

Kurt Lesker CMS-18 Multi Target Sputter Deposition SOP

NOTE: Latest revisions are in Blue.

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1.0 Safety

- 1.1 **High Voltage** - High Voltage Radio Frequency and High Voltage DC is used throughout the system. System maintenance may only be performed NRF Staff. Do not remove any tool covers or defeat any interlock on this system.
- 1.2 **Moving Components** - The User should be aware *at all times* of the moving components associated with this tool. For instance, the turret unit does rotate and does present a potential hazard. The User must exert caution *at all times* such that a limb, finger, or article of clothing does not become trapped or entangled (or worse, violently detached) when components of the machine are in motion.
- 1.3 **Heat** – The sample platen is heated and should never be touched.

2.0 Quality Control and Calibrations

2.1 Sputter Rates

- 2.1.1. The Sputter rates contained in the spreadsheet located on the sputter tool computer were accurate at the time of calibration and should only be used as an estimate. Rate calibrations are not performed on a periodic schedule. Due to the complexity of the sputter process, these rates may change slightly over time. If you need a very specific film thickness you must run a test deposition on a specific gun.

2.1.2. Test Sample Procedure to Measure Thickness:

- 2.1.2.1. Load clean polished silicon or a clean glass slide for the test. Run recipe long enough to obtain a film thickness of at least 1000 angstroms (thicker is better). Do not cover your sample with a shadow mask or tape. Dip a swab into a bottle of AZ1512 and touch a small area of photoresist onto the test sample. You don't want the PR to be too thick or it will be hard to bake. Bake the sample for 3 mins. at 112C for wet etch and 10 mins for plasma etch. Small bottles of photoresist are located on the bottom shelf of the Litho Bay chrome rack. Etch the film using the appropriate wet chemistry or plasma etch. Remove the photoresist using acetone after etch and measure the film etch step using the Stylus Profiler. Once you have the calibrated rate, email the results to NRF Staff. You may request that your target be loaded into the same sputter gun in the future for consistency.

Available Sputter Materials – Partial List. Contact Staff before purchasing new materials. We may already have it....

Ag	Ni	InO/ZnO	W2B
Al / 2% Si	Pd	ITO	Y2O3
	Pt	Ru	
Au	Ti	Si undoped	ZnO
Bi2O3	W	SiO2	ZnO / 2%Al2O3
Cr	Al	Ta	Zr
Cu	Hf	TaN	ZrB2
Ge	HfO	TiB2	ZrN
Ir	In2O3	TiN	
Mo	InGaZnO	TiO2	

2.2 Film Quality

2.2.1. For ultra-sensitive oxide targets such as Indium Zinc Oxide, InGaZnO, the main chamber base pressure must be $<5.0e^{-7}$ Torr. This is also true for reactive oxide recipes. The best way to achieve this is to request that the target be loaded at the end of the day and reserve the tool for the next morning. This can be done via email to Staff in most cases.

2.3 Heater Box Temperature

2.3.1. The temperature of the heater box is controlled by 2 thermocouple sensors located several inches from the sample holder. **There is a substantial temperature offset between the system readout and actual sample temperature.** Please check the calibration curves posted and consult with the process engineers for elevated temperature processes.

3.0 Pre-Operation

- 3.1 Please read and observe reservation requirements on the RSC Kurt Lesker Sputter equipment page.
- 3.2 When NRF Staff changes the sputter targets, a note regarding loaded targets will appear in the logoff notes. To see the note, go to the sputter

equipment page and click on "Status Log". The sputter materials loaded will be listed in order guns 1-4. The time stamp of the note will also give you an idea of when the chamber pump down started.

- 3.3 Before logging onto the tool, check that the ion gauge is not on. It's a quartz tube located at the rear of the sputter chamber. It's very bright when it is on and indicates the chamber is still pumping down to the base pressure of $2e-6$ Torr. Wait until the filament is off before logging onto the Tumi.
- 3.4 Log onto the tool via the Tumi.
- 3.5 Log onto the tool using your name and password.
- 3.6 On the machine, use the Deposition screen (click the Deposition tab along the top of the screen) to verify that the targets you need are listed and match the Staff logoff notes. If not, log off the TUMI with a comment/email to Staff stating the problem and Call NRF Staff.

