Standard Operating Procedure: Sputter

Kurt J Lesker

December 2025

Contact Information:

Shawn Wagoner (swagone@gmu.edu)

Sezin Sayin (ssayin@gmu.edu)

Pranav Choori (pchoori@gmu.edu)

Table of Contents

1. Lab Safety Information

- ✓ All GMU NFF users are required to complete the Lab Safety Orientation (LSO) before performing any lab work.
- ✓ Proper Personal Protective Equipment (PPE) should always be worn before entering the clean room: safety glasses, hair net, shoe covers, gloves, and lab coat. Additional PPE is available for specialized chemical work as needed.
- ✓ No shorts, sandals, tank tops, or spaghetti-strap shirts are allowed in the clean room!
- ✓ Material Safety Data Sheets (MSDS) are available in a binder in the gowning room.
- ✓ Read the SDS for any chemicals you plan to use before proceeding with your work. Any materials used in the clean room for the first time should be brought in after the approval of NFF staff.
- ✓ A safety buddy is required in the clean room with you when doing chemical work. They must remain in the clean room the entire time you are handling the chemical. Feel free to ask NFF staff if no one qualified is available!
- ✓ Prohibited clean room items: cardboard, pencils, cloth, hats/coats, and contact lenses.
- ✓ Accepted clean room items: plastic, pens, synthetic fabrics, clean room paper.

2. Sputter Safety Information

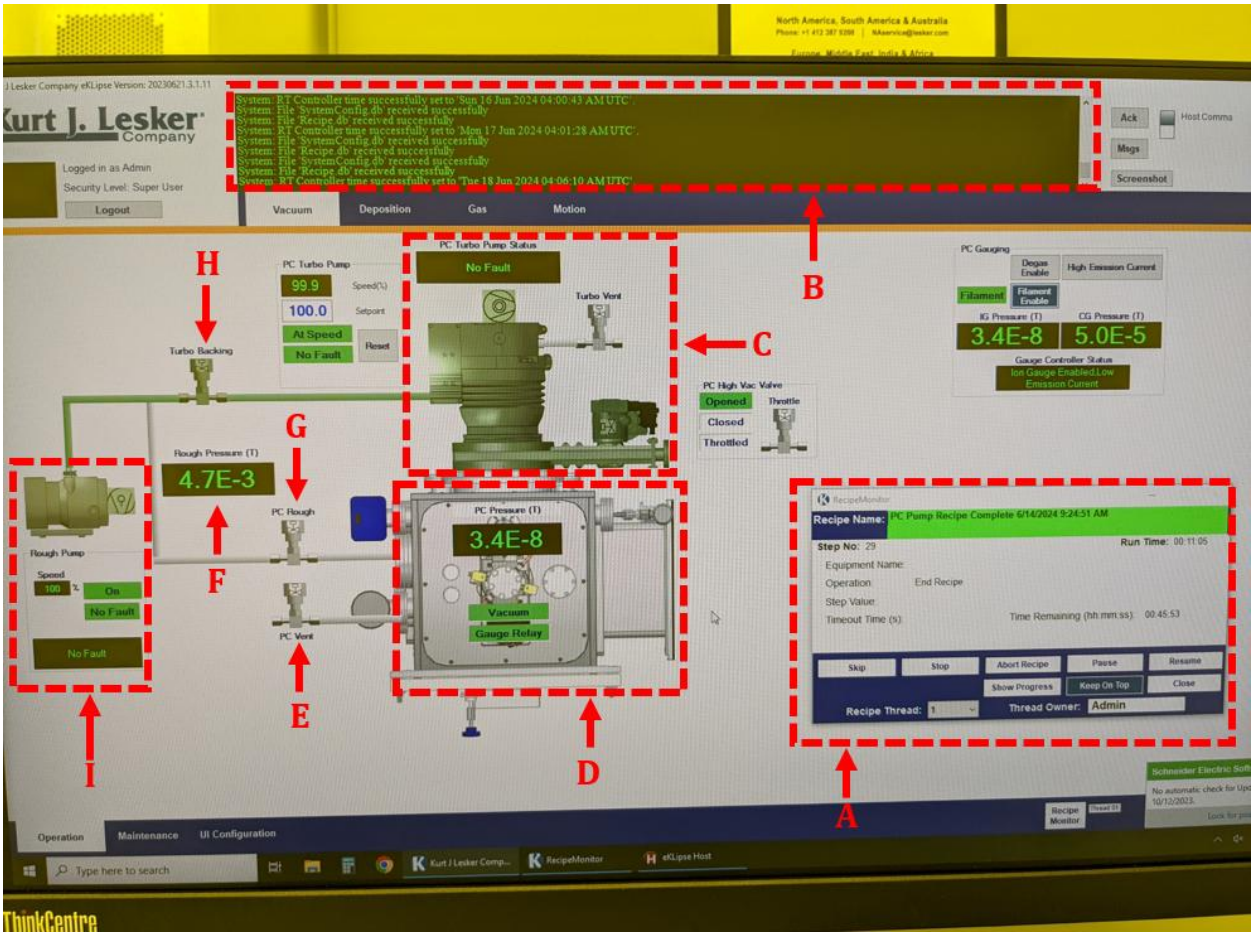
- ✓ Any irregular system behavior should be reported to NFF staff promptly. Never attempt to fix the system yourself!
- ✓ All substrates are mounted to a holder with screws and clips. Use enough clips to firmly mount the substrate to the holder.
- ✓ Be careful when loading the holder so you don't drop it in the sputter. Load sample holder into the system gently, and nudge it slightly on the lip it sits on while holding it to ensure it has been loaded properly.
- ✓ Pump down the system once you are finished using it, and return the sample holder to the dry box.
- ✓ Do not put wafers with PDMS or any other unapproved materials into the vacuum chamber.
- ✓ Use of any deposition material that is not already available requires:
    - NFF review and approval
    - You or your lab to purchase the source (*ask if you need help*)
- ✓ When in doubt… ask NFF staff!
- ✓ Gloves can become contaminated when loading wafers or removing wafers. Always check your gloves and replace them when necessary.
- ✓ Failure to use the system safely and properly may result in your access to the system being reviewed and/or revoked.
- ✓ Fill out the logbook before you begin.
- ✓ If a new recipe is required ask for assistance from the NFF staff.

