

University of Minnesota Nano Fabrication Center

Standard Operating Procedure

Equipment Name: Varian E-beam evaporation

Coral Name: ebevap-varian

Revision Number: 2

Model: 3118

Revisionist: K.Burkland

Location: Area 2

Date: 08-22-05

1 Description

The electron beam evaporator is used to solid dielectrics (no powders) onto substrates. Evaporation is done under a high vacuum in a water cooled bell jar chamber. Evaporation is achieved by heating a source with an electron beam. As the source material evaporates, it forms a thin film on the samples.

Three units control the electron beam: a power supply, source controller and a sweep controller.

2 Safety

- a If you are evaporating and the building alarm sounds, TURN OFF THE POWER SUPPLY CIRCUIT BREAKER and leave immediately.
- b To prevent sodium contamination, wear poly gloves whenever handling the source metals or the inside of the chamber.
- c Wear UV glasses when viewing the beam to prevent eye damage.

3 Restrictions/Requirements

- a Must be a qualified user
- b Log in and out of the system using Coral
- c Fill out the logbook.

4 Required Facilities

- a Compressed air 60psi
- b Process city water
- c Exhaust

5 Definitions

- a Ion gauge filament. Measures the pressure of the chamber while pumping with the diffusion pump (Cryo Pump)
- b Hearth. Located inside the chamber and holds the metal sources.
- c Planetarium. The fixture that holds the substrates inside the chamber.
- d Shutter. A metal paddle that will cover/uncover the source metals.

6 Setup

Sample Loading

- a The Ion gauge filament. Measures the pressure of the chamber while pumping with the diffusion pump (Cryo Pump)
- b Press the red Auto Sequence labeled STOP button.
- c Switch the AIR RELEASE toggle switch to AUTO. This will vent the bell jar in approximately 5 minutes.

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- d To raise the Bell Jar, move the toggle to the LEFT on the HOIST control. Only raise Bell Jar enough to load the sample. If the Bell Jar is raised too far, it will bend the support rod.
- e Load the sources into the hearth (up to four). Four sources can be loaded using the CRUCIBLE SELECTOR knob.
- f Switch the AIR RELEASE toggle switch to MANUAL to close the VENT.
- g Close the SHUTTER.
- h Load the substrates onto the planetarium. Fasten the holders to prevent them from falling during rotation.
- i Turn on the PROGRAM BOARD (the access panel needs to be flipped down). The T/X light should blink, then stop. If the light keeps blinking, the crystal needs to be replaced by a staff member.
- j Lower the Bell Jar by moving the toggle to the RIGHT on the HOIST control. Stop 4 –5 inches short, and ensure that the BELLJAR is aligned evenly, then push the DOWN button again until it is completely closed.

7 **Operating Instructions**

- a To begin pumping the Bell Jar, press START to start the Auto Sequence pump down.
- b When the pressure gauge is reading below 150 mTorr on the small vacuum gauge, turn on the ion gauge filament. A sufficient vacuum can be reached after 45 minutes to an hour. The minimum pressure to operate is 6×10^{-5} torr.
- c Enter the parameters on the program board. (this should already be on).
- d Make sure that the CONTROL POWER is set to AUTO
- f The PROGRAM light should be on. If not, toggle the switch. **YOU MUST PRESS ENTER** after each parameter is entered.
- g RISE TIME: is the time spent to ramp from zero power to SOAK POWER 1.
- h SOAK TIME 1: is the time spent at SOAK 1.
- i SOAK TIME 2: half of this time is spent ramping from SOAK POWER 1 to SOAK POWER 2, the other half is spent at SOAK POWER 2 .
- j **RATE: this is the evaporation rate per second. Do not go above 5.**
- k **TOOLING A** ratio for proper thickness measurement by the crystal. **It is posted on the bell jar.**
- l **SOAK POWER 1:** SOAK POWER 1 should be set 1 – 2% below SOAK POWER 1. The purpose of both SOAK 1 and SOAK 2 is to evenly heat the source. This will allow the metal to out gas and also heat evenly, so the evaporation begins, it will be uniform.
- m **SOAK POWER 2** should be set 1 – 2% above SOAK POWER 1.
- n **MAX POWER:** this setting prevents the beam from exceeding this level and damaging the equipment.
- o **IDLE POWER:** always set at zero (0).
- p **GAIN:** this controls the rate stability. The lower the gain, the more stable the deposition rate. Typical gains range from 1 to 10, (2) two is used most often.
- q **DENSITY** and **ZRATIO** are characteristics of the evaporant. See the process personal if you need to refer to the Film Evaporation Reference
- r **SOURCE/ SENSOR:** always set at 1/1.
- s Move the **KEYBOARD** switch to **LOCK**. The **PROGRAM** light will turn off.