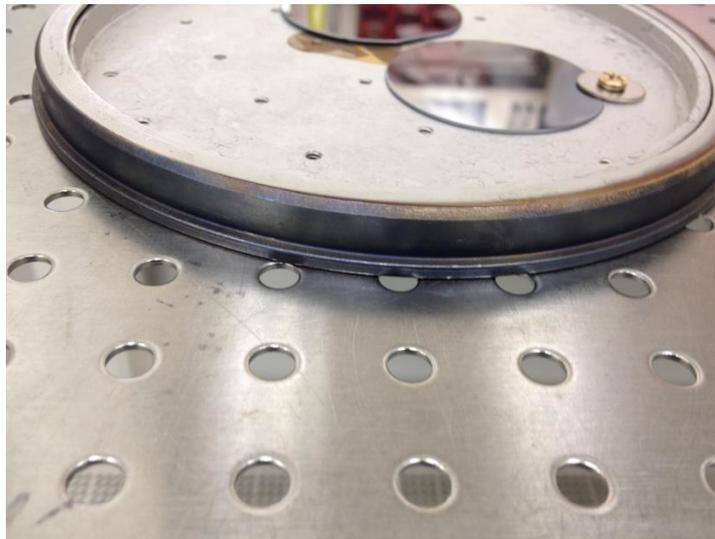
4.0 Sample Load

- 4.1 Log into the tool using your login name and password.
- 4.2 Verify that the target you need is loaded into the machine. Click the "Deposition" tab at the top of the screen. The target name is shown for each source. If your target is not loaded, contact Staff and log off the tool.
- 4.3 The base pressure is checked to be $<2e-6$ Torr during each pumpdown from atmosphere.
- 4.4 If you would like to check the actual Process Chamber base pressure before you start. Click on the Vacuum Screen Tab. Run the "PC Pump" recipe on the right side of screen. The pump down routine will run and at the end turn on the ion gauge. The pressure will be displayed under "IG Pressure" shown below. The gauge will turn off if the pressure is better than $2E-6$i.e. should only be on for a short period if everything is good.
- 4.5 Click "LL Vent" on the right side of the screen.
- 4.6 The Recipe Monitor window will open and the "LL Vent" recipe will execute. When done, you will see the message in green below. You may now open the load lock door.

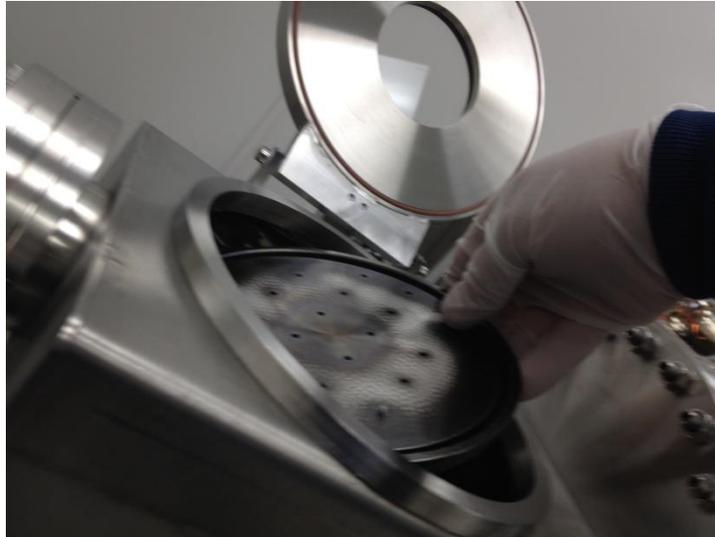


4.7 Secure your sample to the 6 inch sample holder. Use the screws and clips provided. **Caution: The sample may not extend past the height of the lip of the holder or 6mm total (this includes the sample and clip height).** **Note: The ONLY tape that may be used in this system is 3M High-temp Polyimide Kapton Tape. If you absolutely have to use glue, the only types that are allowed are Varian Torr Seal or Kurt J. Lesker KL-325K.**

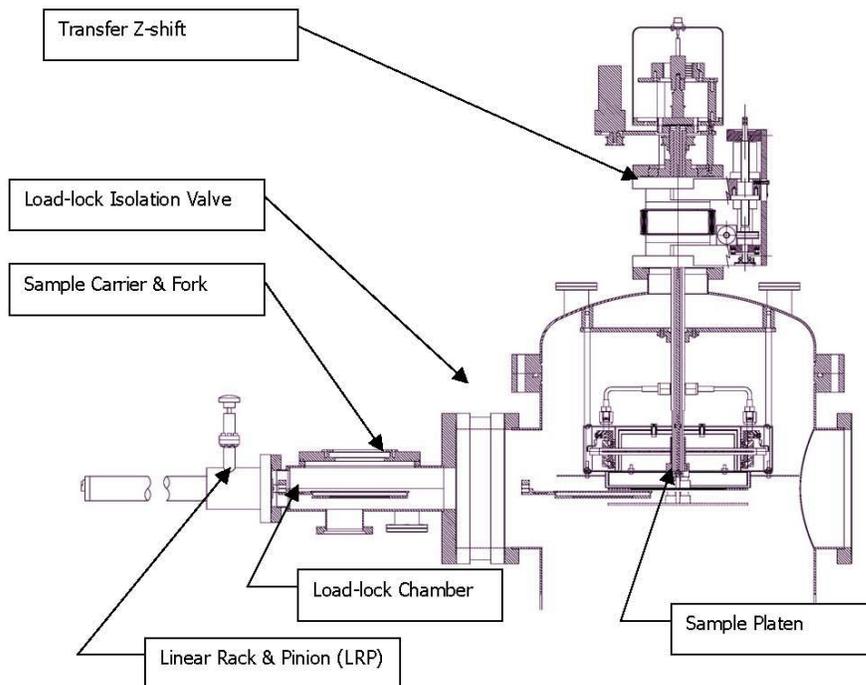
4.8 Place the support ring around the sample holder as shown below.



4.9 Using your right hand, load the sample holder “face” or “sample” down onto the load fork (see pic below) and shut the load lock door.