3. Principles of Sputter

Sputtering is a form of physical vapor deposition (PVD). Sputtering is a physical process where argon ions bombard the surface of a "target." The target material is ejected from the target surface and travels under a vacuum to create a film on the surface of a substrate. Uses plasma created by RF and DC power sources to sputter thin films of various semiconductors and metals onto your wafer. Allows for a pre-sputter clean to remove organics and water particles from the wafer surface to improve adhesion. Creates clean, consistent layers with very little thickness deviation across the wafer surface.

Most materials can be sputtered, including conductors, insulators, and semiconductors. Sputtering creates thin films, less than one micrometer thick on the sample surface. Four magnetron sputter sources, six-inch diameter maximum substrate size, pre-sputter clean for removal of native oxide on sample surface, co-sputter from multiple targets. Simple, intuitive GUI lets you know exactly where you are in your process and how much time is still needed.

4. Software Overview



A: Recipe Status Window. Displays the status of the current recipe, the step of the recipe that the system is working through, and how much longer is needed to complete the current step.

B: System Status Window. Provides a variety of status updates about the tasks the system has recently completed. These entries are stored in a log file, and they include any errors or issues that pop up during system operation.

C: Turbo Molecular Pump. Handles the later, higher-pressure stage of the pump down process. The long flat portion of the bottom of this GUI image represents the turbo valve that opens in the later stage of pump down.

D: Process Chamber (PC). The chamber that your sample is secured in where sputtering takes place. The GUI indicates if there is vacuum in the chamber or not, and what the current pressure is.

E: PC Vent Valve. Valve that opens when the chamber is venting. It typically opens shortly after the roughing valve closes.

F: Rough Pressure Gauge. This value comes from a gauge that measures pressure in the line leading from the Roughing Pump to the PC.

G: PC Rough Valve. Valve that opens to expose the chamber to pressures created by the Roughing Pump. Typically only open during the first stage of pump down.

H: Turbo Backing Valve. Opens when PC Rough valve is closed so pressure from the Roughing Pump can backup the Turbo Pump.

