Purpose
To describe the procedure used for sputtering various materials using the Airco Temescal Sputtering deposition system in the AMPEL cleanrooms.

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Introduction
The Sputter 2002 system is an automated vacuum process control system for Physical Vapor Deposition (PVD) of metals and non-metals, consisting of a control cabinet, chamber cart, Cryo pump compressor cart and mechanical vacuum pump.

The control cabinet houses a microprocessor, operation control panel, Ion gauge controller, Cryo pump temperature monitor, Convectron gauge controller, RF tuning/loading control, RF sputter power supply and various other minor control electronics.

The automation allows users to operate the RF Sputter 2002 with minimal training and is interlocked for system failsafe.

The chamber cart, situated next to the control cabinet, consists of a chamber backed by a CTI Cryo-Torr 8 pump and vacuum valve system.

The access panels on the front of the cart are interlocked to cut power to Sputter Gun if any are opened.

The RT Sputter power supply along with the Cryo pump compressor and mechanical pump are controlled by the micro processor in the control cabinet via remote contractor panel which are all located outside the cleanroom.

Operation
To begin, check to make sure,
- Cryo pump water supply valve is open (outside cleanroom)
- Nitrogen supply line is connected
- Compressed air line is connected
- Required gas supply bottle valves are open (outside cleanroom)
  - Current gases are: Argon, Nitrogen OR Oxygen

Turn “System” power switch “ON” & Ion Gauge Controller “ON”

A. INITIAL START-UP OPERATION:
This procedure is normally not necessary and should only be done by the Cleanroom Engineer, unless instructed otherwise.

1. Press “Main On” switch momentarily
2. Mechanical pump turns on and automatically performs the following steps
   a. Foreline Valve opens (after a 2 second delay)
   b. After 10 - 15 minutes the vacuum should drop below 100mT
   c. Mechanical pump & Foreline valve will close
   d. Cryogenic (Cryo.) Compressor turns on (after a 2 second delay)
   e. There is then a time delay of 2.5 hours before System Ready to use, that is, when Cryo. Pump is cold (Cryo. pump temperature gauge is below 25 Kelvin)

B. PUMP DOWN CHAMBER OPERATION

1. Set up substrate and target material and close bell jar
2. Press “Pump Down” switch which automatically starts the following sequence:
   a. Mech. pump starts up
   b. Rough valve opens (after 4 second delay)
   c. When vacuum drops below 50 microns, shown on the Chamber TC Meter, the Rough Valve & Mechanical Pump turn off
   d. Gate valve opens (Loud Noise!!)

Turn on Sputter gun water valve (behind front lower left door)

3. At this point, the ion gauge filament may be turned “ON” by pressing the green button on the Varian Gauge controller
4. It should take about half an hour for the pressure to reach <5x10^{-5} Torr (the deposition proceeds at a few mTorr pressure.

C. ARGON PURGE OPERATION (MAYBE OPERATED WITH THE HELP OF AN ADDITIONAL INDIVIDUAL) (Make sure the pressure within the chamber is at or below 6.0 x10^{-6}Torr)

1. NB: this step is optional and depends on the material sputtered and its desired purity; IT IS ESSENTIAL FOR GOOD QUALITY TITANIUM.
2. Turn on process gas (Argon) and adjust flow to 198-200sccm
3. Turn on Exhaust valve controller and close valve (close LED on)
4. Close the Argon valve on tank outside the room
5. Wait for the pressure to drop to 0mTorr (~ 50sccm argon flow at this point). This step takes about 10-15 min
6. Once the 50sccm argon flow has reached within the chamber open the valve on the tank and let the gas to flow for 1 min.
7. Repeat steps 3-5 3 more times (total 4 times argon flushing)
8. At the end of the last cycle leave the valve on the argon tank open
9. Adjust the gas flow to 155sccm
10. Let the argon flow at 155sccm for 10 min. for the chamber to adjust itself