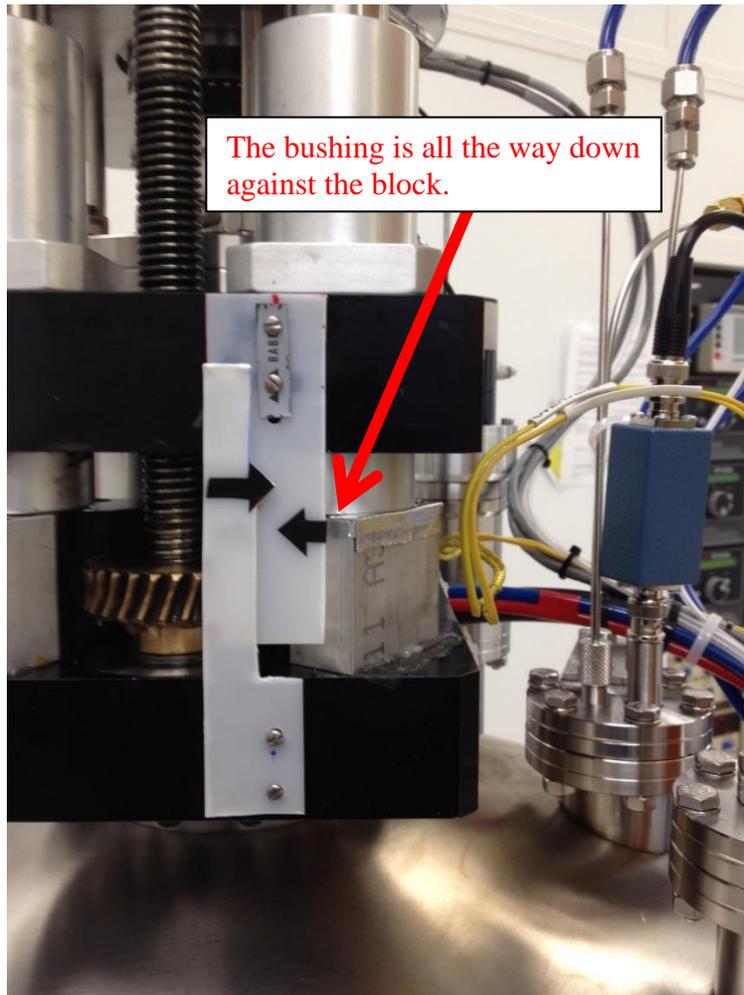
- 4.10 Click “LL Pump” on the right side of the screen. The LL Pump recipe will execute and display “LL Pump Recipe Complete” in green in the Recipe Monitor window when the tool is ready for the next step.
- 4.11 Refer to the following drawing for terminology during this procedure.



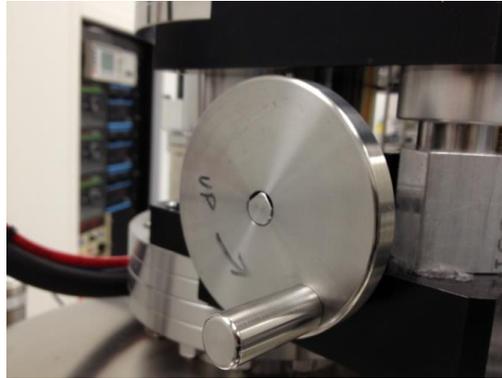
- 4.12 Click “Transfer to Chamber” on the right side of the screen. The recipe will pause with message “User Set Z Axis to Full down Position”



4.13 When “Pause – User Confirm Z-Shift Position” appears in the “Step” field, verify that the platen is all the way down. See red arrow in pic below. Normally it is already in this position from the last user.



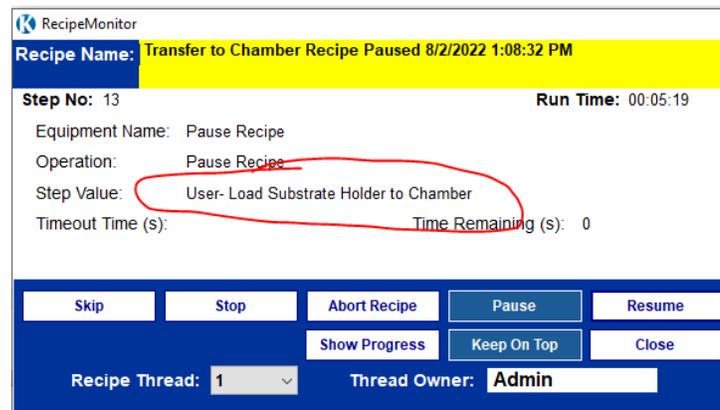
- 4.14 If not all the way down, rotate the Transfer Z shift manual knob (see pic below) clockwise until the sample platen is lowered completely. Stop when you feel resistance, i.e. do not force it!



- 4.15 Click the “Resume”, see below.

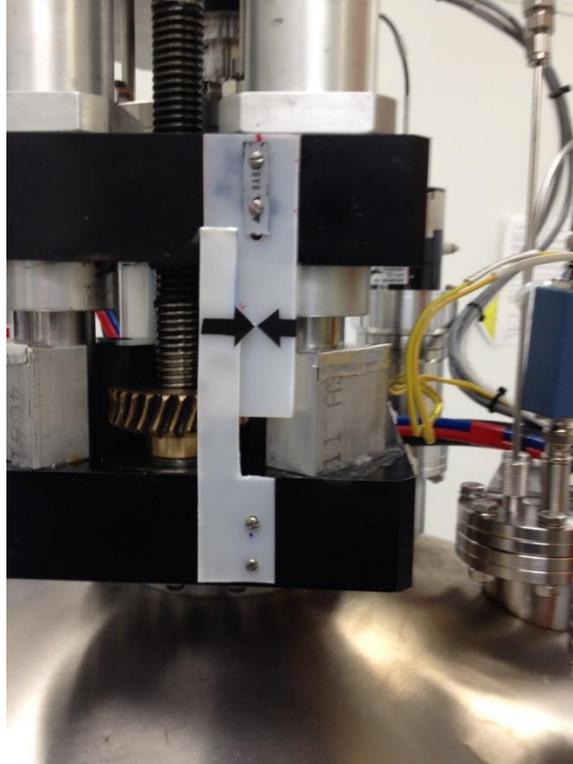


- 4.16 The load lock/dep chamber isolation valve will then open. The recipe will pause with the following message.



