

**UNIVERSITY OF CALIFORNIA, MERCED**

**SCIF CLEANROOM FACILITY**

**STANDARD OPERATING PROCEDURE (SOP)**

**Electron Beam Evaporation System (ATC / ATC Orion Platform)**

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**1. PURPOSE**

To provide a detailed, standardized, and safe procedure for thin film deposition using electron beam evaporation, ensuring reproducibility, equipment protection, and user safety.

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**2. SCOPE**

Applicable to all trained users operating the SCIF electron beam evaporation system for thin film deposition of metals and compatible materials.

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**3. RESPONSIBILITIES**

- **Users:** Follow SOP and ensure correct process parameters
  - **Core Staff:** Maintain system and provide training
  - **Facility:** Ensure utilities, safety, and compliance
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**4. REQUIRED SYSTEM CONDITIONS**

**4.1 Utilities**

- **Cooling Water:**
  - Temperature: 10–25 °C (recommended 15–20 °C)
  - Stable flow, filtered (<50 µm)
- **Power:**
  - Main system ON and properly grounded
- **Gas:**
  - Dry N<sub>2</sub> for venting (2–7 psig typical)

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## 4.2 Interlocks (MUST be satisfied)

- Cooling water flow
- Chamber vacuum
- Chamber closed

**Note:** These interlocks control power delivery — the system will not operate unless satisfied.

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## 5. SAFETY REQUIREMENTS

### 5.1 Hazards

- High voltage (lethal)
  - Vacuum implosion risk
  - UV radiation from plasma
  - Thermal hazards (hot source/substrate)
  - Magnetic fields (if applicable)
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### 5.2 Personal Protective Equipment (PPE)

- Cleanroom gloves
  - Safety glasses (UV-rated recommended)
  - Lab coat
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## 6. DETAILED OPERATION PROCEDURE

### STEP 1: START COOLING SYSTEM

- Turn ON chiller or facility cooling loop
- Verify:
  - Flow is stable

- No leaks
- Temperature within range
- Confirm water interlock resets (if applicable)

**Important:** Operating without cooling can damage source, magnets, and feedthroughs.

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## **STEP 2: POWER ON SYSTEM**

- Ensure emergency stop is released
- Turn ON:
  - Main power (PD box)
  - Control electronics
- Verify:
  - Vacuum gauges active
  - Controllers initialized

**Note:** High-power supplies remain OFF until vacuum and cooling interlocks are satisfied.

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## **STEP 3: CHAMBER PREPARATION (IF NEEDED)**

- Ensure chamber is at atmosphere
- Open chamber safely:
  - Use hinge/hoist properly
  - Insert safety pin (if applicable)
- Clean chamber:
  - Vacuum loose particles
  - Wipe with IPA and lint-free wipes
- Inspect:
  - O-ring condition
  - No contamination

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#### **STEP 4: LOAD SUBSTRATE**

- Prepare substrate:
  - Clean (acetone, IPA, or process-specific method)
  - Dry thoroughly
- Mount substrate:
  - Use clips, holder, or transfer plate
  - Avoid fingerprints
- Confirm:
  - Proper orientation
  - Secure attachment

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#### **STEP 5: SECURE SUBSTRATE HOLDER**

- Insert substrate holder into chamber stage
- Ensure:
  - Proper seating (bayonet/pin/cradle type)
  - Smooth rotation (if enabled)
- Set:
  - Working distance
  - Rotation (if applicable)

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#### **STEP 6: CLOSE AND SEAL CHAMBER**

- Lower chamber lid carefully
- Ensure:
  - No cables pinched
  - O-ring seated properly

- Clamp chamber lid securely
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## **STEP 7: PUMP DOWN CHAMBER**

### **7.1 Initial Pumpdown**

- Close vent valve
- Open appropriate isolation valves
- Start:
  - Mechanical pump
  - Turbo/cryopump

### **7.2 Monitor Pressure**

- Observe transition from rough vacuum to high vacuum
- Typical base pressure:
  - $\leq 1 \times 10^{-6}$  Torr

### **7.3 Notes**

- Pumpdown may take time after venting
  - Optional improvements:
    - Mild bake (<120 °C)
    - N<sub>2</sub> purge cycles to remove moisture
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## **STEP 8: SET DEPOSITION PARAMETERS**

Configure:

- Material selection
- Beam current / power
- Deposition rate (Å/s)
- Thickness setpoint (QCM)
- Substrate rotation

- Working distance

Optional:

- Substrate heating/cooling
  - Plasma or ion pre-cleaning
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## **STEP 9: INITIATE E-BEAM EVAPORATION**

### **9.1 Pre-Check**

- Vacuum stable
- Cooling active
- No exposed connections

### **9.2 Start Beam**

- Turn ON e-beam power supply
- Gradually ramp emission current
- Observe:
  - Material melting
  - Stable evaporation

### **9.3 Stabilization**

- Wait for steady deposition rate
- Adjust beam alignment if required

### **9.4 Open Shutter**

- Open only after stable rate is achieved
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## **STEP 10: MONITOR DEPOSITION**

Continuously monitor:

- Deposition rate ( $\text{\AA}/\text{s}$ )
- Film thickness (QCM)

- Beam stability
- Chamber pressure

Adjust beam current to maintain desired rate.

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#### **STEP 11: COMPLETE DEPOSITION**

- Close shutter at target thickness
  - Gradually ramp down beam power
  - Turn OFF e-beam supply
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#### **STEP 12: COOLDOWN**

- Allow:
  - Source cooling
  - Substrate cooling
- Maintain vacuum during cooldown

**Note:** Prevents oxidation and thermal stress.

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#### **STEP 13: VENT CHAMBER**

- Slowly introduce dry N<sub>2</sub>
  - Avoid rapid venting to:
    - Protect pumps
    - Prevent contamination
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#### **STEP 14: UNLOAD SUBSTRATE**

- Open chamber
- Before touching the system, ensure the substrate holder and chamber stage are properly grounded. Failure to do so may result in electric shock due to static charge and high voltage.

- Remove substrate carefully
- Inspect film quality

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## 7. POST-OPERATION

- Turn OFF:
  - Power supplies
  - Cooling (if appropriate)
- Record:
  - Material
  - Thickness
  - Deposition rate
  - Any issues

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## 8. TROUBLESHOOTING GUIDE

<b>Issue</b>	<b>Cause</b>	<b>Action</b>
No deposition	Beam misaligned	Adjust beam
Unstable rate	Poor vacuum	Re-pump / clean
Arcing	Contamination/moisture	Bake chamber
Non-uniform film	No rotation	Enable rotation
Low rate	Low beam power	Increase gradually

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## 9. CRITICAL DOs & DON'Ts

### DO

- Verify interlocks before operation
- Ramp power slowly

- Maintain clean chamber

**DON'T**

- Apply power at high pressure (>1 Torr)
- Operate without cooling
- Vent chamber rapidly

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**10. ACKNOWLEDGMENT & APPROVAL**

**Director Name:** \_\_\_\_\_

**Director Signature:** \_\_\_\_\_

**Date:** \_\_\_\_\_

**User Name:** \_\_\_\_\_

**User Signature:** \_\_\_\_\_

**Date:** \_\_\_\_\_