I: Roughing Pump. Isolates each process gas the system can use when they're not in use, and regulates their flow rate when they are in use.

J: Process Initialization Bar: Buttons that initialize all main processes found here. This includes running recipes (deposition AND pre-sputter clean), pumping the chamber and venting the chamber.

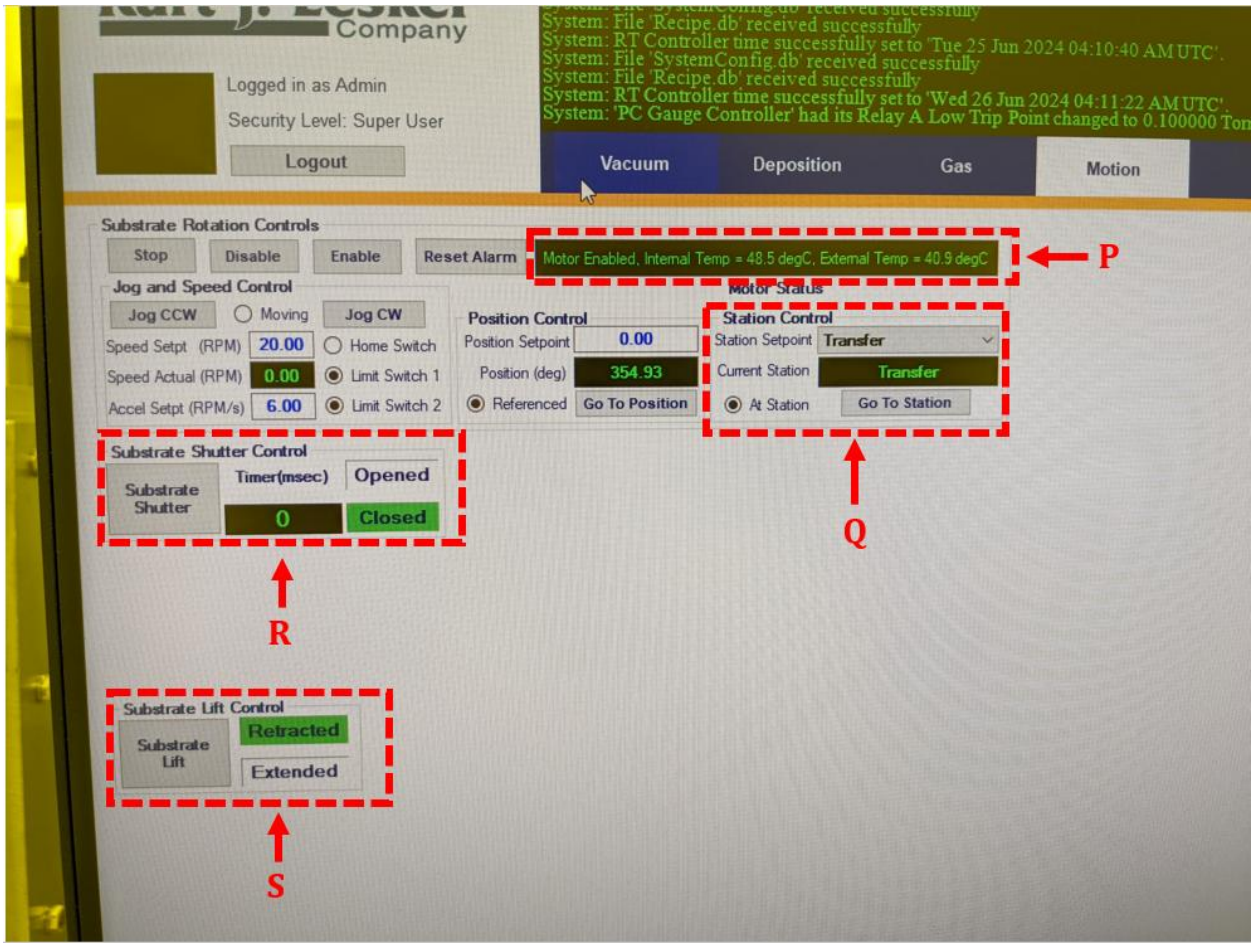
K: Recipe Status Window. Displays the status of the current recipe, the step of the recipe that the system is working through, and how much longer is needed to complete the current step.

