SOP-MDSC-200
AJA ATC ORION-8 SPUTTER DEPOSITION SYSTEM

MATERIALS DISCOVERY & SYNTHESIS CENTER
DEPT. OF ENGINEERING, DEAN'S OFFICE
UNIVERSITY OF CALIFORNIA, IRVINE
CONTENTS

I. CHECKLIST FOR TRAINED PERSONNEL .........................................................3
II. SAFETY ...........................................................................................................4
III. STARTUP ......................................................................................................5
IV. OPERATION - RATE MEASUREMENT .............................................................6
V. OPERATION - SOFTWARE ..............................................................................7
VI. OPERATION - TRANSFER, DEPOSITION ....................................................8
VII. SHUT-DOWN .............................................................................................15
I. GUIDE FOR TRAINED PERSONNEL

This is a list of things to always remember when operating the sputter tool:

**Operation**

- Always take rate measurements with a blank carrier mounted to the main chamber. This will protect the quartz piece needed for the heater’s pyrometer to work. If this piece is coated with metal after your experiment, you will be charged up to the full price of the replacement piece.
- A good strike pressure is 10mtrr-30mtrr. The sputter dep rate is not good at this range, but a plasma is easily started.
- A good coat pressure is 3 mtrr. This is a minimum value that can be consistently held by the equipment.
- All programs should have strike layers before coat layers. Strike layers ignite the plasma at high pressure and medium power with the shutter closed. Idle STPT must be used in all layers to smoothly transition between your program steps.
- When loading the substrate carrier: load lock and main chamber must be at 5E-5 torr pressure or lower.
- The carrier should be placed in the load-lock in “y-left” orientation and sit flush with the transfer arm.
- Turning the propeller crank counterclockwise will raise the propeller, clockwise will lower it (I don’t have this memorized, I check each time).
- Twist the propeller assembly to the arrow marker before lowering to ~20mm.
- The surfaces of the catcher and carrier backside should be in contact before rotating the propeller 60 degrees to “lock” it into place. The rotated position is marked with a dot.
- Set the carrier height to 15mm before starting your program.
- Confirm which targets are mounted to each source 1-8 before working. The latest target configuration is written on the side of the system cabinet. The arrangement may differ day-to-day.
- Always wear your lab coat and nitrile gloves when working. Avoid transfer of oils from your hair, skin, or cell phone to the substrate carrier or any internal parts to protect the vacuum level.
- The lab manager may give you retraining or notification if you fail to follow the written procedure. Your access to the facility may be revoked for recurring negligence.

**Startup/Shutdown**

- Keep the main valves of the gas bottles open. Open the pressure regulators before working, and close them when you’re done working.
- If the Ar pressure regulator is not opened before you start working, your program will error out after several minutes due to insufficient process gas flow.
- The N2 vent gas line is tee’d to a quarter-turn valve open to atmosphere. When you are working and have the N2 regulator open, **make sure to close the**
quarter-turn valve, or you will drain a significant amount of the N2 supply, which could disrupt the schedule. When you shut down, close the N2 regulator, and open the valve to atmosphere.

- Some equipment will not work if the chiller is not circulating cooling water. After an experiment, do not turn off the chiller pump without approval from the lab manager. Doing so could cause the turbo pumps to overheat, or residual heat on the sputtering sources to degauss the magnets.
- If using the substrate heater, you must wait until the heater reads 100C or less before transferring the sample to the load lock. It will still be hot, and you must use heat-resistant gloves to place the carrier on a stack of cleanroom wipes.
- After each experiment, you must remove the clips from the substrate carrier, then scrub its surface with a scotch brite and IPA. The carrier must be returned with no residue and the clips returned to place with their 4-40 screws and nuts. You are not expected to remove all the metal film buildup, but the surface needs to be thoroughly scuffed to prevent flaking.

This procedure describes the instructions for the safe usage of the ATC Orion-8 Sputter Tool.

The Orion-8 is a vacuum sputtering system with load lock that can deposit thin layers of material over a substrate using DC or RF bias.

II. SAFETY

- Users may not move heated samples out of the process chamber until the temperature controller PV reads less than 100C. Heat-resistant gloves must be used to handle a hot carrier.
- Users may never vent or open the process chamber without approval.
- The energized system runs high voltage. Users may not open the cabinet to troubleshoot any system errors.
- There are several pinch points on the system, mainly the hinged lid of the main chamber and lid of the load lock. Keep hands and fingers clear of their closures.
- Gloves, wipes, and scuff pads used to clean the carrier must be discarded in the green waste bins.
III. STARTUP

1. Don appropriate PPE including lab coat, nitrile gloves, and safety glasses.
2. Before operation, find out the arrangement of targets in the main chamber. Verify the expected target-to-gun mapping based on the system whiteboard. If changes are necessary, please notify staff.
3. Verify that the power breakers are set to “ON”. Turn on the chiller behind the machine if it is not already powered.
4. Set the pressure regulator on the Nitrogen gas cylinder to 0-5 PSI. Any positive value is OK.
5. Set the pressure regulator on the Argon gas cylinder to about 20 PSI. This must never exceed 30 PSI.