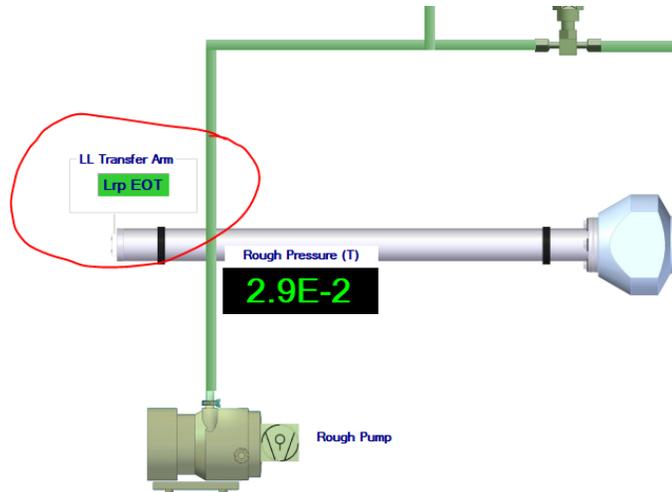
- 4.17 Rotate the LOAD ARM Load Arm knob until the sample is inserted completely into the process chamber and bumps into the sample holder. It will meet a mechanical stop.

- 4.18 Raise the sample platen slowly by turning the Transfer Z-Shift knob until the 2 black arrows on the plastic indicator are aligned. See pic below.



DO NOT RAISE THE PLATEN UP HIGHER THAN THIS WITH THE LOAD ARM INSIDE THE CHAMBER.

- 4.19 Return the LOAD ARM to home position. If you hear any badness (like the sample holder falling off the load arm) call NRF Staff. Using the flashlight mounted on the control rack, verify that your sample is centered on the platen holder ring. If it is not, stop and contact NRF Staff. If OK, click the “Resume” button again.
- 4.20 Verify the load arm is all the way back home. “Lrp EOT” should be green.



- 4.21 Raise the sample platen completely to the top (deposition position) by turning the Transfer Z-Shift knob anti-clockwise. See below. Stop when you feel resistance, i.e. do not force it!



- 4.22 Click "Resume" when done.

5.0 Sample Pre-Treatments

5.1 Sample Clean with Argon or O2

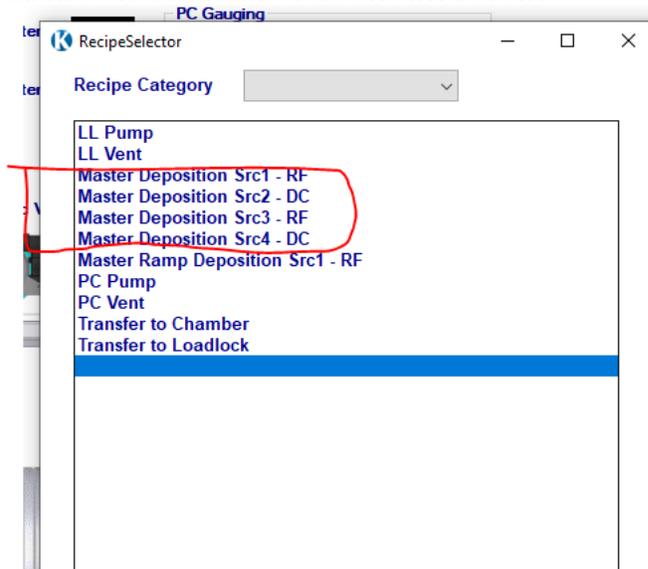
- 5.1.1. If you wish, you can remove a surface layer of your sample before deposition.
- 5.1.2. The amount of material removed will depend on the material type and you must use at your own risk.
- 5.1.3. A 30 second treatment should be plenty to clean the surface.
- 5.1.4. Before deposition run the recipe called "Argon_Clean".

5.2 Sample Clean with Oxygen Plasma

- 5.2.1. If you wish, you can clean the surface layer of your sample before deposition.
- 5.2.2. A 30 second O2 plasma should be plenty to clean the surface.
- 5.2.3. Before deposition run the recipe called "O2_Clean".
- 5.2.4. **Note:** This recipe will turn on the ion gauge at the end and wait for the base pressure to return to $<2e-6$. Be patient, it may take 10-15 minutes.

6.0 Sputter Types and Materials

- 6.1 There are 3 different sputter recipe types based on the type of material being sputtered:
 - A. **Standard Recipes** – standard argon sputter at 5mTorr partial pressure. The 4 standard recipes for all metals are named as shown below.



Material	Gun	Recipe Name	Dep Rate A/second	POWER	Input Needed thickness (A)	TIME/SEC	O2 Ratio	Process Pressure
Ag	2	Master Deposition Src 2 - RF	9.30	250	20.00	2		
Ag	4	Master Deposition Src 4 - DC	9.30	250	200.00	22		
Ag	2	Master Deposition Src 2 - DC	6.70	150	2000.00	239		
Ag	4	Master Deposition Src 4 - DC	6.70	150	500.00	75		
Ag	1	Master Deposition Src 1 - RF	4.60	200	500.00	109		
Ag	3	Master Deposition Src 3 - RF	4.60	200	500.00	109		
Al	2	Master Deposition Src 2 - DC	1.34	200	500.00	373		
Al	4	Master Deposition Src 4 - DC	1.34	200	1000.00	746		
Al	1	Master Deposition Src 1 - RF	1.05	250	1000.00	952		
Al	3	Master Deposition Src 3 - RF	1.05	250	1000.00	952		
Al	1	Master Deposition Src 1 - RF	1.57	400	3000.00	1511		
Al	3	Master Deposition Src 3 - RF	1.57	400	1000.00	837		
Au	2	Master Deposition Src 2 - DC	4.38	150	500.00	114		

