UNIVERSITY OF CALIFORNIA, MERCED
SCIF CLEANROOM FACILITY
STANDARD OPERATING PROCEDURE (SOP)
Atomic Layer Deposition (ALD) System Operation (Savannah S100/S200/S300 or Equivalent)
Location: SE1: 154, Class 100/1000 Cleanroom

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1. PURPOSE

To provide a detailed, standardized, and safe procedure for thin film deposition using Atomic Layer Deposition (ALD), ensuring reproducibility, conformality, and precise thickness control while protecting equipment and users.

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2. SCOPE

Applicable to all trained users performing thin film deposition using ALD systems for oxides, dielectrics, and nanostructured coatings.

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3. RESPONSIBILITIES

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

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4. SYSTEM OVERVIEW

Atomic Layer Deposition (ALD) is a cyclic thin film deposition technique based on alternating, self-limiting surface reactions.

Typical ALD cycle:
- Precursor A pulse
- Purge
- Precursor B pulse
- Purge

Capabilities:
- Atomic-scale thickness control (~Å per cycle)

- Highly conformal coatings
- Uniform deposition on high aspect ratio structures
- Thin films from nm to tens of nm scale

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5. REQUIRED SYSTEM CONDITIONS

5.1 Utilities

- Nitrogen gas (≥ 99.999% purity recommended)
- Vacuum pump operational (~10^{-1} to 10^{-3} Torr typical base range)
- System heaters operational (chamber, lines, precursor)
- Electrical supply (115 VAC system)

5.2 System Conditions

- Chamber clean and free of contamination
- Precursors properly installed and sealed
- No vacuum leaks
- Temperature controllers functioning
- Proper gas flow and pressure control

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6. SAFETY REQUIREMENTS

6.1 Hazards

- High temperature surfaces (150–250°C)
- Hazardous chemical precursors (some pyrophoric)
- Vacuum system hazards
- Pressurized gas systems
- Heated gas lines and valves

6.2 PPE

- Cleanroom gloves
- Safety glasses
- Lab coat

6.3 Critical Safety Rules

- Never open chamber below operating temperature (~150°C)
- Never disconnect precursor cylinders improperly
- Ensure nitrogen flow before operation
- Do not operate without vacuum
- Follow all SDS guidelines for precursors

7. DETAILED OPERATION PROCEDURE

STEP 1: SYSTEM PRE-CHECK

- Verify:
  - Nitrogen supply ON
  - Precursors available
  - Chamber clean
  - No leaks
  - System powered

STEP 2: SYSTEM STARTUP

- Click **PUMP**
- Turn **HEATER ON**
- Allow chamber to reach ~150°C (~15 minutes)

👉 Do NOT open chamber before temperature is reached

STEP 3: LOAD SAMPLE

- Click **VENT**
- Open chamber lid
- Place substrate (face up) using tweezers

- Close chamber
- Click **PUMP**
- Allow thermal stabilization (~5–10 minutes)

STEP 4: SET PROCESS CONDITIONS

- Set nitrogen flow: ~5–20 sccm
- Confirm pressure (~100 mTorr typical)
- Verify temperature (~150°C or as required)

STEP 5: RECIPE SETUP

- Load existing recipe template
- Modify:
  - Number of cycles
  - Pulse times
  - Purge times
- Save recipe under user directory

👉 Typical growth rate: ~1 Å per cycle (material dependent)

STEP 6: RUN PROCESS

- Click **RUN (START)**
- Confirm execution
- Monitor:
  - Pulse signals
  - Pressure
  - Cycle progression

STEP 7: PRECURSOR MONITORING

- Ensure pulses are present and consistent

👉 If precursor pulse missing → check valve

👉 If water pulse missing → STOP and notify staff

STEP 8: DEPOSITION

- System runs automatically through cycles
- Monitor:
  - Pressure stability
  - Pulse amplitude
  - Temperature

STEP 9: COMPLETE PROCESS

- Wait for “RUN HAS COMPLETED”
- Record process in logbook

STEP 10: UNLOAD SAMPLE

- Click **VENT**
- Open chamber
- Remove sample using tweezers
- Close chamber

STEP 11: PURGE MANIFOLD (MANDATORY)

- Close precursor valves
- Load purge recipe
- Run purge cycle

👉 Repeat for all precursors used

STEP 12: SHUTDOWN

- Maintain low nitrogen flow (~5 sccm)
- Leave system in standby
- Do NOT shut down software unless emergency

8. TROUBLESHOOTING GUIDE

Issue	Cause	Action
No precursor pulse	Valve closed	Open valve
No water pulse	Empty source	Notify staff
Pressure instability	Leak / contamination	Stop process
Poor film quality	Incorrect parameters	Adjust recipe
Non-uniform film	Temperature/flow issue	Verify conditions

9. CRITICAL DOs & DON'Ts

DO

- Use proper purge cycles
- Maintain clean chamber
- Monitor process continuously
- Use approved precursors

DON'T

- Open chamber when cold or mid-process
- Skip purge steps
- Use unknown precursors
- Operate with leaks or unstable pressure

10. CONTAMINATION CONTROL

- Clean chamber regularly
- Avoid outgassing substrates
- Use clean handling tools
- Maintain precursor line cleanliness

11. WASTE HANDLING

- Dispose of wipes and materials properly
- Follow SCIF hazardous waste protocols
- Handle precursor waste per SDS

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12. EMERGENCY PROCEDURES

- Power issue → Shut OFF immediately
- Vacuum failure → Stop process
- Gas issue → Close supply
- Abnormal behavior → Abort run

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13. TRAINING COVERAGE

Users are trained on:
- ALD fundamentals
- Recipe programming
- Precursor handling
- System operation
- Safety procedures

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14. ACKNOWLEDGMENT & APPROVAL

Director Name: ____________________________________

Director Signature: _________________________________

Date: ____

User Name: _______________________________________

User Signature: ____________________________________

Date: ____