L: Source Status Window: For each source that can supply the power needed to create plasma in a deposition (currently two DC and one RF), this window shows the current power being supplied, and other information about how the source operates (tooling factor, material density, etc).

M: Substrate Rotation: This value shows the current substrate rotation, allowing the user to ensure that feature is working properly.

N: PC Pressure reading: This value echoes the Process Chamber pressure reading that is also shown in “D” on the Vacuum screen.

O: Source Overview Window: This GUI image provides useful information about the Sputterer’s sources. This includes the materials available in each source, the run time that each source has been used for, and whether the source you’ve chosen is open or closed at any given point.



P: Motor Status Bar: Provides information on the status of the motor that drives substrate rotation. System operation will likely fail if “Motor Enabled” is not visible.

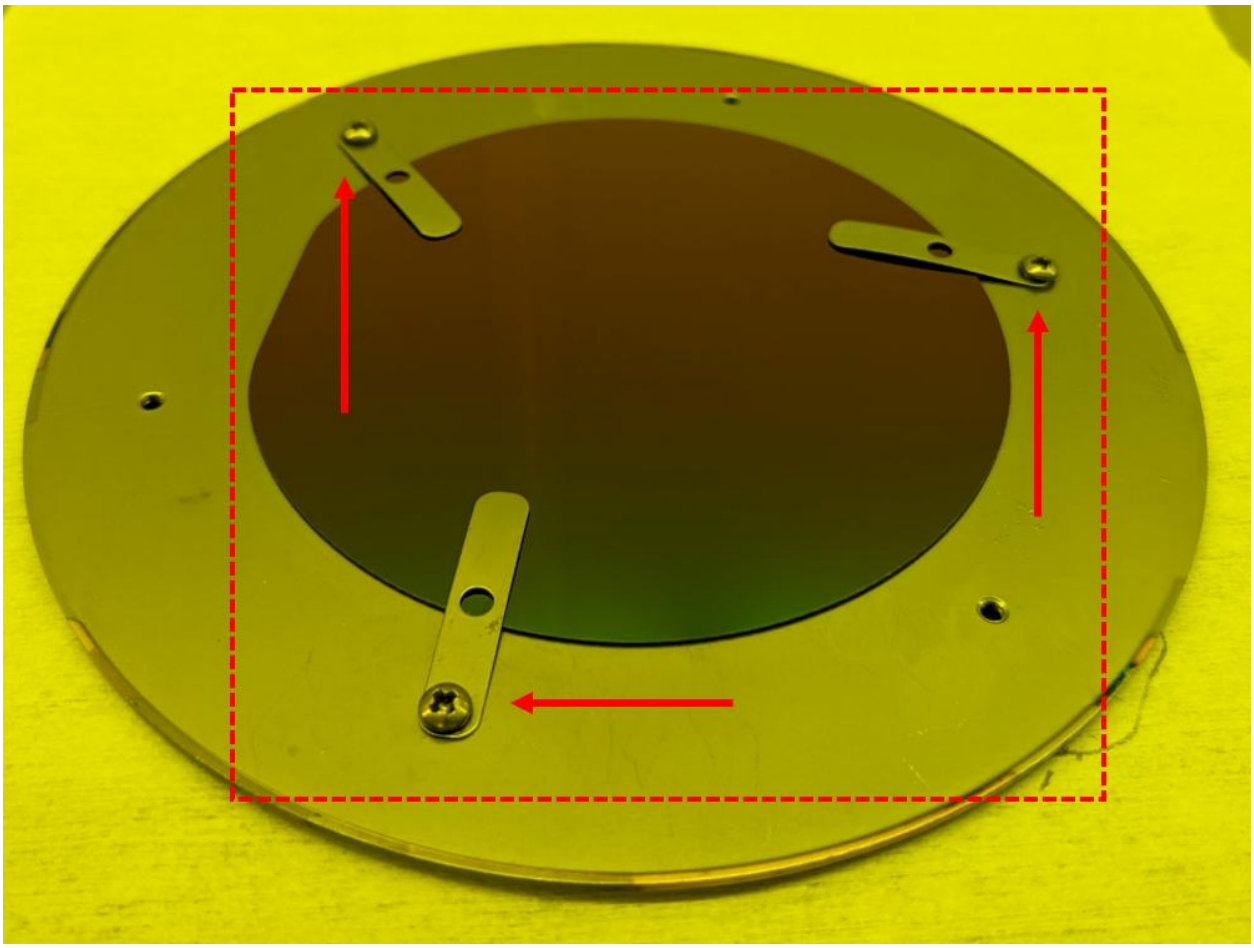
Q: Station Control Menu: Allows you to go to the “Transfer” station once you finish processing a sample, which is needed to remove your sample when the chamber is vented.

