

# Nanomaster NSC-3000 DC Magnetron Sputter Tool

## Standard Operating Procedure

Faculty Supervisor: Prof. Robert White, Mechanical Engineering (x72210)

Safety Office: Peter Nowak x73246 (Just dial this directly on any campus phone.)  
(617)627-3246 (From off-campus or from a cell phone)

Tufts Emergency Medical Services are at x66911.

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### Warnings:

The tool uses high power and low vacuum during deposition. Do not attempt to open the chamber until the deposition cycle is complete.

### Required Checkout:

You must be formally tested by the faculty supervisor before you may use this tool unsupervised. When you are first learning procedures, work with experienced lab users (students, post docs, faculty or staff) to become familiar with the tool before requesting a formal checkout procedure.

### **1.0 Material Requirements:**

- 1.1 Equipment: substrate, wafer tweezers, metal targets
- 1.2 Personal Protective Equipment: nitrile gloves, safety glasses
- 1.3 Chemicals: none

### **2.0 Procedure:**

#### Notes:

- *The NSC-3000 will be left on (under vacuum). When you arrive at the tool look for a note and check in the log book or chamber to determine if someone else is pumping down and preparing to sputter before you vent.*
- *If you arrive at the tool and it is off and at atmosphere please contact Professor White or Jim Vlahakis or the microfab techs*
- *If you need to log into the NSC software use the password drive*
- *If you are sputtering ITO or magnesium you must load a dummy target and completes a required clean up procedure after your deposition is complete. See pages 2 & 5*

#### **Vent the tool (if you arrive and there is no sample in the chamber):**

1. Open the N2 tank main valve. The regulator should already be set to 90 psi outlet pressure.
2. Check that there is sufficient N2 in the tank for your job. If N2 level is less than 300 psi contact lab staff to have the N2 bottle replaced.
3. On the "Vacuum" tab click "Vent Chamber". The turbo should immediately turn off (green light next to "turbo" goes off) and the turbo speed should slowly start to spin down. You will see the pressure start to increase. The system will automatically open the chamber vent valve.
4. When the pressure gets to around 10 Torr, the "roughing pump" light should turn off – the rough pump is now off.
5. Once the pressure reaches 700 Torr (overscale on the sensor), the "Open Ch. Vent Valve" button will no longer be grayed out. Click "open chamber vent valve".
6. The "open chamber vent valve" button will flash red, and the "venting chamber" light will flash yellow/green.
7. Wait for a few minutes for the "venting chamber" light to stop flashing and turn off.
8. Turn off the "open chamber vent valve" button.
9. **Turn off the main valve on the N2 cylinder.**
10. You can open the chamber.

### Load samples and targets:

1. Click on the "Vacuum" tab, and make sure that the tool is vented to atmosphere (current chamber state = idle, pumps off, pressure gauge off).
2. Lift the top of the chamber up and back, secure with the screw near the hinge so that the top cannot accidentally swing down.
3. Carefully remove the belljar. Place it on the belljar holder on the floor so that the bottom of the seal does not get dirty and it does not roll away and break.
4. Place samples on the platen, face up. Include some method of measuring film thickness – often we use a glass microscope slide with a thick line drawn on it with a Sharpie marker. The marker can be dissolved after deposition with acetone, leaving a step on the slide surface which can be measured with the DekTak.
5. Check the two targets at the top of the chamber. Make sure you have the targets in that you wish to use. If you are sputtering ITO or magnesium you must load the dummy target into the other gun, it will become contaminated during the run. Please don't contaminate another expensive target.
  - a. To remove a target, open the gun shutter (on the computer in the "engineering" tab).
  - b. Carefully pry the target out using the chisel or the red-handled screwdriver. It is held in magnetically. Be careful not to drop the target or damage it.
  - c. The type of material for each target is scratched into the EDGE of the target.
  - d. To put a new target in (after removing an old one). Check that there is a little bit of conductive paste on the back of the target. If not, put a very small amount of conductive paste on the flat circular ring on the gun using a fab wipe. Do not use too much paste! Just a little.
  - e. Once a little conductive paste is on the gun, gently put it into place in the socket... a magnet will pull it in; be careful not to let the target snap in violently and crack.
6. Turn on the thickness monitor. It will flash "P Fail" when you turn it on. Just press "stop" to make this go away.
7. If "O Fail" appears on the thickness monitor, the thickness monitor crystal needs to be replaced. (See below).
8. Check the crystal life on the thickness monitor by pushing "display" twice. The lefthand screen will show a number like "6 – 83" the second number is the remaining life in the crystal in %. In this example, 83% of life remains. If life is below 60% the crystal should be replaced. See instructions below for replacing the crystal.
9. Once the samples and targets are loaded, inspect the belljar rubber seals for particles and make sure they are clean. They can be cleaned carefully with IPA on a fab wipe. If needed, put a **small** amount of Dow Corning vacuum grease onto the seals using a fab wipe.
10. Carefully replace the belljar. Make sure the seals are centered and seat well.
11. Tape a piece of Mylar plastic over the clear part of the belljar. This approx. 8" by 6" piece of Mylar protects that region of the belljar from being coated with metal so that you can see into the chamber during deposition. It can be used for multiple depositions – but once it gets too hard to see through, replace it.
12. Close the top, and make sure the seal seats well.

