

Tri-layer Sputtering System Standard Operating Procedure

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1 Before the training

Users need to read and follow the DVH group Lab Safety Plan before start any training.

Only the master users of the system are allowed to change or do maintenance on the system. Master users must have enough knowledge on vacuum system, compressed gas cylinder operation, cryogenics. DRS Compressed Gases and Cryogenics online training and hand on training by experienced people will meet this requirement.

Think first before you do anything, and follow the SOP. Respect safety rules and procedures!

2 Risk Assessment and Precautions

Potential hazard	Precaution
Dangerous electric voltage	Don't touch anything inside and on back of the cabinet.
Worn out electric cables	Inform the master user to repair, don't touch!
General risk using vacuum system and compressed gas cylinder	Take the DRS standard online training.
Equipment failure	Do Not turn on Gun power source if chamber is not at vacuum. Do Not Use sputtering gun without Cooling water. Do Not leave while you are using the equipment. Let the master user know if noticed a problem, say water leak etc.
Short lifespan of the equipment	Turn off Ion Gauge before operating a manual valve on the chamber to avoid pressure spike on IG. Avoid using vacuum grease inside the chamber. Turn off the mechanic pump after using the system.

Table 1: Risk and Precautions

Procedure

Mounting Sample

1. Rinse substrate with acetone, followed by IPA; dry with Nitrogen gun.
2. Use Kapton tape or silver paste to hold sample on the sample chuck
3. Be sure sample sticks to the chuck.

Loading Sample

1. Make sure the system is in standby mode and the chamber pressure should be in the range of 1×10^{-7} Torr.
2. Sign into logbook and record chamber pressure from Ion Gauge (IG).
3. Turn on roughing pump.
4. Open Load Lock Roughing Valve (Fig. 1) to clean/pump the load lock.
5. Close Load Lock Roughing Valve and begin venting chamber with N₂ gas.
 - Don't clamp the load lock cap.
 - Use the Load Lock Vent Valve (Fig. 1), only open gently and barely.
 - Be sure to hold the Exchange Rod while venting the chamber, this will prevent pop up of the load lock cap.
 - Do Not overpressure!
6. Remove rod and turn off N₂ gas.
7. Screw on the chuck to the rod and place into the Load Lock.
8. Pump the load lock.
 - Open Load Lock Roughing Valve and check the load lock pressure.
 - Close the Load Lock Roughing Valve when pressure reaches $\approx 1 \times 10^{-2}$ Torr.
 - If pressure goes down slow, try purge N₂ gas then pump cycles.
 - Clamp or hold down the cover for the rod to avoid leaks.
9. Turn off IG and Close Main Gate Valve (Fig. 2).

10. Open Ion-mill Ar Line.
11. Close Ion-mill Ar Line when above 0.100-0.150 Torr.
12. Pull up on exchange rod and open Load Lock Chamber Valve (Fig. 1).
13. Lower rod into the vacuum chamber until chuck reaches the chuck holder.
 - Chuck holder should initially be located underneath the load lock
 - If this is not the case, rotate chuck holder (clockwise only) into position.
14. Once the chuck is in the holder, unscrew exchange rod and lift out of the chamber. If needed, clamp or hold down the cover for the rod to avoid leaks.
15. Close the Load Lock Chamber Valve (Fig. 1). You can pump the load lock, but make sure the Load Lock Roughing Valve is closed after.
16. Verify Load Lock Roughing Valve is closed; Open Chamber Roughing Valve and pump to 0.100 Torr, then close. **Important:** Do not pump below 0.100 Torr; avoids out-gassing from roughing pump.
17. Make sure the Main Chamber Roughing Valve is closed; Open Main Gate Valve; main chamber should pump down to $\approx 7 \times 10^{-7}$ Torr quickly.

