Standard Operating Procedure
E-Beam Evaporator with thermal evaporation sources - BOC Edwards Auto 500

The BOC Edwards Auto 500 electron-beam evaporation system can deposit ultra pure thin films of materials with high melting points and achieve fast deposition rates. It also features two thermal evaporation sources along with the e-beam source inside the chamber.

1.0 Operation Procedures

Toxic Fumes – When loading and unloading samples try not to breathe the fumes or metal dust powders from inside the chamber, since many of the metals can be toxic to inhale. The walls of the chamber will be coated with metals and they can flake off. When cleaning the chamber use the vacuum cleaner to remove any loose particles. You may also use the portable fume extractor (white box on wheels usually stationed at the PECVD system). Just roll it over and put the tube in the opening when you open the door and it will remove the fumes. To turn it on just click it on. It is variable speed. Highest speed is just clicked on.

Please take a moment to review general lab safety information in section 4 of this document.

1.1 Find the e-beam-thermal LOG Book. Sign-in with date, name, advisor’s last name, starting/ending thickness monitor #, Start time and End time. Also list which metals are placed in which pocket (if using e-beam), which metals you will deposit and what thickness will be deposited. List any comments as you work, such as problems, etc. If you are using the thermal evaporator, list what type of boat you used and what material and thickness you will deposit.

1.2 On the touch screen, press VENT and wait ~4-5 minutes. **DO NOT FORCE THE DOOR OPEN.** Gently pull on the handle to check if it is vented. It should open easily. It is a slow vent. The reading on the screen will not read 7.6e2 like it should, it only shows ~2e2 Torr.

1.3 Open the e-beam shutter by pressing on the SS1 button, on the left side shutter controller. To open the thermal evaporator shutters use the SS1 or SS2 buttons on the right side shutter controller.

1.4 Use the TURRET CONTROLLER KNOB to choose your e-beam crucible pocket desired and make sure you can see the appropriate metal in that crucible and check that the metal level is sufficient to use (~>1/4 full as a minimum). If more
metal is needed contact cleanroom staff. Do not remove the crucible from the pockets or change pockets.

1.5 To load new or different metals in the thermal evaporator, see cleanroom staff for help.

1.6 Check the CRYSTAL LIFETIME by pressing the DATA button on the Edwards FTM7 thickness monitor until the USAGE light is illuminated. If the value is around 900 or more, contact cleanroom staff to replace the crystal.

1.7 Mount your samples into the CHAMBER:
   1.7.1 Take the glass slide containing your samples and clip the glass slide (facing down) to the upper round plate with the metal clips on the edge of the holder. **DO NOT USE TAPE** on the round metal holder.
   1.7.2 You may attach your sample to the glass slide using tape, graphite paste, or silver paste which will dry and hold the sample in place, on the slide.

1.8 Close the chamber door. Make sure to lift the handle before latching it down.

1.9 On the screen, press SEAL.

1.10 On the screen, press PROCESS and wait until the pressure is BELOW \(5 \times 10^{-6}\) Torr (P3) for best deposition. This will take ~2.5-3 hours time.

1.11 Record the pressure in the e-beam Log Book should be @ or below \(5 \times 10^{-6}\) Torr (P3) before starting.

1.12 Make sure the LEFT-most buttons on the SUBSTRATE HEATER controller and the ROTARY WORKHOLDER are pressed on. Then press the START button on the ROTARY WORKHOLDER (the right button) to start rotation.

1.13 Turn on the e-BEAM POWER SUPPLY (located on the floor, to the left of the main chamber, right next to the white fume hood.) Flip up the triple electric circuit breaker.

1.14 Press the ON/OFF button on the EB3 Source Control.

1.15 Wait to see the ‘Power’ light to turn on (about 5 secs).

1.16 Turn the CURRENT knob all the way down to MIN(counter clockwise).

1.17 Press the GUN button ON the e-beam control unit.

1.18 You should see 0 mA current.

1.19 Use the TURRET CONTROLLER KNOB to choose your e-beam crucible pocket desired and make sure you can see the appropriate metal in that crucible and check that the metal level is sufficient to use (~>1/4 full as a minimum). If more metal is needed contact cleanroom staff. Do not remove the crucible from the pockets or change pockets.

1.20 Press the RUN button on the THICKNESS MONITOR twice, making sure it returns to ‘Closed’, illuminated. This will clear the running total of thickness (the right hand green LED display).

1.21 Turn on the EB3 Sweep Control (center knob on the bottom of the EB3 Sweep Control power supply). Switch it to the right “1”(On) from “0”. You will see
green LED’s flickering on the controls. Do not change any other knobs on this power supply.