D. RF SPUTTERING OPERATION:

Press “Sputter” switch to start operation

1. RF generator control panel will power up if water flow is present, Interlocks are closed & vacuum is below 100 mTorr.
2. The followings steps (3-5) are necessary if the argon purge (step C) operation is omitted:
3. Turn on process gas(es) and adjust flow to 100 sccm or higher
4. Turn on Exhaust valve controller and close valve (close LED on)
5. Wait for pressure to stabilize (you typically want between 10 – 20 mTorr)
6. Choose sputter source (NB: NEVER CHANGE THE SOURCE IF THE RF POWER IS ON)
7. Set RF power dial to Minimum & set multimeter dial to V3IG
8. Press “RF ON” button
9. Adjust Power supply control from minimum to near mid point slowly until “Incident Power” and “Reflected Power” meters begin to move.
10. Adjust “Loading” and “Tuning” dials to minimize reflected power and maximize incident power (typical values are 150 W forward and 0 W reflected).
11. Repeat steps 17-18 as needed until the desired plasma power has been reached.
12. Once proper tuning is achieved, the reflected power meter should read zero or very near zero.
13. IF YOU ARE UNABLE TO REACH THIS LEVEL, DO NOT PROCEED ANY FURTHER! CONSULT WITH CLEANROOM ENGINEER OR SUPERUSER.
14. Let plasma proceed under the above conditions for 2 min.
15. Adjust the argon gas flow to 198-200sccm (Pressure will adjust to ~ 12mTorr)
16. Position the sample above the target at this point and time for proper film thickness
17. Be present (i.e. Babysit) to monitor and adjust as need to minimize the reflected power while sputtering. For some materials, the process seems to remain quite stable while for others a significant drift has been observed; the user will need to know his/her process well to successfully sputter material.

18. **IF YOU NEED TO SWITCH FROM ONE SPUTTER GUN TO ANOTHER, BE SURE TO REDUCE GENERATOR POWER TO MINIMUM AND PRESS “RF OFF” BEFORE SWITCHING SOURCE SELECTOR!**

To Stop operation:
1. Reduce RF power to minimum then press “RF OFF” button
2. **Press “Main Off” button momentarily** (this will deactivate power to RF generator and mass flow controls for supply gas).
3. Wait at least 15 minutes before closing the cooling water to the sputter guns.

**E. VENT CHAMBER OPERATION:**

*Make sure that the sputter guns have cooled for at least 15 minutes after sputtering and close off the cooling water valve.*

1. Turn off RF generator and exhaust valve controller
2. Press “Vent” switch & hold for 3 seconds
   a. Gate valve shuts closed
   b. Vent valve opens after a 2 second delay
   c. Chamber is filled with house nitrogen
3. After chamber reaches atmospheric pressure
   a. Vent valve closes
   b. Vent switch light turns off
   c. Chamber can now be opened
4. To resume pump down, press “pump down” switch after closing chamber

**F. STAND-BY AND SHUT DOWN OPERATION:**

1. Turn off sputter gun water valve
2. Pump down: press “pump down” switch
3. Close gas supply bottle valves (outside cleanroom)

*The shut-down operation should only be performed by a cleanroom engineer as the system should normally be left at stand-by.*

Press “Main Off” switch and hold for 10 seconds for complete shut down.

**G. SAMPLE LOADING & SPUTTERING OPERATION**
Sample loading in this machine is tricky (sometimes frustrating) as the driving mechanism between the knob and the sample holders is not 1:1. Fortunately, the drive is 1:1 to switch between targets once the initial position has been properly established.

1. Choose the target, 1 or 2, that will be used for sputtering
2. Turn the knob on top of the bell jar to that number
   a. Make sure the main shutter allows you to see the chosen target
   b. If one of the 4 samples holders lines up with your target, buy lottery tickets as this is your lucky day.
   c. Otherwise, the more likely scenario is that none, or not the one you want to use, line up with the target.
   d. Choose a direction for the knob and turn one full turn,
   e. Check for line up
   f. Repeat d-e until your desired sample holder lines up with your target
3. Mount your sample on the sample holder with the provided vacuum compatible sticky tape. Mounting on the square tube reduces the separation between sample and target and improves your chances of success.
4. Close the bell jar
5. Move the main shutter to closed
6. Turn the sample knob one full turn in either direction, making sure to note which direction you actually turned: this moves the samples 180 degrees away from the target.
7. Pump down chamber (Section B above).
8. Pre-sputter following instructions in section C above.
   a. Pre-sputter should be done everytime to clean the target
   b. Good rule of thumb is 10-15 minutes of pre-sputter if the target was already installed and has been used recently
   c. Longer pre-sputter, up to 1 hour or more, is recommended for a freshly installed target, a new target or depending on how sensitive your process is to target contamination.
9. Bring the sample above the target by turning one full turn in the direction opposite to that of step 6.
10. Move the main shutter to the target position
11. You are now sputtering on your sample; make sure to start timing your deposition.
12. After sputtering for the desired amount of time, turn the main shutter to closed
13. Stop sputtering as per section C above.
14. Wait at least 15 minutes for the water to cool down the RF gun
15. Turn off the cooling water to the RF gun
16. Vent as per section D and remove sample
17. Leave the machine in Stand-by mode as per section E above.