**Replacing the crystal (if crystal life is below 30% or “O” fail on thickness monitor):**

1. The crystal is located in the back of the chamber behind the platen; it is a small circular sensor.
2. Pull the circular top off the crystal straight up, it will pull out.
3. Push the thin crystal disc out of the holder with your finger and throw it away.
4. Get a new crystal from the box, and put it carefully into the holder. The electrode pattern goes towards the back of the holder (the part that will connect to the electrical connectors in the sensor base).
5. When placing the crystal in the holder, try to avoid touching the front surface of the crystal.
6. Press the holder firmly back into the sensor base inside the chamber.

**Pump Down**

1. Once everything is loaded, click on the “pump down chamber” button on the “vacuum” tab.
2. Check that the turbo pump switch on the vacuum tab is switched to “enabled”.
3. The tool should begin to pump down – the roughing pump light will come on.
4. You should see the pressure begin to drop within 30 seconds. If this does not happen, click “Vent chamber” and check the seal around the belljar edges.
5. After approximately 1 minute the turbo should turn on and begin spinning up and the pressure should drop more rapidly.
6. Wait until the tool achieves a good base pressure before proceeding. A base pressure below  $5 \cdot 10^{-6}$  torr is preferred. (The longer you wait, the better the base pressure. The better the base pressure, the better your film quality. It may be necessary to pump down for more than an hour to achieve a good base pressure.)

*Note : If you plan to leave the lab for a few hours while the tool pumps down, that's fine. It might be a good idea to leave a note with your name and phone/email telling people that you are pumping down and when you expect to finish your deposition, in case someone comes while you are not there and vents the tool!*

**Set up Argon Pressure**

Once base pressure is achieved, it is time to check the Argon flow rate to achieve the desired process pressure.

1. ***Open the main valve on the N<sub>2</sub> tank***
2. ***Open the main valve on the Argon tank***
3. Check that the regulator output for N<sub>2</sub> reads 90 psi, and the Argon regulator output reads 15 psi.
4. Check that there is enough gas in the tanks to complete your deposition... if the pressure in either tank is below 200 psi, inform the lab manager.
5. On the “engineering” tab, click the button to “enable” gas flow. The valve leading from the Argon tank to the on/off valve is now open.
6. Adjust the flow setpoint in the gas flow box on the engineering tab to achieve the desired process pressure. 23 sccm seems to give approximately 5 mT, and is what is programmed in all of the saved recipes.
7. On the “engineering” tab, click the button to turn off “gas flow”. The valve leading from the Argon tank to the needle valve is now closed. The chamber pressure should go back down.

### Set up Recipe

1. On the “operator” tab, click “LOAD RECIPE” and select the desired recipe.
2. On the “process” tab, check all the recipe parameters. In particular:
  - a. Make sure that the deposition is thickness controlled, and set the desired thickness for your deposition (in Angstroms; recall 1 nm = 10 Å). Do not deposit material thicker than the maximum allowed deposition thickness listed in the table below.
  - b. **Make sure that the gun which you loaded the material into is turned on, and make sure that the other gun is off (unless you are doing co-sputtering).** Enable the proper gun then make sure that the power level is correct. Recommended default power level is 200 W. Each saved recipe for different materials may have different power levels based on our experience with film quality.
  - c. Make sure that the film type is correct. The film type controls which film the thickness monitor expects. The following properties are pre-loaded in the thickness monitor for each material (don’t change this... the table below is just here for your information).
  - d. In the process settings, the platen rotation should be on and the gas flow should be on.
  - e. Set the clean time (1 minute is recommended). For co-sputtering, set the clean time to zero.
  - f. Adjust the argon gas flow setpoint to what you determined in the previous step (if you want to use a pressure other than the default 5 mT which you get with 28 sccm Ar)