Figure 3: Gas Cylinder Operating Pressures (OLD VALUES 5&7PSI)

IV. OPERATION - RATE MEASUREMENT

1. Before beginning any rate measurement, transfer a blank substrate carrier into the chamber at the highest position. Refer to VI. OPERATION - Steps 7-14. Use the lever on the upper left of the main chamber lid to swing the QCM into position. The QCM sensor should always be positioned at the limits of the lever’s range of motion.

Figure 4: Improper configuration (left), proper configuration with carrier in place (right) – sputter deposition may proceed

2. Rate measurements are taken before an experiment, to approximate the time that a gun must be energized to achieve some thickness of film deposited.
Deposit rates can also be used in co-sputtering to obtain a desired alloy composition.
Example: If Gun 2 is mounted with Ni and is powered at 200W DC, the thickness monitor shows 2.5 angstrom/s. If you want a 50nm film of Ni, you should sputter with gun 2 at 200W for 500/2.5 = 200s.
Example: You want another Ni film with 2% Mo. You calculate that Mo would have to deposit at 0.62 angstrom/s, with Ni at full power (200W). Using the aforementioned procedures, you would try several power levels until you find a value between 10W-200W DC that results in .62 angstrom/s Mo.

3. Open the document called “Thickness Monitor” in the upper left corner of the desktop. Search for the table with material properties and find your material. You will need its density and z-factor (acoustic property).

4. If you cannot find your material, you will use its density in g/cm3 from another reference, and use 1.00 for z-factor.

5. Use the encoder to select a saved film from 1-50. You will overwrite this film.

6. Hit the “program” key on the thickness monitor.

7. Set the density of the material to be measured using the encoder. Tap the “next” button until you see “z-factor”.

8. Set z-factor using the encoder. Tap “next” once.

9. Tap the “program” button to save these film properties. Make sure the film number that was set is showing when you hit the program key. Tap “next” to confirm that both properties saved your desired values.

10. Deposit the material in manual mode at a power up to 200W for metals, or 100W for ceramics. Record the deposit rate shown on the thickness monitor. Do not record for longer than 30 seconds. For manual mode instructions, see VI.

V. OPERATION: SOFTWARE

11. Some materials, such as ceramics, deposit very slowly. You may need to use a stopwatch, and calculate a rate using the accumulated thickness value on the right-hand side of the QCM readout.

V. OPERATION: SOFTWARE

Manual Mode

1. The Phasell-J software is kept open at all times. Login using your assigned 4-letter password.

2. Never deposit material unless the substrate carrier is in-place.

3. Enable substrate rotation at any value 5-40 RPM.

4. Enter your desired Ar flow rate in sccm, under “MFC 1”. The standard value is 40 sccm. Click the red button under MFC 1 to change it to “ON” position, it will light green.

5. Click “PRESSURE” under “PRESSURE CONTROL”. Set this to 10 mtorr as your strike pressure.

6. Go to the DC or RF power supply with your desired material. Type a watt setpoint value between 10-200w. Click the button above “output” to energize the gun.
7. Change the pressure control value to 3 mtorr, or your desired coat pressure. Click the shutter icon to open the shutter, and initiate material deposition.

Automatic Mode

8. A basic process will include an RF clean step, then one or more sets of material strike + material coat layers.
9. Click “CREATE LAYER” on the main screen to program each layer.

Strike Layer

10. Enable substrate rotation, then set your desired rotation speed.
11. Set Pressure Mode at 10 mtorr
12. Enable your desired DC or RF power supply. Use 50W for the strike STPT.
13. Set SHUTTER ENABLE = OFF
14. Set COAT TIME = 5.0 seconds
15. Set IDLE STPT = STPT value
16. Save this file with your desired filename. Example: 240101 Cu Strike DC2 GUN 2

Coat Layer

17. You can modify the strike layer and save with a different name to make the coat layer.
18. Keep pressure mode enabled, but change the setpoint from 10mtorr to 3mtorr.
19. Set SHUTTER ENABLE = ON
20. Set Watts STPT = your desired coat power
21. Set COAT TIME = your desired coat time (based on thickness monitor rate and desired thickness)
22. Set IDLE STPT = STPT value
23. Save this file with your desired filename. Example: 240101 Cu DC2 GUN 2 250W

VI. OPERATION - TRANSFER, DEPOSITION

1. You will transfer in your substrate using the load lock. When you arrive, it will be under vacuum. Vent the chamber by turning off the “vacuum pumps” switch on the PD30S – upper right corner of the system, above the label that reads “Load Lock”.
2. Verify that the main chamber is at operating pressure (1E-6 torr or less) according to the INFICON controller. Press “I/O” twice to enable the pressure sensor. The chamber will typically be around 5E-7 torr if it hasn't been vented for several days. It may read in E-6 torr range if it was vented on the day-of working. Better vacuum levels will result in slightly higher deposit rates.
3. Lift the lid of the load-lock at an angle to prevent striking the flat surface. Scratches on the lid may prevent the chamber from pulling vacuum. Place the lid on the standoffs in the workspace, flat-side down.