H. TARGET PREPARATION

Targets should always be on a soft copper backing plate to ensure proper cooling of the target. Sputtering with a target that is not proper heat sinked will result in melting of the target material, in some instances ruining the target.

When ordering a new target: it is best to have it factory set with indium mounted backing.

Mounting of targets on a backing plate should only be performed by, or under the supervision of, the cleanroom engineer.

Mounting a target on a soft (i.e. Annealed) copper backing plate.
1. Make sure you are using an annealed copper backing plate, about 1 mm in thickness and 3 inches in diameter (note the use of Cromagnon unit system “inches”)
2. Use the silver epoxy normally stored in the cleanroom fridge (in east chase)
3. Mix a small amount of epoxy on a glass slide
4. Spread a very thin layer of epoxy on both the target backside and one side of the backing plate.
5. Install the target on the backing plate using a circular motion to avoid trapping air bubble (trapped air bubbles will result in poor thermal conductivity, hence local heating and possible destruction of the target or its mount)
6. Leave overnight in the epoxy curing jig (or under a heavy weight making sure the target does not slide off the backing plate).
I. TARGET CHANGING OPERATION

Target changing should only be done under the supervision of the cleanroom engineer or an experienced superuser. Many targets have been wrecked in 2004-2005 due to improper installation leading to melting of epoxy mounted samples and, in one case, melting of a Zinc target.

1. Remove the main shutter; use the 7/16 (or ½) inch socket to unscrew the central bolt. Note, using the closest metric socket MAY appear to work but will shear the bolt in the long run.
2. Use the red tee handle hexagonal key to unscrew the target cap. Again, note that the machine uses the Cromagnon era unit system “inches” based on the length of some appendage on a long dead king (probably an English king seeing that an inch is only about 2.54cm). Hence, make sure to use the proper set of hex keys otherwise you WILL damage the screws.
3. Remove the cap; notice that it probably has spacer rings.
4. Unscrew the target: notice that the top piece is the target holder and it probably has some spacer rings as well.
5. Choose the desired target; make sure it has a copper backing.
6. Choose the right amount of spacer rings: you want the maximum thickness of rings that will still allow you to tightly screw in the target.
7. Install the target, making sure it fits snugly in the holder piece.
8. Make sure the target is fairly tightly screwed on the gun to ensure proper thermal conductivity. This is done by tightening the screws in a “star” pattern. Failure to sufficiently tighten the target will result in target damage.
9. Install the cap
   a. Choose the spacer rings; you should use a spacing as small as possible while ensuring that the cap and target are not electrically connected.
   b. Install the cap
   c. Use the digital multimeter to ensure that the cap and target are not electrically connected
10. Install the main shutter making sure the holding bolt is snug but not too tight

TROUBLESHOOTING PROCEDURE:

If your are experiencing any difficulties with the vacuum process system, first check the following…

1. Water supply is on
2. Air line supply is on
3. Power to chamber cart
4. Power to control cabinet
5. Power to remote contactor panel
6. Vacuum to cryo pump is below 100 microns

If all the above conditions are met and there still is a problem, the best course of action is to report the problem to Nanofabrication Facility personnel.

MAINTENANCE PROCEDURE

Cryo pump and compressor per CTI- Cryogenics Cryo-Torr 8 service manual, section 7

Mechanical pump; oil level check periodically, monthly inspection of oil condition for coloration or smell. Change as required.

Micro processor: back-up battery ( Omron # 3G2A9-BAT08 ) replacement every five years per Omron CQM1 Operations Manual Cat.W226-E3-2 section 2-1-7

Yearly electrical system checks for loose wiring and overall performance of system.
Quarter yearly check-up and cleaning of RF Generator air screens and transmitter to remove dust build up per Plasma-Therm Inc HFS-500E Instruction manual.
DRAWINGS AND SCHEMATICS

1) S02-014E Electrical schematic
2) S02-014F Panel schematic
3) E00-051 Tc interlock sketch & schematic
1. PUMP T.C. PRESSURE READING FOR LESS THEN 1 mT.
   SET T.C. HEATER CURRENT WITH R21 FOR 0.000 V @ OUTPUT
   (100V @ T.C.)

2. GO BACK TO ATM. PRESSURE
   SET R26 INDICATOR SCALE FOR 2000 V
TABLES & LISTS

1. Omron Micro processor program instruction list
2. Omron I/O Assignment list
3. Bill of Material list
4. Service Record Sheet
### AMPEL Sputter Coater

<table>
<thead>
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STS Service Record Sheet  

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Used By  

Reason For Service: 

Work Done: 

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