



Chapter 6.35

NRC Evaporator

(nrc)

(582)

1.0 Equipment Purpose

- 1.1 The NRC is a high vacuum thermal evaporation system similar to V401. It has two sets of electrodes so that two materials can be deposited and uses a cryopump to attain the pressures suitable for thermal evaporation. There is a quartz crystal monitor to determine the deposition thickness in $\text{\AA}$ and rate $\text{\AA}/\text{sec}$. There is a shutter arm inside the bell jar, which can be rotated to begin the deposition of the source material onto the wafer. The vacuum system uses a cryopump, and has a base pressure of $\sim 7 \times 10^{-7}$ Torr.
- 1.2 The NRC Evaporator is a high vacuum thermal evaporation system. The nrc can accommodate two crucibles at a time to allow two sequential evaporations. There is one 6-inch/4-inch wafer holder. A crystal monitor enables direct read-out in $\text{\AA}/\text{sec}$ resolution for deposition rate and in nm for thickness. The nrc may evaporate several materials as defined below.

2.0 Material Controls & Compatibility

- 2.1 Materials allowed for evaporation
 - 2.1.1 Ag, Al, Au, Co, Cr, Cu, Fe, In, Ni, Pd, Si, Sn, Ti, ITO
- 2.2 Compatibility note:
 - 2.2.1 The nrc allows materials with very high vapor pressures to be evaporated in the tool. Members evaporating higher temperature materials (Al, Au, Cr, etc) may see some trace residue of Zn and similarly high vapor pressure materials in their films. **Most applications are unaffected by these trace contaminants.** Members need to evaluate their required process control on an individual basis.
- 2.3 Do NOT use tapes, plastics, or wax without discussing their use with process staff. Exception: Kapton tape is permitted.

3.0 Training Procedures & Applicable Documents

- 3.1 This tool requires members to pass the Evaporator Training Class (evapclass) as a prerequisite.
- 3.2 Basic Tool: This tool requires enabling and a formal qualification session, but does not have an online test.
 - 3.2.1 Get trained by any qualified member.
 - 3.2.2 Arrange a qualification session with a superuser to show competency on the tool.
 - 3.2.3 Estimated time to completion: 1-2 days.
- 3.3 Superusers and staff qualify members on this tool.

4.0 Definitions & Process Terminology

- 4.1 To be added

5.0 Safety

- 5.1 Follow general safety guidelines for the lab; the safety rules outlined in [Chapter 1.01 - Marvell NanoLab Chemical Hygiene Plan](#) and the following:
- 5.2 Do NOT use tapes, plastics, or wax without discussing their use with process staff. Exception: Kapton tape is permitted.
- 5.3 Do NOT leave the vacuum system until you are certain the bell jar is seated correctly and the system is roughing down properly.
- 5.4 Always wear clean light blue nitrile gloves (for vacuum) when working inside the bell jar.
- 5.5 Always wait for at least 5 minutes (depending on temperature and duration of evaporation) before venting the system to allow materials in the bell jar to cool.
- 5.6 Always clean up after yourself by removing used boats & rods and vacuuming fallen source powder and metal flakes in the chamber.
- 5.7 Always leave the system under vacuum when you have finished your run.

6.0 **Process Data**

- 6.1 Process data will be added as it becomes available

7.0 **Available Processes, Gases, Process Notes**

7.1 Boats

- 7.1.1 There are two types of boats kept in stock for use in the NRC. These are 4" tungsten dimpled boats. One is pure W, the other is coated with Al₂O₃.

7.2 Baskets

- 7.2.1 For materials which react with tungsten boats and cause cracking (such as Al), tungsten baskets may be preferred.

7.3 Shielding

- 7.3.1 Member dedicated shields are available on request from the Nanolab. Shields are made by the machine shop and will be charged to the member's account. These are typically used by high vacuum response processes such as Pb, In, and Sn.

7.4 Powders

- 7.4.1 For powders, if the current is turned up too quickly, the powders may heat too quickly. Fast heating results in boat vibration and ejection of powder out of the boat. If you had trouble getting enough thickness with evaporation, check below the boat when you open the bell jar and see if your powder ejected out of the boat.

7.5 Known Special Processes

7.5.1 BaF₂

- 7.5.1.1 Density: 4.89
- 7.5.1.2 Z-ratio: 0.793
- 7.5.1.3 Tooling factor: 35%
- 7.5.1.4 Source: Standard W boat
- 7.5.1.5 Current: ~195A starts evaporating
- 7.5.1.6 Refractive index: 1.4-1.5
- 7.5.1.7 Max layer thickness: 1um before running out of material in boat.

7.6 Tool Etiquette

7.6.1 Crystal Monitor

Crystal monitors are available to members who wish to retain their own crystal. They are <\$6. Crystals monitors are changed by members. Request assistance if you do not know how to change the crystal monitor on the tool and staff will train you.

Members are welcome to change crystals on nrc should they wish to have their own crystal - note that doing so can change the tooling factors present in the tool. Crystals are designed to go slightly over 100% life and still function. Flaking can cause abnormal behavior prior to this point - this is rare with proper care to avoid contact with the crystal monitor, and avoiding multiple different material depositions on the same crystal.

