Chapter 6.34

Electron Beam Evaporator One

(ebeam1) (582)

1.0 Equipment Purpose

1.1 Ebeam1 serves as the NanoLab's magnetics and extreme temperature evaporator. Refractory metals and magnetic materials are well served by the placement of shutters and design of the electron gun, making maintenance more manageable than normal evaporators.

2.0 Material Controls & Compatibility

2.1 Substrates must be vacuum compatible (no significant volatile compounds remaining)

2.2 Lift-off processing with standard LOR5A process is considered the maximum tolerable offgassing from a substrate.

2.3 Evaporation materials which reach a vapor pressure of 1x10^-7 Torr at temperatures below 900K are not allowed in the ebeam1 chamber.

2.4 Evaporation of compound materials (Sulfides, Oxides, Nitrides, Carbides) is not allowed in the ebeam1 chamber.

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.

3.4 Applicable Documents:

3.4.1 Lab Manual 6.30 – Evaporation Overview

3.4.2 Lab Manual 6.31 - Evaporator Training Class

4.0 Definitions & Process Terminology

4.1 **PVD Evaporation:** A process in which material is heated until it reaches a vapor state, which then emanates via diffusion until contact with a cold source which removes enough heat from the vapor to return it to a solid state.

4.2 **E-Beam:** A beam of electrons sourced at high voltage (10 kV on cha). The beam heats the material to be deposited. The beam is guided by a series of magnets, which are tuned to focus the beam on the center of the crucible.

4.3 **Beam sweep:** A series of electromagnetic coils that offer a tunable magnetic change to the beam positioning magnetics. Used to center the beam and direct the beam in a pattern to avoid localized overheating of the melt.

4.4 **Base Pressure:** The highest vacuum obtained between closing the chamber and beginning the deposition process. 5x10E-6 is the minimum operating base pressure for the cha. 5x10E-7 is required for good film quality.

4.5 **E-Gun:** The filament and electrical fixturing that fires the e-beam and holds the turret.

4.6 **Hearth:** The portion of the E-gun that holds the source material.

4.7 **Turret:** The rotating portion of the hearth used to select pocket positions.

4.8 **Pocket:** The machined slots in the turret used to hold crucibles of material.

4.9 **Crucible Spacer:** A machined disk of graphite used to raise the crucible liner off the pocket wall and ensure the crucible liner is centered.

4.10 **Crucible Liner:** Used to both contain the deposition melt and reduce the amount of volume required to build a melt to evaporate films from.

4.11 **Melt:** The molten/sublimating material to be deposited on the wafer.

4.12 **Shutter:** Scissor type metal plates used to interrupt source to substrate line of sight.

4.13 **Wafer Holder:** 3-wafer lift off dome engineered to be at 90 degrees from source to substrate to allow lift off geometry.

4.14 **Crystal Monitor:** A 6 MHz gold crystal monitor used to measure the deposition rate.

4.15 **Deposition Controller:** Maxtek MDC-360C deposition controller used to interpret crystal monitor output.

4.16 **Ion Gauge:** Ion gauge used to measure high vacuum. Highly sensitive to pressures >10E-4 Torr.

4.17 **Roughing Pump:** Dry pump used to bring chamber from atmosphere to 70 mTorr

4.18 **Cryopump:** CTI cryogenics pump used to bring chamber from <100 mTorr to 5 x 10E-7

4.19 **Vapor Pressure:** The amount of gas pressure a material will generate at a given temperature. Material will evolve gas until vapor pressure is reached.

4.20 **VContamination:** The vapor pressure at which a material reaches contamination level concentrations in contaminated films. In the Marvell NanoLab evaporators, this is defined as 1x10E-7 Torr.

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 Molten Metal

5.2.1 While the process is running, the evaporating melt is significantly hot. Be advised that the following safety hazards are to be taken seriously. Simple forethought can prevent unnecessary injury.

5.3 Radiant Light:

5.3.1 Never look directly at a melt when running more than 50mA into the melt! Molten metal radiates a significant amount of energy from black-body emission.

5.3.2 Always use the provided visual shielding to view a bright melt. The effects are similar to staring into the sun.

5.4 Warm Crucibles:

5.4.1 A crucible must cool sufficiently before being removed from the hearth.

5.4.2 The crucible liner and spacer combination allows the melt to reach much higher temperatures at much lower powers, but also requires a longer cooling time.

