UNIVERSITY OF CALIFORNIA, MERCED

SCIF CLEANROOM FACILITY

STANDARD OPERATING PROCEDURE (SOP)

RF Magnetron Sputtering System Operation (VTC-1RF / RF-300I or Equivalent)

Location: SE1: 154, Class 1000 Cleanroom

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1. PURPOSE

To provide a detailed, standardized, and safe procedure for thin film deposition using RF magnetron sputtering, ensuring reproducibility, equipment protection, and user safety.

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2. SCOPE

Applicable to all trained users performing thin film deposition using RF sputtering systems for metals, oxides, and dielectric materials.

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3. RESPONSIBILITIES

- **Users:** Follow SOP and ensure proper parameters
- **Core Staff:** Maintain system and provide training
- **Facility:** Ensure utilities, safety, and compliance

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4. SYSTEM OVERVIEW

RF sputtering uses plasma (typically Ar gas) to eject atoms from a target, depositing them onto a substrate.

Capabilities:

- Thin film deposition (nm–μm scale)
- Oxide and dielectric materials (RF mode)
- Metal coating (RF/DC depending system)

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5. REQUIRED SYSTEM CONDITIONS

5.1 Utilities

- Argon gas (≥ 99.999% purity recommended)
- Vacuum pump operational (10^{-3} to 10^{-6} Torr range)
- Water cooling active (for sputtering head)
- RF power generator (13.56 MHz, up to ~300W)

5.2 System Conditions

- Chamber clean and sealed
- Target installed correctly
- No vacuum leaks
- Thickness monitor operational (if available)

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6. SAFETY REQUIREMENTS

6.1 Hazards

- High voltage RF power
- Plasma radiation
- Vacuum implosion risk
- Pressurized gas cylinders
- Thermal heating (substrate up to ~700°C possible)

6.2 PPE

- Cleanroom gloves
- Safety glasses

- Lab coat

6.3 Critical Safety Rules

- Never exceed gas pressure limits (<3 PSI input)
- Never operate without cooling
- Do not use flammable gases
- Ensure proper grounding

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7. DETAILED OPERATION PROCEDURE

STEP 1: SYSTEM PRE-CHECK

- Verify:
    - Pump oil level
    - Cooling water level
    - Target installed correctly
    - Chamber clean

👉 Manual confirms pump oil and water level must be checked before operation

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STEP 2: LOAD SAMPLE

- Open chamber
- Place substrate on holder
- Ensure:
    - Clean surface
    - Proper positioning
- Close and seal chamber

STEP 3: START UTILITIES

- Turn ON:
    - Water chiller
    - Vacuum pump
    - Main system power

STEP 4: PUMP DOWN

- Evacuate chamber
- Target:
    - ~1 Pa initial vacuum check
- Verify:
    - No leaks
    - Stable pressure

👉 Manual indicates ~1 Pa confirms good sealing

STEP 5: ARGON GAS INTRODUCTION (PURGE)

- Open Ar gas
- Increase pressure to ~100–120 Pa
- Purge chamber (~5 minutes)

Then reduce pressure to:

- ~10 Pa (working pressure)

👉 This purge + working pressure sequence is critical for clean plasma

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STEP 6: SET PROCESS PARAMETERS

- RF Power:
    - Start ~30 W

- Pressure:
    - ~10 Pa
- Rotation:
    - 1–10 rpm
- Optional:
    - Substrate heating
    - Thickness monitor setup

STEP 7: IGNITE PLASMA

- Turn ON RF generator
- Enable output
- Adjust matching network

👉 RF must be matched ($P_r \approx 0$) for stable plasma

STEP 8: PRE-SPUTTER (TARGET CLEANING)

- Block substrate (use shutter)
- Run plasma for ~2–3 minutes

👉 Removes contamination from target surface

STEP 9: DEPOSITION

- Open shutter
- Begin deposition
- Monitor:
    - Plasma stability
    - Pressure
    - Power

- Adjust:
    - RF power
    - Gas flow

STEP 10: MONITOR FILM GROWTH

- If thickness monitor available:
    - Set material density
    - Monitor rate

👉 Thickness depends on current, time, and material constant

STEP 11: COMPLETE DEPOSITION

- Close shutter
- Reduce RF power gradually
- Turn OFF RF

STEP 12: SHUTDOWN

- Turn OFF:
    - Gas flow
    - Pump
    - Cooling
- Vent chamber slowly
- Remove sample

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8. TROUBLESHOOTING GUIDE

Issue	Cause	Action
No plasma	Low pressure / mismatch	Adjust gas & match
Arcing	Contamination	Clean chamber
Low deposition rate	Low power	Increase RF
Non-uniform film	No rotation	Enable rotation
Poor adhesion	Dirty substrate	Improve cleaning

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9. CRITICAL DOs & DON'Ts

DO

- Pre-sputter before deposition
- Use high-purity Ar gas
- Maintain clean chamber
- Monitor pressure continuously

DON'T

- Run at high power for long duration
- Use contaminated targets
- Skip purge step
- Operate without cooling

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10. CONTAMINATION CONTROL

- Clean chamber regularly
- Avoid introducing dust/oils
- Clean substrate before deposition
- Store targets properly

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11. WASTE HANDLING

- Dispose wipes and residues properly
- Follow SCIF hazardous waste procedures

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12. EMERGENCY PROCEDURES

- Power issue → Shut OFF immediately
- Vacuum failure → Stop process
- Gas leak → Close cylinder
- Plasma instability → Turn OFF RF

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13. TRAINING COVERAGE

Users are trained on:

- Plasma physics basics
- RF power and matching
- Target handling
- Deposition parameter control
- Thickness monitoring
- Safety procedures

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14. ACKNOWLEDGMENT & APPROVAL

Director Name: _____
Director Signature: _____
Date: _____

User Name: _____
User Signature: _____
Date: _____