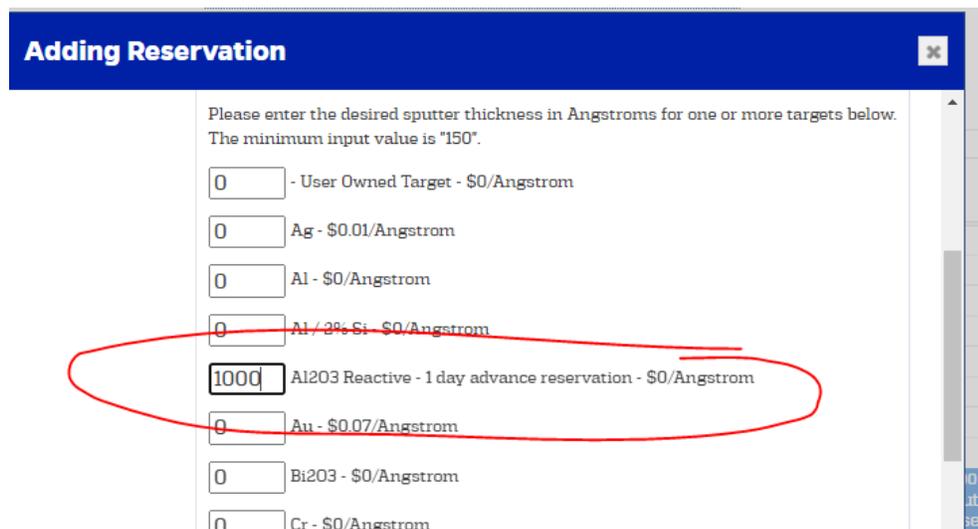
B. Insulating Target Materials Recipes – argon sputter (sometimes includes other gases) of insulating materials. Usually done in RF guns 1 or 3. Insulating materials have poor thermal conductivity and crack easily. Because of this, magnetron power must be increased and decreased slowly to prevent target damage. These recipes typically take approximately 4 minutes to ramp power both up and down. Please allow an additional 15 mins for your sputter reservation. These targets require special care. The power and deposition times (the green colored columns below) will be entered using the “KL_Sputter” Excel worksheet, shown below. Take great care to enter the correct power from the spreadsheet or the target may be destroyed. Insulators shown below.

Material	Gun	Recipe Name	Dep Rate A/second	POWER	Input Needed thickness (A)	TIME/SEC	O2 Ratio	Process Pressure
Insulators Consult with NRF Staff before you run the following targets for the 1st time. Running the wrong recipe will break the Target								
Ge	1	Ramp Master Deposition Src 1 - RF	1.10	125	280.00	236		
Ge	3	Ramp Master Deposition Src 3 - RF	1.10	125	280.00	236		
HfO	1	Ramp Master Deposition Src 1 - RF	0.31	150	100.00	321		
HfO	3	Ramp Master Deposition Src 3 - RF	0.31	150	70.00			
ZrO	1	Ramp Master Deposition Src 1 - RF	0.14	150	1124.00	8285		
ZrO	3	Ramp Master Deposition Src 3 - RF	0.14	150	1800.00	11429		
In2O3	1	G1_125_5_ramp_O2_mfc4	0.55	125	4000	7273		
In2O3	3	G3_125_5_ramp_O2_mfc4	0.55	125	2000			
ITO	1	Ramp Master Deposition Src 1 - RF	0.87	125	100.00	115		
ITO	3	Ramp Master Deposition Src 3 - RF	0.87	125	400.00	480		
ITO	3	G3_ITO	?					
ITO	3	Ramp Master Deposition Src 3 - RF (Krishna 60w platen down)	0.30	80	1000.00			
IZO	1	Ramp Master Deposition Src 1 - RF	0.650	125	100.00	152		
IZO	3	Ramp Master Deposition Src 3 - RF	0.650	125	100.00	152		
InGaZnO	1	Ramp Master Deposition Src 1 - RF	0.525	125	1000.00	1905		
InGaZnO	3	Ramp Master Deposition Src 3 - RF	0.525	125	2000.00			
Si	1	Ramp Master Deposition Src 1 - RF (need ramp time update)	0.36	150	500.00	1389		
Si	3	Ramp Master Deposition Src 3 - RF (need ramp time update)	0.36	150	1000.00	2778		
Doped Si - 2_wafers target	3	Ramp Master Deposition Src 3 - RF	0.15	100	100.00	867		
SiO2	1	Ramp Master Deposition Src 1 - RF	0.21	350	450.00			
SiO2	3	Ramp Master Deposition Src 3 - RF	0.21	350	300	1429		
TaN	1	Ramp Master Deposition Src 1 - RF	0.6	150	200	333		
TaN	3	Ramp Master Deposition Src 3 - RF	0.6	150	500	833		
TiN	1	Ramp Master Deposition Src 1 - RF	0.275	150	500			
TiN	3	Ramp Master Deposition Src 3 - RF	0.275	150	2000	7273		
TiO2	1	Ramp Master Deposition Src 1 - RF	0.138	150	1000.00	7246		
TiO2	3	Ramp Master Deposition Src 3 - RF	0.138	150	1000.00	7246		
Y2O3 (platen full down)	3	Ramp Master Deposition Src 3 - RF	0.200	180	200			
ZnO	1	Ramp Master Deposition Src 1 - RF	0.458	125	5000.00	10917		
ZnO	3	Ramp Master Deposition Src 3 - RF	0.458	125	500.00	1092		
ZnO	1	G1_125_5_ramp_O2_mfc4	0.450	125	1000.00	2222		
ZnO	3	G3_125_5_ramp_O2_mfc4	0.450	125	2000.00	4444		
ZnO/2%Al2O3	1	Ramp Master Deposition Src 1 - RF	0.356	125	100.00	281		
ZnO/2%Al2O3	3	Ramp Master Deposition Src 3 - RF	0.356	125	15.00	42		
ZrN	1	Ramp Master Deposition Src 1 - RF		150		#VALUE!		
ZrN	3	Ramp Master Deposition Src 3 - RF		150		#VALUE!		
TaC	1	Ramp Master Deposition Src 1 - RF		150		#DIV/0!		
TaC	3	Ramp Master Deposition Src 3 - RF		150		#DIV/0!		
BST	3	G3_BST	0.7			0		
		Ramp Master Deposition Src 1 - Src 3 RF with MFC4						