Ion Milling

1. Refer to **Mounting Sample** and **Loading Sample** to place sample into Trilayer system.
2. Make sure the sample is on top of the Ion Mill Gun.
3. Turn off IG, Open Ion Mill Ar Line; Turn on IG pressure should read $\approx 1.8 \times 10^{-4}$ Torr.
 - If pressure is different, change the needle valve nearby the Ion Mill Ar Line to adjust
 - The needle valve should only be turned gently and barely, it is very sensitive
4. Turn on Ion Mill Power, followed by Source, then Beam Power.
5. Open shutter for desired milling time. To clean sample surface, 2-5 seconds should suffice.

6. Close shutter, turn off Beam, Source and Ion Mill Power.
7. Turn off IG, Close Ion Mill Ar Line.

Metal Deposition

1. Rotate (clockwise only) chuck holder to desired gun location.
2. Turn off IG; Open Sputtering Ar Line; check that ≈ 2 mTorr is reached.
3. Close Main Gate Valve (Fig. 2) until desired deposition pressure is reached. Check table below for pressure value.
4. Reset water timer. **Important:**
 - Make sure the water meter on the wall moves when you turn on the timer.
 - Make sure the time is longer than your operation.
 - If possible, verify the water flow stops after timer stops.
5. Switch on power supply for sputtering guns.
6. Press appropriate material's button, make sure the power knob is zeroed. Then turn on High Voltage.
7. Begin ramping up voltage until a plasma is lit, stop when desired current is reached. The voltage and current value should not differ too much from the table below. Ramp down if needle on gauge reaches red.
8. Leave pre-sputtering for 1 minute.
9. Open shutter (counter-clockwise when look down); leave open for desired deposition time.
10. Close shutter, ramp down voltage to zero slowly, turn off high voltage, turn off main power, and reset water timer for 10min to cool down the gun.
11. Open Main Gate Valve completely and close Sputtering Ar Line.

Removing Sample

1. Rotate chuck back below the load lock.

2. Turn off IG; Close Main Gate Valve (Fig. 2).
3. Open Ion Mill Ar Line.
4. Close Ion Mill Ar Line above 0.100-0.150 Torr.
5. Pump the load lock then close the Load Lock roughing valve, see Sample Loading section for details.
6. Lift the transfer rod, Open Load Lock Chamber Valve (Fig. 1). If pressure < 0.120 Torr, close Load Lock Chamber Valve. Refill chamber.
7. Extract sample chuck with Exchange Rod.
8. Close Load Lock Chamber Valve, remove clamp on the load lock cap if any, vent and remove chuck and sample.
9. Place Exchange Rod back in load lock chamber. Pump the load lock then close the Load Lock roughing valve, see Sample Loading section for details.
10. Open Main Chamber Roughing Valve (Fig. 2) and pump to 0.100 Torr. **Important:** Do not pump below 0.100 Torr; avoids outgassing from roughing pump.
11. Make sure Main Chamber Roughing Valve is close; Open Main Gate Valve completely and turn on IG.
12. Turn off roughing pump, turn off flash light.
13. Sign out in log book.