Figure 6: INFICON Vacuum Controller: Main Chamber Pressure (Left) Gauge on/off button (right)

Figure 7: Open LL Lid at an Angle. Manometer reads atmospheric ~7.6E2 torr
4. Load the substrate using the titanium clips underneath the substrate holder. Align the substrate holder as shown. The grooves form a letter “Y” opened towards the left-hand side. The screw heads for each wafer clip sink into the groove of the paddle.

![Image of substrate holder](image)

Figure 8: Orientation of Substrate Holder

5. Once per experiment, use some isopropanol and a cleanroom wipe to wipe the viton o-ring for the load lock. This will help maintain its vacuum level.

6. Replace the lid of the load lock. Power on the load lock turbo pump from the control panel.

7. When both the load lock manometer and main chamber ion gauge (INFICON controller, Figure 3) read E-5 torr range or lower: open the gate valve using the crank between the main chamber and load lock. Loosen the lock nut, then rotate the crank counterclockwise until it stops. When you close this crank, rotate until it snaps to the closed position, then tighten the lock nut.
8. Verify that the quartz crystal thickness monitor and substrate holder mount are clear for the transfer arm to move into the main chamber.

Figure 9: Main Chamber - Load Lock Gate Valve Crank

Figure 10: Quartz Thickness Monitor is Out of the Way so the Substrate Holder can Enter
9. Use the crank on the transfer arm to move the substrate holder from the load lock to the main chamber.

![Substrate Holder in Position](image)

**Figure 11: Substrate Holder in Position**

10. Spin the upper part of the catcher assembly until you see the drawn arrows line up together
11. Lower the substrate mount using its crank such that its propeller blades into the substrate holder. This is a position of ~20mm on the ruler. Visually, the flat plate
of the catcher assembly will sit flush against the back surface of the substrate carrier.
12. Rotate the substrate mount clockwise 60 degrees to the pictured stop point. The propeller blades will now support the fins of the carrier.
13. Raise the substrate mount using the crank until it is in the marked position ~15mm.

Figure 13: Substrate Holder Mounted to Main Chamber for Sputtering

14. Use the transfer arm crank to move the transfer arm back into the load lock.
15. Close the gate valve between the main chamber and load lock.
16. Log in to the system software using your assigned password.
17. Click “Run Process”. Select the desired filename and click “Start Process”.
18. After the recipe has completed, you may remove your sample from the chamber.
19. If the substrate heater was used, wait until it reads less than 100°C before proceeding. The cooling water channels will bring the carrier down to this temperature, then it can be handled with heat-resistant gloves. The hot carrier should be placed on several clean room wipes.
20. Open the gate valve between the main chamber and load lock. Extract the substrate holder using steps 13-18 in reverse order. You will open the gate valve, move in the transfer arm, lower the carrier to the arm, release the carrier, move the carrier into the load lock, then close the gate valve.

VII. SHUTDOWN

21. Close the MC-LL gate valve and vent the load lock to atmospheric pressure (7.6E2 torr on the manometer).
22. Open the lid of the load lock and remove the substrate holder. Unmount the substrate and keep the sample in a sealed container.
23. Remove the wafer clips of the substrate carrier by unscrewing the 2 sets of 4-40 nuts and bolts. Take care not to lose any hardware. Leave these items in the metal dish on the workspace.
24. Take the substrate carrier over to the fume hood. Use a scuff pad and IPA to clean the surface. Users are expected to spend five minutes cleaning the surface at medium pressure. There must be a visually even surface.
25. After five minutes of scrubbing, you must clean all residue with IPA and several clean room wipes. Discard the wipes, scuff pad, and soiled gloves in the waste container.
26. Screw the wafer clips back into their original position on the substrate carrier, using the 4-40 nuts and bolts. Return the clean carrier to the load lock.
27. Replace the lid of the Load Lock and leave it pumped down using the switch on the control panel.
28. Close the valve of the Argon gas bottle. Keep the Nitrogen regulator open. Keep both turbo pumps and the system power “ON”. Turn off the system computer monitor and clean up the workspace for the next user.

VIII. VERSIONS

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Version Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>000A</td>
<td>09/20/22</td>
<td>vc</td>
</tr>
<tr>
<td>001A</td>
<td>5/3/24</td>
<td>vc</td>
</tr>
<tr>
<td>010A</td>
<td>6/27/24</td>
<td>vc</td>
</tr>
</tbody>
</table>