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- t Wait for the bell jar to pump down to the desired vacuum
- u **POWER SUPPLY SET UP.**
- 1 Make sure the crucible selector is set to the correct position.
 - 2 Open the water valve on the wall behind the Evaporator.
 - 3 Turn the circuit breaker to the **POWER SUPPLY** on.
- v Turn the **SOURCE CONTROL POWER** on.
- 1 All four interlocks should light **GREEN**. If not, the beam cannot be turned on:
 - Water
 - Transformer
 - Vacuum
 - Doors (closed)
- w Turn the **SWEEP CONTROLLER** on, it is located on the back of the panel of the unit.
- x Turn the **HIGH VOLTAGE** on. Press the **H.V. ON** button.
- y Turn the **FILAMENT CURRENT** on. Press the **Fill ON** button.
- z Set up the **SWEEP PATTERN** on the sweep controller
- Patter should be set to 1 (circle)
 - Turn the sweep current by pressing **ON**. (No sweep for Al)
 - Refer to the Sweep Control directions for set up.
- aa **EVAPORATE**
- 1 Turn the **ROTATION** on.
 - 2 Start the **AUTO CYCLE**. Press **START, ZERO, START**.
 - 3 Open the View Shutter to see inside the bell jar. Once the beam is visible (usually at **SOAK 2**), center the beam on the **SOURCE** by adjusting the **X** (left/right) and **Y** (away/toward). The beam should not touch the crucible. If you are evaporating **Al** the sweep controller should be **OFF**. If evaporating nickel, do not turn the amplitude above 0.4 – nickel is very volatile and will spark, etc. You can use the remote pendant to adjust the parameter if desired. Check the source periodically, it should not be bubbling or moving around. Press **STOP** and try again.
 - 4 When the cycle reaches the **DEPOSIT** step, **OPEN** the **SHUTTER**. If this is not done, the source will be destroyed.
 - 5 After the desired, close the **SHUTTER**, and press **STOP** on the
- bb **DEPOSITION CONTROLLER.**
- 1 If you are going to evaporate from another source, wait 5 minutes before switching the crucible to allow the source to cool and prevent any damage to the o-rings. You can enter the parameters for the next source on the **PROGRAM BOARD** and begin evaporation.
- cc **SHUTDOWN**
- 1 **STOP** will be lit.
 - 2 Press the **H.V. RESET** on the power supply
 - 3 Press the **FIL OFF** on the Source Controller.
 - 4 Turn the Circuit Breaker **OFF** on the **POWER SUPPLY**.
 - 5 Turn the **SOURCE CONTROLLER** off.
 - 6 Turn the **SWEEP CONTROLLER** off.

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- 7 Turn the ROTATION off.
- 8 **IMPORTANT: WAIT 20 MINUTES BEFORE YOU TURN THE COOLING WATER OFF!!** The filament and sources need to cool.
- 9 Press the red Auto Sequence labeled STOP button.
- 10 Switch the AIR RELEASE toggle switch to AUTO. This will vent the bell jar in approximately 5 minutes.
- 11 Turn the ion gauge filament OFF.
- 12 Raise the Bell Jar by pushing the RAISE button on the HOIST control, and then remove your samples and the source. To close, stop 4 –5 inches short, and ensure that the BELLJAR is aligned evenly push the DOWN button again until it is completely closed and follow the PUMPDOWN procedure.

8 Problems/Troubleshooting

- a The system is not pumping down. If the samples have moisture on them, i.e. water or photoresist, the chamber will take longer to reach the desired pressure.
- b If the samples are dry, there may be particles on the O-ring preventing a good seal. Vent the system and wipe off the O-ring with a wipe soaked with methanol and try to pump down the chamber again.
- c The T/X light keeps on flashing when the Program Board is turned on. This indicates that the crystal that monitors the evaporated metal needs to be changed by a staff member or the replaced crystal has been installed improperly.
- d The chamber lid will not close. If you meet any resistance, raise the bell jar and readjust the planetarium to the indicated makings and try again.
- e The metal will not evaporate. This may happen for a number of reasons.
 - 1 Check to see if the hearth is in the correct position
 - 2 Re-check the entered parameters on the program board. Flip the rocker switch back to Program and press the corresponding white buttons and check the original entries. If an entry is not correct and needs to be changed, press the CLEAR button. Enter the correct parameter and press the ENTER button. It would be beneficial to restart the deposition by pressing STOP, START again.
 - 3 If the cooling water has been left on without evaporating any metal, the source metal may be too cold. Turn off the cooling water for at least 30 minutes to allow the metal to warm up and retry the evaporation process again.
 - 4 There is no beam visible when program board has reached SOAK POWER2. The Beam Controller has most likely been moved too far in either the X or Y position. On the Beam controller, press PGM. Press the X beam position and return to 0.0 by moving the arrow in the up or down direction, repeat the process for the Y beam position. At this point, the beam should be in view and moving the X/Y beam position should be minimal. If problems persist, STOP the Program Board and notify the process person for assistance.