- C. **Reactive Recipes** – reactive gases are added to the chamber to reactively create films. Example: O₂ is added to chamber while sputtering Chromium to create Chromium Oxide. .
- D. Reactive sputter reservations require 2 steps:

Step 1 – Contact Bill Lewis or David Hays (cell phone or text) and arrange for the target to be loaded one day before your reservation. Bill or David will let you know at that time when to reserve the tool.

Step 2 – Reserve the tool per RSC Staff Instruction. FYI- the reservation will usually be between 8-10AM Reserve the target by selecting the Reactive Target, Example below for Al₂O₃. Refer to the spreadsheet on the tool for a full list of available reactive recipes.



Adding Reservation

Please enter the desired sputter thickness in Angstroms for one or more targets below.
The minimum input value is "150".

<input type="text" value="0"/>	- User Owned Target - \$0/Angstrom
<input type="text" value="0"/>	Ag - \$0.01/Angstrom
<input type="text" value="0"/>	Al - \$0/Angstrom
<input type="text" value="0"/>	Al / 2% Si - \$0/Angstrom
<input type="text" value="1000"/>	Al ₂ O ₃ Reactive - 1 day advance reservation - \$0/Angstrom
<input type="text" value="0"/>	Au - \$0.07/Angstrom
<input type="text" value="0"/>	Bi ₂ O ₃ - \$0/Angstrom
<input type="text" value="0"/>	Cr - \$0/Angstrom

7.0 Running a Deposition

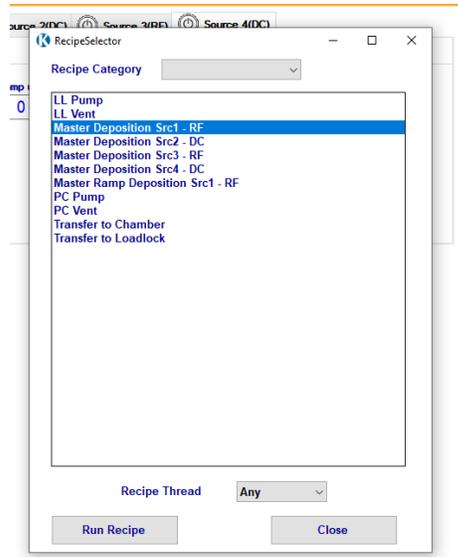
- 7.1.1. Open the "KL_Recipes_XXXX" workbook on the sputter tool desktop.
- 7.1.2. Find the "Material" in column A you are sputtering.

A	B	C	D	E	F	G	H
Master Deposition Recipes have 4 min target clean steps							
Material	Gun	Recipe Name	Dep Rate A/second	POWER	Needed thickness (A)	TIME/SEC	SPECIAL INSTRUCTIONS
Ag	2	Master Deposition Src 2 - RF	9.30	250	20.00	2	
Ag	4	Master Deposition Src 4 - DC	9.30	250	200.00	22	
Ag	2	Master Deposition Src 2 - DC	6.70	150	2000.00	299	
Ag	4	Master Deposition Src 4 - DC	6.70	150	500.00	75	
Ag	1	Master Deposition Src 1 - RF	4.60	200	500.00	109	
Ag	3	Master Deposition Src 3 - RF	4.60	200	500.00	109	
Al	2	Master Deposition Src 2 - DC	1.34	200	1000.00	746	
Al	4	Master Deposition Src 4 - DC	1.34	200	2500.00	1866	
Al	1	Master Deposition Src 1 - RF	1.05	250	1000.00	952	
Al	3	Master Deposition Src 3 - RF	1.05	250	5000.00	4762	
Al	1	Master Deposition Src 1 - RF	1.57	400	3000.00	1911	
Al	3	Master Deposition Src 3 - RF	1.57	400	1000.00	637	
Au	2	Master Deposition Src 2 - DC	4.38	150	500.00	114	
Au	4	Master Deposition Src 4 - DC	4.38	150	500.00	114	
Au	1	Master Deposition Src 1 - RF	3.33	200	1000.00	300	

7.1.3. Determine which Source gun has the material you are sputtering. See below.



- 7.1.4. In the spreadsheet enter the thickness in Angstroms you need and enter the value into the spreadsheet column F.
- 7.1.5. Write down the Power column E (green) and Time/Sec column G for the material, you will need to enter these 2 values.
- 7.1.6. If you are running a “Reactive” process you will also need to input the “O2 Ratio” and the “Process Pressure” from the spreadsheet for the material you are depositing.
- 7.1.7. Click “Run Recipe” on the right hand side of the KJL software screen. Select the recipe (see column C of the spreadsheet). Select the recipe and click “Run Recipe”.