5.4.3 Use the provided cooling plate to cool metal melts, and ALWAYS remove metal melts from a hearth with tweezers.

6.0 Process Data

6.1 Process data will be added when it becomes available

7.0 Available Processes, Gases, Process Notes

7.1 N/A

8.0 Equipment Operation

8.1 Loading the chamber

8.1.1 Enable ebeam1 on Mercury

8.1.2 Press Vacuum

8.1.3 Turn off Auto Pump

8.1.4 Turn on Auto Vent

8.1.5 Wait for chamber to vent (~3-4 mins)

8.1.6 Turn off Auto Vent

8.1.7 Clean chamber, load samples

8.1.8 Select the correct pocket from the lower touchscreen

8.1.9 Place melt in pocket

8.1.10 Repeat pocket rotation and melt placement until all melts are in place

8.1.11 Insert crystal monitor

8.1.12 Turn on Auto Pump and close chamber

8.1.13 Chamber door often requires body weight pressed against it to get the chamber to seal.

8.1.14 Wait for crossover to complete (3-4 mins)

8.1.15 Press Rotate

8.2 Setting up your process

8.2.1 On the MDC-360c controller, press Abort, then Reset

8.2.2 Press Program

8.2.3 Select edit Material

8.2.4 Use up/down arrow keys to choose a material, use the right arrow key to edit that material number.

8.2.5 Change the name and properties of the material using the number pad.

8.2.6 Be sure to use Source 1 for any material.

8.2.7 Press the left arrow until you are at the main menu.

8.2.8 Select edit process

8.2.9 Use up/down arrow keys to choose a material, use the right arrow key to edit that material number.

8.2.10 Change the name and properties of the material using the number pad.

8.2.11 Press Status, Abort, Reset.

8.2.12 Press Start

8.2.13 Select your relevant process

8.2.14 Press start again

8.2.15 Press Manual

8.2.16 Press graph until your desired chart is shown (Rate Dev. Is recommended)

8.3 Running your process.

8.3.1 Select the correct pocket from the lower touchscreen

8.3.2 Turn on sweep controller and set X and Y to zero

8.3.3 Press Power On on JEOL power supply

8.3.4 Check that all lights except 256P are green on power supply controller, and that OFF light is lit

8.3.5 Press ACCEL ON, wait for 10kV to stabilize

8.3.6 Press Filament on, wait 10 seconds

8.3.7 Ramp filament current to 20 mA

8.3.8 Manually ramp current to deposition temperature according to your process

8.3.9 Adjust beam position with sweep controller as necessary

8.3.10 Press Shutter on PLC touchscreen to begin deposition

8.3.11 After deposition, press Shutter again

8.3.12 Ramp current down to 20 mA

8.3.13 Press OFF (On the upper power controller)

8.3.14 Note deposition thickness from controller, press Abort, Reset

8.3.15 Repeat section 8.2 and 8.3 until all layers are complete

8.3.16 Press Rotate on PLC touchscreen

8.3.17 Press Back

8.4 Removing samples and shutting down

8.4.1 Press Vacuum on touchscreen

8.4.2 Turn off Auto Pump

8.4.3 Turn on Auto Vent

8.4.4 Wait for chamber to vent (3-4 mins)

8.4.5 Turn off Auto Vent

8.4.6 Remove samples and vacuum up all particles

8.4.7 Turn on Auto Pump, close door (some force may be required)

8.4.8 Wait for crossover to high vacuum, turn on ion gauge

8.4.9 Disable ebeam1 on Mercury

9.0 Troubleshooting Guidelines

9.1 Can't read process controller display

9.1.1 Process controller screen field of view is limited. Lower your viewing angle.

10.0 Study Guide

10.1 Basic Qualification Checklist: (Superusers may add to this list as desired)

10.1.1 Understand the importance of the planetary wafer holder

10.1.2 Understand rise and soak

10.1.3 Understand vapor pressure and deposition rate and how they are related

10.1.4 Understand the safety concerns of hot melts

10.1.5 Understand ebeam1 material restrictions

11.0 Appendices, Figures & Schematics

11.1 N/A