8.0 Equipment Operation

- 8.1 Enable nrc on Mercury.
- 8.2 Disengage the [vacuum] button and wait about 10 seconds for the gate valve to audibly shut.
- 8.3 Press [vent] to vent the bell jar.
- 8.4 Raise the bell jar.
- 8.5 Put on vacuum gloves available on Evaporator Preparation Cart.
- 8.6 Remove the stainless steel chimney and the wafer holder. Place these items only on clean surfaces (Techni-cloth or Al foil).
- 8.7 Check that the shutter arm swings freely.
- 8.8 Check that the crystal monitor is operational.
- 8.9 Wipe the gasket on the bottom of the bell jar with IPA (yellow bottle) and a Techni-cloth.
- 8.10 Load boat onto electrodes.
- 8.11 Place chimney and wafer holder into position.
- 8.12 Lower the bell jar slowly to avoid collision.
- 8.13 Engage the [vacuum] button.
- 8.14 Observe system until high-vacuum crossover.
- 8.15 Engage ion gauge filament
- 8.16 Program the crystal monitor with Z ratio and Density of your material.
- 8.17 Select the desired filament with the toggle switch.
- 8.18 Flip the circuit breaker on the power supply to the "on" position.
- 8.19 Ensure the the mode selector is in "manual".
- 8.20 Ramp to the evaporation current for your deposition by adjusting the power knob.
 - 8.20.1 Note that the power knob is a multiple-turn knob, and multiple turns are required to reach evaporation power levels. Ignore the labeled values on the front panel, they are inaccurate.
- 8.21 A digital ammeter is located in the grey box located above and to the left of the evaporator. It is auto ranging and for monitoring current only.
 - 8.21.1 Use this to track current output as you turn the power knob.
- 8.22 When the evaporation stabilizes, open the shutter.

- 8.23 When the evaporation is complete, turn the power knob down to zero.
- 8.24 Cut the power to the electrodes by flipping the circuit breaker to the “off” position on the front of the evaporator.
- Note:** The electrodes become quite hot during the evaporation. Allow the system to cool for at least 5 minutes before venting.
- 8.25 Disengage the [vacuum] button and wait about 10 seconds for the gate valve to audibly shut.
- 8.26 Press [vent] to vent the bell jar.
- 8.27 Raise the bell jar.
- 8.28 Put on vacuum gloves on evaporator preparation cart.
- 8.29 Remove your sample and source material.
- 8.30 Vacuum any debris from the stage inside the bell jar.
- 8.31 Lower the bell jar slowly to avoid collision.
- 8.32 Engage the [vacuum] button.
- 8.33 Observe system until high-vacuum crossover.
- 8.34 Engage ion gauge filament.
- 8.35 Clean your workspace.
- 8.36 Disable nrc on Mercury.

9.0 Troubleshooting Guidelines

9.1 Regeneration

- 9.1.1 The cryopump periodically needs to be regenerated. This is caused by the pump **filling up**. *Careless mistakes, such as forgetting to close the high-vacuum valve before venting can make regeneration necessary.* There are three different things that let you know if a regeneration is necessary:
- 9.1.2 Most obvious is if the cryopump pressure gauge (located to the right of the bell jar pressure gauge) reads anything greater than zero.
- 9.1.3 If the cryopump temperature becomes greater than 20 K or so.
- 9.1.4 If the NRC is not pumping down very well or has a poor base pressure ($> 4\text{E-}6$ Torr). The cryopump temperature readout is not always accurate. Do not use it only to determine the need for regeneration. If you are sure the cryopump needs regeneration, report it as a problem using Mercury.

10.0 Study Guide

- 10.1 Basic Qualification Checklist: (Superusers may add to this list as desired)
 - 10.1.1 Ensure member understands front/back electrode material restrictions
 - 10.1.2 Have member load boat
 - 10.1.3 Have member load wafer
 - 10.1.4 Have member set up crystal monitor
 - 10.1.5 Have member operate bell jar and obtain vacuum
 - 10.1.6 Have member operate power supply and run process

11.0 Appendices, Figures & Schematics

11.1 Vacuum Ports in 582

11.2 General information

11.2.1 There are 6 ports available on the south side of 582, all connected to a main vacuum unit in the 581 chase behind the tools.

11.2.2 A vacuum hose is available to serve all these ports. The set up can be used to vacuum up solid pieces such as silicon debris or other material from cleanroom surfaces or inside of equipment. Staff periodically cleans/services the vacuum unit. However, if any problem(s) occur, members need to report the fault as utility on the equipment list.

11.3 Vacuum Operation

11.3.1 Connect the vacuum hose to the nearest port by flipping the port cover up and pushing the hose into the opening.

11.3.2 Turn the timer switch clockwise to turn on the vacuum and set it for the number of minutes you need the vacuum to be on.

11.3.3 Reset the timer if you need more time to use the vacuum.

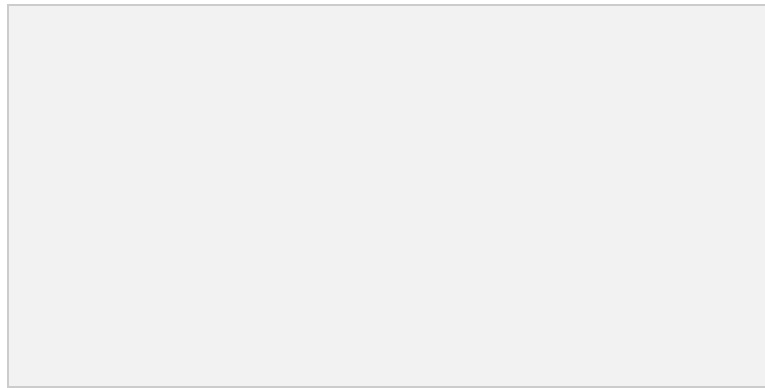


Figure 12.3.1 - Vacuum Port and Hose



Figure 12.3.2 - Activation Switch / Timer