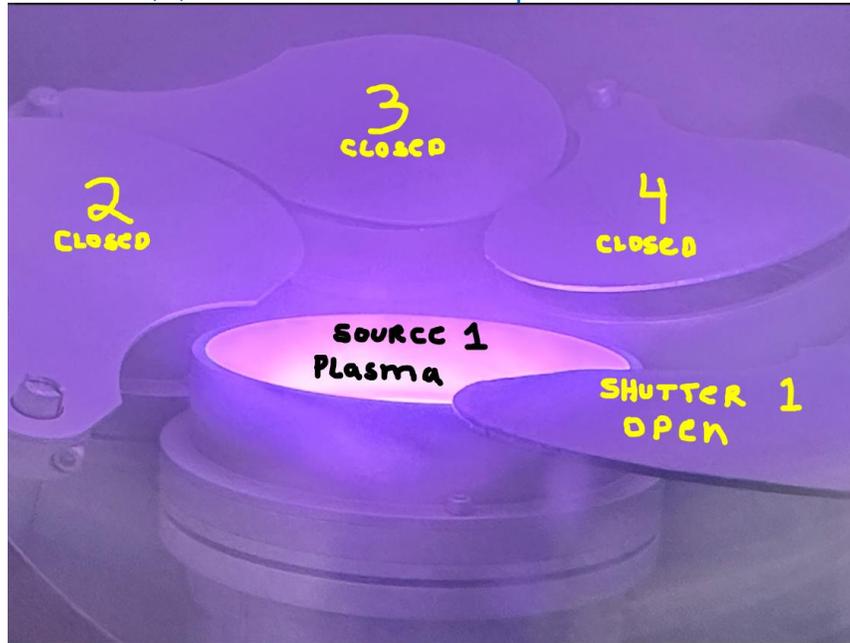


7.1.8. The next window will appear. Enter the Power and time in seconds in the far right value fields. Red circles below. If you are running a “Reactive” or “Ramp Recipe” recipe you may also be prompted to enter the “O2 Ratio” and the “Process Pressure”. Refer to the KL_Recipes” Excel worksheet shown above for the values to be entered. If it asks for a value that does not exist in the spreadsheet, call Staff immediately for assistance.

Recipe Name	Step	Equipment Type	Equipment Name	Equipment Operation	Notes	Minimum	Maximum	Value
Deposit with Timer - PC1_Src1 - Bias V...	2	Power Supply	Power Supply 1 Output Setpoint	Set Value = n.nn	Enter Power			200
Deposit with Timer - PC1_Src1 - Bias V...	4	System	Recover Process	Set Value = abc123	Select "No" for a new de...			No
Deposit with Timer - PC1_Src1 - Bias V...	5	System	Process Time	Set Value = n.nn	Enter Deposition Time in s...			120

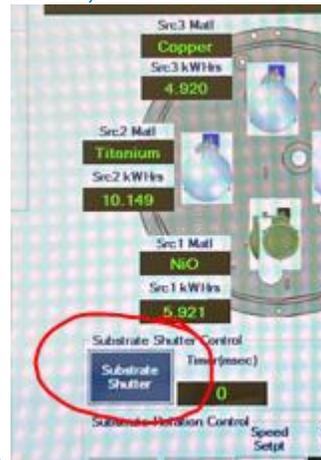
- 7.1.9. Click “Continue Load”. The recipe will execute.
- 7.1.10. The tool has no way of knowing if the mechanical shutters are opened or closed. For this reason, you must physically check.
- 7.1.11. Observe the recipe while it runs. When it has ignited plasma for the appropriate magnetron source(s) and the shutter is indicated as open on the computer screen, open the viewport window and check that the shutter for the gun you need is actually open. The pic below shows Source 1 shutter open and the shutters for

Sources 2,3,4 are close as an example.



7.1.12. If the shutter is closed, press abort in the recipe window and call Staff for help.

7.1.13. When the deposition process starts, the "Substrate Shutter will

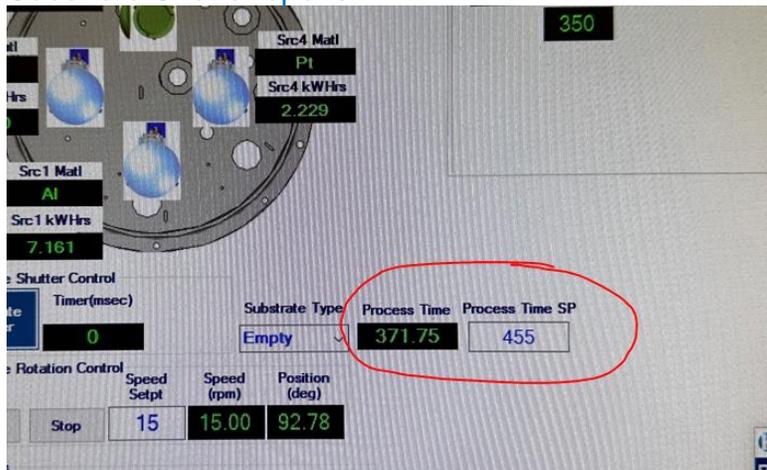


open. The icon will turn blue.

- 7.1.14. Check that the substrate shutter is open. It's located directly below the sample holder. See below



- 7.1.15. You can monitor the process time on the deposition screen, see below. "Process Time SP" is the deposition time you entered. "Process Time" is the actual elapsed time processed. This number will be used to recover the deposition if the recipe aborts during the deposition. Process time starts when the Substrate Shutter opens.



- 7.1.16. If plasma is lost during deposition and the recipe aborts, contact RSC Staff. The "Process Time" widow will stop the counter and display the deposition time elapsed up to the abort process. Once the problem is resolved, the remaining sputter time can be recovered automatically by doing the following. Run the recipe again with the same power and time entries as entered initially. Double click on the "no" value for the recovery

step shown below and select "yes". Press "continue load".