Film #	Material	Density (g/cm <sup>3</sup> )	Acoustic Impedance (10 <sup>5</sup> g/(cm <sup>2</sup> s))	Maximum Allowed Deposition Thickness (nm)	Tooling Factor
1	Al	2.7	8.17	500	369.5
2	Ti	4.5	14.06	200	480.3
3	Cr	7.2	28.95	200	388.5
4	Au	19.3	23.18	500	214.8
5	Ni	8.91	26.68	1000	309.5
6	NiTi	6	19	1000	-
7	Ag	10.5	16.69	1000	172.9
8	Cu	8.93	20.21	1000	299.5
9	ITO				
18	Ge				

### Run Deposition

1. Turn on the power to the appropriate gun power supplies.
2. Make sure the thickness monitor is turned on.
3. On the “operator” tab, push “start”. The process will start.
4. Pay attention during deposition to make sure everything is working correctly.
  - a. If the shutter is partially covering the gun during deposition, “End Sequence” and then try again.
  - b. After the pressure has stabilized and platen is rotating, the power should come on and you will see an Argon plasma near the target. If the plasma is not stable (flickering on and off), then push “End Sequence” to stop the deposition and try again. If the plasma is still not stable, you may need to start the plasma with the shutter open using manual control for each step in the “engineering” tab.
  - c. During deposition, watch the chamber pressure. If chamber pressure starts to deviate from your desired deposition pressure, you may need to adjust the Argon flow using the Ar MFC flow setpoint.
  - d. Monitor the deposition rate during deposition on the thickness monitor record this in the log book.
2. When the deposition is complete (as determined by the thickness monitor for your desired film thickness), the tool will automatically turn off DC power and close the Enable Gas Flow valve. If the thickness monitor and control software are not communicating properly, you will have to press “End Sequence” once you achieve target thickness.
3. If you want to stop the deposition early, click the “end sequence” button on the “operator” tab.

4. Once your deposition is complete, you can go up to the “Setup Recipe” step above and run a second deposition without venting to atmosphere. This may be useful if you are deposition two films (such as an adhesion layer and a metal layer... like Cr/Au or Ti/Au or something).

#### **Vent and Remove Samples**

1. Once all depositions are complete, turn off the gun power supplies.
2. Turn off the thickness monitor.
3. On the “Vacuum” tab click “Vent Chamber”. The turbo should immediately turn off (green light next to “turbo” goes off) and the turbe speed should slowly start to spin down. You will see the pressure start to increase. The system will automatically open the chamber vent valve.
4. When the pressure gets to around 10 Torr, the “roughing pump” light should turn off – the rough pump is now off.
5. Once the pressure reaches 700 Torr (overscale on the sensor), the “Open Ch. Vent Valve” button will no longer be grayed out. Click “open chamber vent valve”.
6. The “open chamber vent valve” button will flash red, and the “venting chamber” light will flash yellow/green.
7. Wait for a few minutes for the “venting chamber” light to stop flashing and turn off.
8. Turn off the “open chamber vent valve” button.
9. **Turn off the main valve on the N2 cylinder.**
10. You can open the chamber.

#### **ITO – Magnesium Clean Up**

1. Once the deposition is complete, remove ITO or magnesium target and load Al target, confirm dummy target is loaded in other gun
2. Remove the vacuum foil from the chamber. Wipe down all surfaces with isopropanol on a cleanroom wipe to remove as much residue as you can, do not use too much pressure on the guns or the vacuum seals will be damaged. Place clean foil around the chamber wall, use the High Vacuum foil found under the nearby table.
3. Run a 300 nm aluminum deposition on the empty chamber to encapsulate the remaining ITO.
4. Do not vent chamber after deposition is complete, turn off gun power and thickness monitor, close Ar and N2 cylinders.

#### **Shutdown**

1. *Close the argon and nitrogen cylinder valves at the cylinders (do not adjust the regulators).*
2. Run the “pump down” procedure above and leave the tool under vacuum.
3. Leave the chiller on.

#### **Emergency Shutdown**

If you need to shut down in the middle of a run for any reason, the “end sequence” button on the “operator tab” should be used. Then follow the shut down procedure above.

If something dangerous appears to be happening, you can turn off the gun power supplies, or, if something is really bad, hit the big red emergency off button to shut down all power to the tool. Note that if you shut down all power to the tool the pumps will turn off, which will put significant wear on the turbopump.

If at any time you feel unsure about how to use the tool, please stop work and contact a qualified user or faculty advisor. Please don't forge ahead when you are unsure, you may end up damaging the tool.

**Report all accidents or tool issues to Prof. White at x72210, [r.white@tufts.edu](mailto:r.white@tufts.edu) or to Jim Vlahakis at [james.vlahakis@tufts.edu](mailto:james.vlahakis@tufts.edu).**