- 9.8 Loading the sample (3" wafers, maximum 3 wafers) and supporting accessories (A new Tungsten coil and Aluminum hairpins).
- 9.9 Place a clean glass slide in stand inside chimney for a clear window. (Clean the aluminum chimney before the week of operation. Use "Ovenoff" brand spray cleaner which attacks aluminum. It is best to do this in a sink away from the lab as oven cleaner is NaOH and a killer for MOS devices.)
- 9.10 Hang 2 clean Al sources (hairpins) near the middle of a new Tungsten coil (centered below the chimney hole). This should result in about 8000 Å of Al (proper placement of the charges are necessary for good uniformity).
- 9.11 Turn shutter knob so that the shutter is covering the sources.
- 9.12 Place wafer facing down on top of wafer holder.

- 9.13 Place wafer holder back inside the chimney.
- 9.14 Wipe stainless steel base and bottom of bell jar with lint free paper soaked with 2-propanol.
- 9.15 Lower bell jar, make sure it has good contact with the base plate and turn switch to "PUMP". Push bell jar cage down until vacuum begins to hold it tight and cannot be lifted. The PUMP setting opens up the roughing valve to evacuate the chamber, and then switches over to the diffusion pump when the chamber pressure drops below 10 to 20mtorr.
- 9.16 Switch to ion gauge by hitting the "GAUGE" button when the pressure falls below 5×10^{-4} torr. (This system uses two types of gauges, a "convectron" which is a trade name for a Granville-Phillips Pirani gauge and a Bayard-Alpert ion gauge.
- 9.17 Pump down to 2×10^{-6} to 5×10^{-6} torr. At this pressure, the flux of the residual gases (mostly H₂O) is about 1% of the Al flux during thermal evaporation. Pumping should take ~40 minutes depending on the diffusion pump efficiency.
- 9.18 Turn off the ion gauge before starting the evaporation. Al will initially react with water vapor physio-adsorbed to the chamber surfaces. The reaction $2\text{Al} + 3 \text{H}_2\text{O} \rightarrow \text{Al}_2\text{O}_3 + 3 \text{H}_2$ results in a large volume of H₂ which causes the ion gauge to jump several orders of magnitudes if left on. This can cause damage to the thin filament in the gauge.
- 9.19 Switch evaporator (electrode) power to ON. Increase power by turning Thermionic control slowly clockwise. At ~40 Amps coil begins to glow, but the Al hairpins do not melt. This can be observed through the slide window. Let heat @ 40 Amps about 20 seconds to drive off water vapor.
- 9.20 Increase electrode power to 60 Amps. The charges will evaporate suddenly and the slide will be coated with Al. As soon as this happens, turn the Thermionic control back to 0 Amps to allow cooling. This is called the wetting process since now the Tungsten coil is coated with the Aluminum and will be ready for thermal evaporation.
- 9.21 Open the shutter. Increase electrode power to 60 Amps again and wait for 30 seconds. Slowly turn down Thermionic control and switch electrode power to OFF.
- 9.22 Wait 10 minutes for cooling before removing the wafers. The unload step follows the same procedure as the load step.

9.23 When wafers are removed and "chimney" and other apparatus are returned to the chamber, push down the bell jar and turn knob to "PUMP" position. Hold the jar down until the vacuum pulls down enough to hold it down and the jar cannot be moved.

9.24 When coating is complete for the semester, turn knob to "SHUT DOWN"; otherwise, fill LN and leave it in PUMP mode before the next group uses it.

10.0 Trouble shooting guidelines:

10.1 Pressure not pumping below $1e-2$ torr: clean the bottom of the bell jar and the base plate again to ensure no leaks from the bellar.

10.2 Pressure not pumping below $1e-4$ torr: add LN into the cold trap.

10.3 Pressure not pumping below $1e-4$ torr with LN filled in cold trap: diffusion pump may not function properly. Call Microlab staff for helps.

10.4 No Aluminum evaporated: change the Tungsten coil. There may be contaminations to the coil

10.5 Shutter doesn't move: report a problem using FAULTS or call Microlab staffs for help.