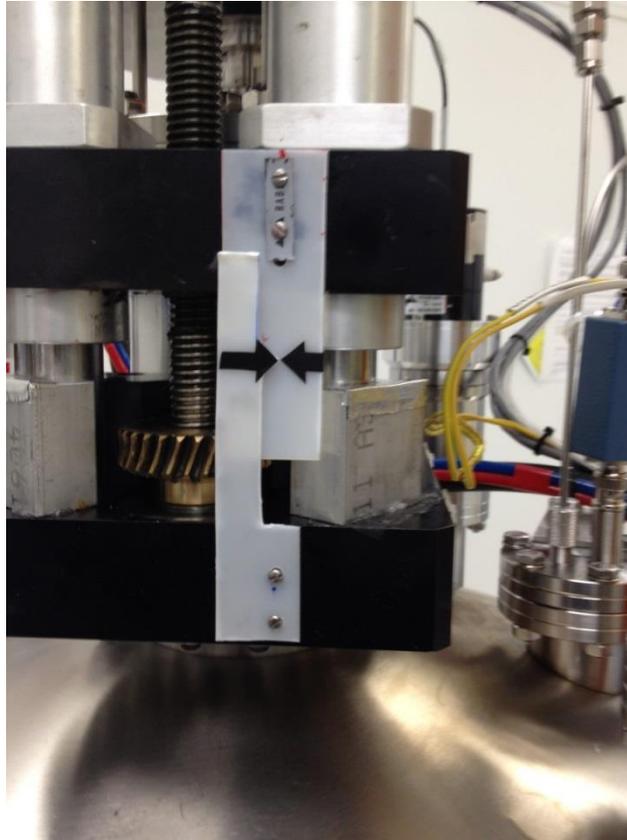
already in place. Then click "Continue Load"

1	Notes	Minimum	Maximum	Value
	Enter Power			300
	Select "No" for a new de...			No
	Enter Deposition Time in s...			500

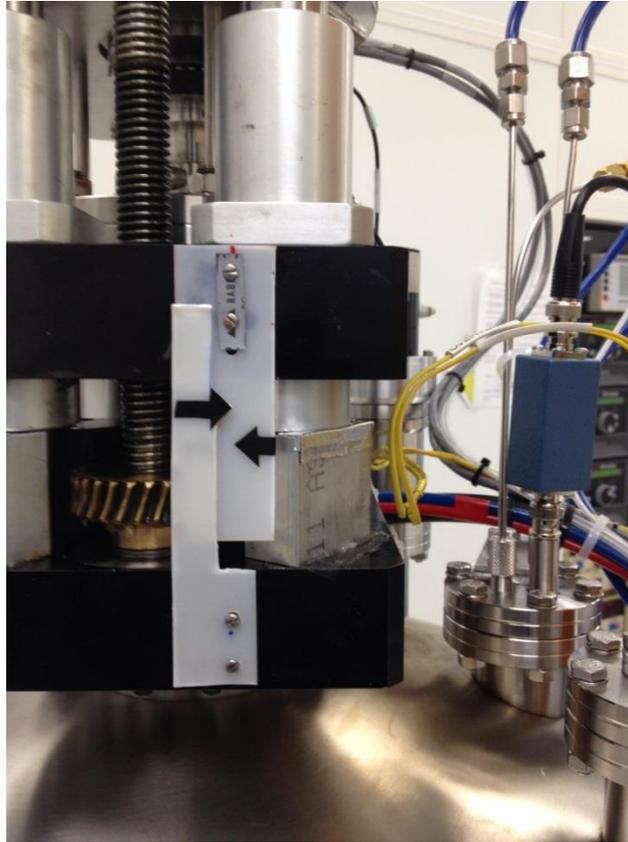
- 7.1.17. When the recipe runs the 2nd time, the "Process Time" on the deposition screen will continue to count down the deposition time remaining i.e. continue the deposition where it left off. It will start counting again when the substrate shutter opens.
- 7.1.18. **NOTE: Reactive Recipes Only** - The recipe will check that the base pressure of the process chamber is $<5e-7$ Torr. You may need to wait for pressure to come down. If pressure is not reached within 15 mins, it will abort the recipe and notify you to "contact NRF Staff"
- 7.1.19. It is always a good idea to verify plasma is on by looking through the view port window during deposition. The shutter handle is to the right of the window. Rotate the handle to look in the window.

8.0 Sample Unload

- 8.1 Click "Transfer to Loadlock" button. When "User set Z axis to arrow to arrow position" appears in the "Step Value" field, rotate the Transfer Z shift manual knob clockwise until the 2 black arrows on the plastic indicator line up. See below.



- 8.2 Click Resume. The load lock/dep chamber isolation valve will then open. When done the recipe will prompt “User-Unload substrate from chamber”. Rotate the LOAD ARM Load Arm knob until the arm is completely inside the process chamber and you feel it bump against the sample holder. Leave the arm in that position.
- 8.3 Lower the sample platen slowly by turning the Transfer Z-Shift knob clockwise until the platen stops turning (don’t force it). It should be all the way down as shown below.



- 8.4 Return the LOAD ARM to home position. If you hear anything unusual (like the sample holder falling) call NRF Staff. If the sample makes it back to the loadlock, click the “Resume” button again.
- 8.5 Vent the loadlock by pressing the “LL Vent” button. You may open the LL door and remove your sample when the LL vent sequence is done.
- 8.6 Pump the load lock back down by pressing “LL Pump”.