1.22 While you wait, you may check the metal values using the DATA button on the Edwards FTM7 controller.
1.22.1 The chart posted on the front of the machine lists different metals and their corresponding density, z-values, and tooling factors that should be assigned to each layer # in the thickness monitor.
1.22.2 Press DATA until the “layer” light is illuminated. Use the up and down arrows to choose the desired layer #.
1.22.3 Each time you press the DATA button you will scroll through the entered numbers. If any of them are incorrect, contact cleanroom staff. Do not change any numbers to be different than assigned.
1.22.4 Press DATA until the “rate” light is illuminated.

1.23 To begin depositing metal, **VERY SLOWLY** turn up CURRENT knob on the power supply control. On average, ramp up at about 10-20 mA/min, to reduce the stress on the filament and to allow the metals to heat properly and slowly.

1.24 In particular with gold metal, if you heat it too quickly you may get spitting of gold on your film.

1.25 Increase the current until the desired deposition RATE is seen on the EDWARDS FTM7 left LED display (usually 0.02 – 0.10 nm/s)... make sure that this rate is STEADY (doesn’t fluctuate much more than 0.02 nm/s). The right LED display will show a running total of deposition.

1.26 You must check the thickness manually and stop at your desired thickness.
1.27 When the desired thickness is reached press the SS1 button to close the shutter.
1.28 Then, ramp down the CURRENT to 0 mA **SLOWLY** (but the ramp down can be done at a SLIGHTLY faster rate than the ramp up).
1.29 Press the GUN button OFF and the ON/OFF button to off on the EB3 Source Control.

1.30 **Wait for 1-2 minutes to allow the crucible to cool properly.**

1.31 If ADDITIONAL metals are needed, turn the TURRET CONTROLLER KNOB to the desired pocket #.
1.32 Return to step 1.17 of the DEPOSITION PROCESS. **Repeat this section for as many different metal layers as desired.**

1.33 Press off the START button on the ROTARY WORKHOLDER controller to stop the rotation.
1.34 Turn OFF the EB3 Sweep Control (center knob on the bottom of the EB3 Sweep Control power supply). Switch it to the left “0”(Off) from “1”. The green LED’s will go off.
1.35 Turn OFF the e-BEAM POWER SUPPLY (located on the floor, to the left of the main chamber, right next to the white fume hood.) Flip down the triple electric circuit breaker.

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1.36 Record any final data in the e-beam log book.
1.37 Please also note any problems or abnormalities in the log book.
1.38 Wait ~5-10 minutes (when the temperature is below 45 °C), then press SEAL.
1.39 On the touch screen, press VENT.
1.40 Wait ~5 minutes until the door opens easily.
1.41 **DO NOT FORCE OPEN THE DOOR OPEN.**
1.42 Remove your sample.
1.43 If you want to load another sample, follow steps starting from step 1.2.
1.44 Close the chamber door.
1.45 On the touch screen, press the PROCESS button to pump the chamber down.
1.46 Leave the door closed and the system pumping at all times when not in use.

2.0 **Specifications / Features**

- Four pocket electron-beam source
- Two independent thermal evaporation sources
- 5 kV high voltage supply
- X-Y beam sweep, substrate heating, substrate rotation
- FTM-7 quartz thickness monitor
- Source materials: SiO2, Al, Ge, Ag and Au, etc.
- Large box chamber: 500 mm diameter x 500 mm high
- Front loading enables easy access into the chamber
- Automatic PLC operated vacuum control system with touch screen display enables easy operation and in-situ thickness monitoring
- Ultimate vacuum: 5 x 10^-7 Torr
- Pumpdown: 7.5 x 10^-6 Torr and < 60 min to 1.5 x 10^-6 Torr

3.0 **User Requirements**

The E-Beam Evaporator with thermal evaporation sources - BOC Edwards Auto 500 must be used by authorized personnel only. All authorized users are expected to read and understand this SOP and follow the operation instructions carefully. No unauthorized personnel may use this equipment. All users must wear appropriate personal protective equipment. To become an authorized user, one must:

1. Complete Environment, Health & Safety (EH&S) training
2. Complete initial orientation and training for the Davis Hall EE Cleanroom
3. Receive training on this piece of equipment from lab personnel
4. Schedule equipment time using the calendar
5. Read and fully understand this SOP

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4.0 General Safety

4.1 Required Personal Protective Equipment
Users must wear coveralls, bouffant caps, shoe covers, safety glasses, and gloves. Shorts, open-toed shoes, high heels, and skirts, are forbidden.

4.2 Emergency Procedures and Contacts
For non-life threatening emergencies: use the main cleanroom phone and call the emergency contact #’s listed on the wall or for police / ambulance, call 645-2222

In case of fire or other life threatening emergency: Exit the cleanroom through an emergency exit door. Pull one of the fire alarms located in the main hallway outside of the cleanroom. Dial campus police / ambulance at 645-2222.

4.3 University after hours laboratory use policy
No working alone, use the buddy system!

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