Figures

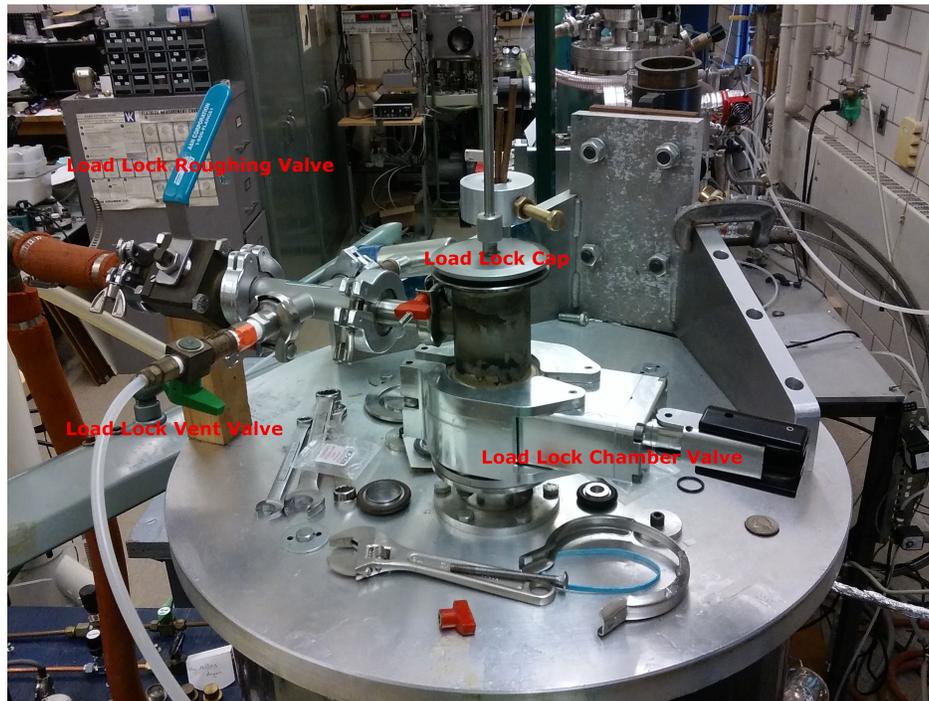


Figure 1: Top of sputtering chamber



Figure 2: Front of Trilayer system

Material	Pressure (mTorr)	Voltage (V)	Current (A)	Deposition Rate
Nb	6.0	250	0.5	1.0 nm/s
Al	6.0	300	0.2	25 nm/min
Au	3.5	450	0.3	3 nm/s
Al ₂ O ₃	???	???	???	???
SiO ₂	???	???	???	???

Table 2: Deposition Parameters

3 Maintenance and Troubleshooting

This section is written for experienced master user. Only brief instructions are given, not a list of detailed steps. Don't follow if not sure what you are doing.

3.1 Full shutdown the system

- Turn off IG, make sure gas valves closed, gun power sources off. Close Main gate valve.
- Turn off compressor on its back, it is nearby the fume hood. Turn off power switches on the front panel and devices rack.
- Close the DI water manual valve nearby the entrance of room 316
- If need to unplug power cord from the wall, remember some of them has a lock, you need to Rotate THEN Pull. Don't force to unplug! These power cord are mostly plugged on the windows' side in 316, while the mechanic pump plug is nearby the RIE system.

3.2 Add helium gas into the compressor

Make sure you receive proper training to handle compressed gas cylinder and follow all safety rules. DRS online training and hand on training by experienced user are needed. Then follow

the procedure in the manual of the compressor. The gas filling port is under the power box on the compressor. Don't forget to flush the line, don't apply suddenly a high pressure, start from zero pressure. Otherwise, the compressor will be damaged.

3.3 Change target and clean chamber window

Make sure IG is off and gate valve is closed before vent the chamber. Don't over pressure, keep the load lock cap path to the main chamber clear and unclamp the load lock cap, such that the load lock cap is like a relief valve. Remove tubings on the main chamber cap before lift it up.

After main chamber cap is lifted open, unscrew and remove the ring on the target. Remove the target. Clean the gun surface, put thermal grease, then new target. Put back the ring and screw on.

Before close the chamber, use water wipes to clean the jar wall inside if Bell Bright is used, then re-spray Bell Bright. Or put Kapton sheet on the glass jar. DON'T use vacuume grease on the inside of the chamber!

3.4 Re-generate cryopump

Properly shutdown the system including the compressor. Let the cryopump to warm up overnight. Then put nitrogen gas flow from the load lock to the cryopump AND remove the relief valve of the cryopump to let nitrogen gas exit. Don't over pressure, you can use the load lock cap as relief valve.

To turn back on the cryopump, make sure the chamber together with the cryopump is well pumped and the system pass pressure rising rate test. See Cryopump manual for details.

