University of Minnesota Nano Fabrication Center
Standard Operating Procedure

Equipment Name:	Varian E-beam evaporation		
Coral Name:	ebevap-varian	**Revision Number:**	6
Model:	3118	**Revisionist:**	Kevin Roberts
Location:	Bay 3 - Keller Hall	**Date:**	2/10/2015

1 Description

The electron beam evaporator is used to evaporate solid dielectrics (granules, 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.

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 Badger

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 Make sure Mode dial is on MAN.

b Turn off ion gauge using IG1 button.

c Switch HI VAC valve to CLOSE.

d Switch AIR RELEASE under MANUAL VALVES label to OPEN.

e Make certain "Convectron Gauge A" is above 7.0 x 10^2 Torr for 2 minutes.

f Raise bell jar using HOIST RAISE switch.

g Switch AIR RELEASE under MANUAL VALVES label to close.

h Load samples and source(s) as you normally would.

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 bell jar using LOWER HOIST switch. (Make sure black arrows are aligned).

k Make sure AIR RELEASE is in closed position.

l Switch ROUGH under MANUAL VALVES label to OPEN.

m Watch Rough Pump Gauge ("A"). Allow it to reach 1 x 10^-1 Torr

(~10 min.).

n Switch ROUGH to CLOSE position once 1 x 10^-1 Torr is reached.

o Switch HI VAC to OPEN position.

p Wait 30 seconds after cross-over, then turn Ion Gauge on using "IG1"

button.

7 Operating Instructions

1 The minimum pressure to operate is $6x10^{-5}$ Torr.

2 Enter the parameters on the program board. (this should already be on).

3 Make sure that the CONTROL POWER is set to AUTO.
YOU MUST PRESS ENTER after each parameter is entered.

4. RISE TIME: is the time spent to ramp from zero power to SOAK POWER 1.
5. SOAK TIME 1: is the time spent at SOAK 1.
6. 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 .
7. RATE: this is the evaporation rate per second. Do not go above 5.
8. TOOLING A ratio for proper thickness measurement by the crystal. It is posted on the bell jar.
9. SOAK POWER 1: SOAK POWER 1 should be set 1 – 2% below SOAK POWER 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.
10. SOAK POWER 2 should be set 1 – 2% above SOAK POWER 1.
11. MAX POWER: this setting prevents the beam from exceeding this level and damaging the equipment.
12. IDLE POWER: always set at zero (0).
13. 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.
14. DENSITY and ZRATIO are characteristics of the evaporant. See the process personal if you need to refer to the Film Evaporation Reference
15. SOURCE/ SENSOR: always set at 1/1.
16. Using blue rocker switch, Toggle out of Program Mode.
17. Wait for the bell jar to pump down to the desired vacuum $6x10^{-5}$ Torr.

POWER SUPPLY SET UP.

1. Make sure the crucible selector is set to the correct position.
2. Turn the circuit breaker to the POWER SUPPLY on.
3. Turn the SOURCE CONTROL POWER on.
4. All four interlocks should light GREEN. If not, the beam cannot be turned on: Water
   Transformer
   Vacuum
   Doors (closed)
5. Turn the SWEEP CONTROLLER on, it is located on the back of the panel of the unit.
6. Turn the HIGH VOLTAGE on. Press the H.V. ON button.
7. Turn the FILAMENT CURRENT on. Press the Fill ON button.

8 Set up the SWEEP PATTERN on the sweep controller
Patter should be set to 1 (circle)
Turn the sweep current by pressing ON.
Turn DC Bias ON.
Press PRM.

EVAPORATE

1. Turn the ROTATION on.
2. Turn Oxygen switch on (1 sccm)
3. Start the AUTO CYCLE. Press START, ZERO, START.
4. When the cycle reaches the DEPOSIT step, OPEN the SHUTTER.
5. After the desired thickness, when it has moved on to Thickness 2 = 0, close the SHUTTER, and press STOP on the Programmer.

SHUTDOWN

1. STOP will be lit. Turn off Programmer.
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.
7. Turn the Oxygen off.
8. Turn the ROTATION off.
9. Turn the Ion Gauge off.
10. Allow source to cool for 5 minutes.
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11. Switch HI VAC valve to CLOSE.

12. Switch AIR RELEASE under MANUAL VALVES label to OPEN.

13. Make certain "Convectron Gauge A" is above 7.0 x 10^2 Torr for 2 minutes.

14. Raise bell jar using HOIST RAISE switch.

15. Switch AIR RELEASE under MANUAL VALVES label to close.

16. Unload samples and source(s) as you normally would.

j Lower bell jar using LOWER HOIST switch. (Make sure black arrows are aligned).

k Make sure AIR RELEASE is in closed position.

l Switch ROUGH under MANUAL VALVES label to OPEN.

m Watch Rough Pump Gauge ("A"). Allow it to reach 1 x 10^-1 Torr (~10 min.).

n Switch ROUGH to CLOSE position once 1 x 10^-1 Torr is reached.

o Switch HI VAC to OPEN position.

p Wait 30 seconds after cross-over, then turn Ion Gauge on using "IG1" button.

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.

9 Special Notes on TiO2

Depositing SiO_2 and Al_2O_3 vs Depositing TiO_2 — How They Differ

Al_2O_3 and SiO_2 work fine with crystal feedback, and dep. rate and final thickness can be controlled with crystal controller. Simply program the controller, and it will do everything for you.

TiO2 does not work with the crystal controller, and the dep. rate will be erratic and uninformative. Also, final thickness displayed will be in error.

To deposit TiO_2 effectively:
1) Program TiO_2 with dep. rate 1-5 A/sec and give large (10.00 kA) final thickness to controller.

2) Program Power 1 = 5%, Power 2 = 10% and program Max. Power to either 10, 15, 20, or 25%

3) In practice the controller will go to this max. value and maintain that power while 'seeking' to reach input dep. rate of 1 to 5 A/sec.

4) Simply time run with amount of time shutter is open, and that will determine thickness based on the rates below.

We do not know why TiO2 does not work with crystal control, but it is believed it may be that the crystal is simply too far away from the source.

TiO_2 Deposition Rates
With no oxygen flowing --
10% power = 27 A/min
20% power = 100 A/min
25% power = 140 A/min

With 1 sccm O2 flowing, resulting in 9 x 10^-5 Torr pressure --
25% power = 94 A/min

With 5 sccm O2 flowing, resulting in 1 x 10^-4 Torr pressure --
25% power = 75 A/min