R: Substrate Shutter Menu: Allows you to close the substrate shutter once you’ve loaded your sample, and open the substrate shutter once it is time to remove your sample.

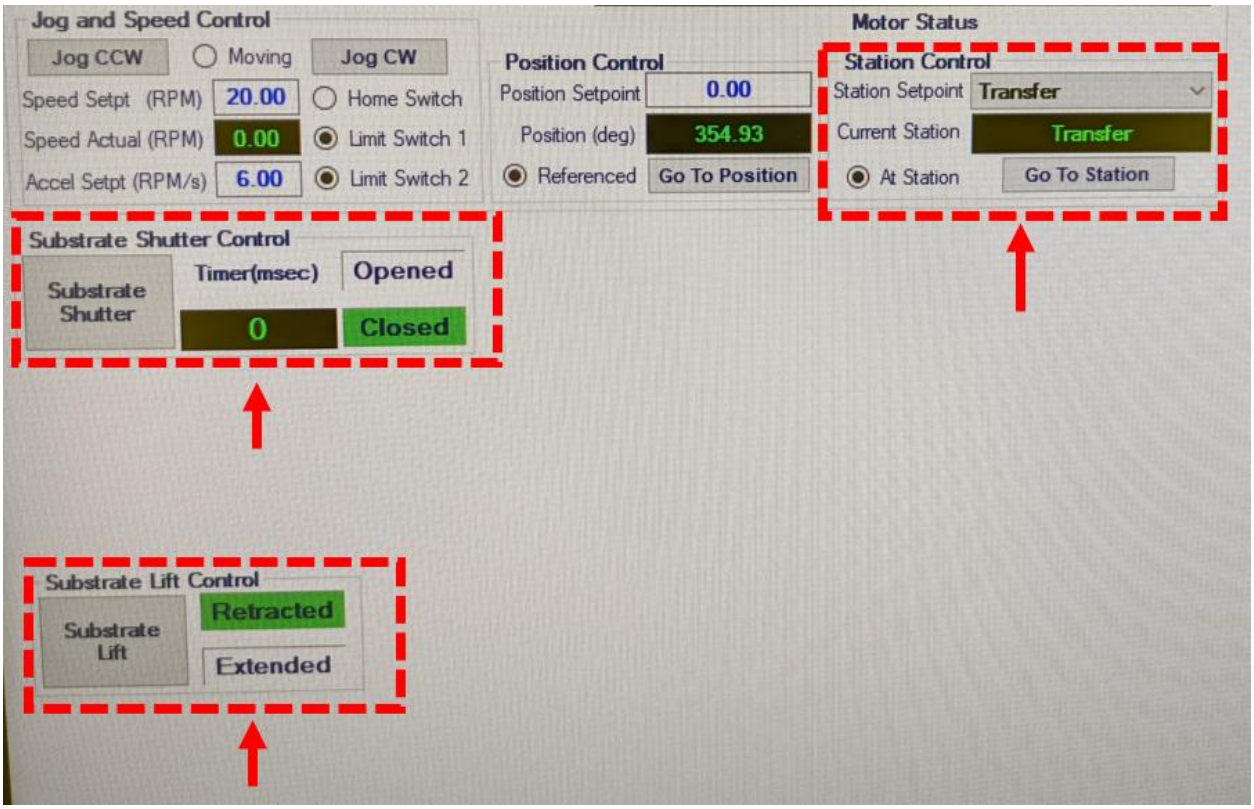
S: Substrate Lift Menu: Allows you to retract the substrate lift once you’ve loaded your sample, and extend the substrate lift once it is time to remove your sample.

5. Operation

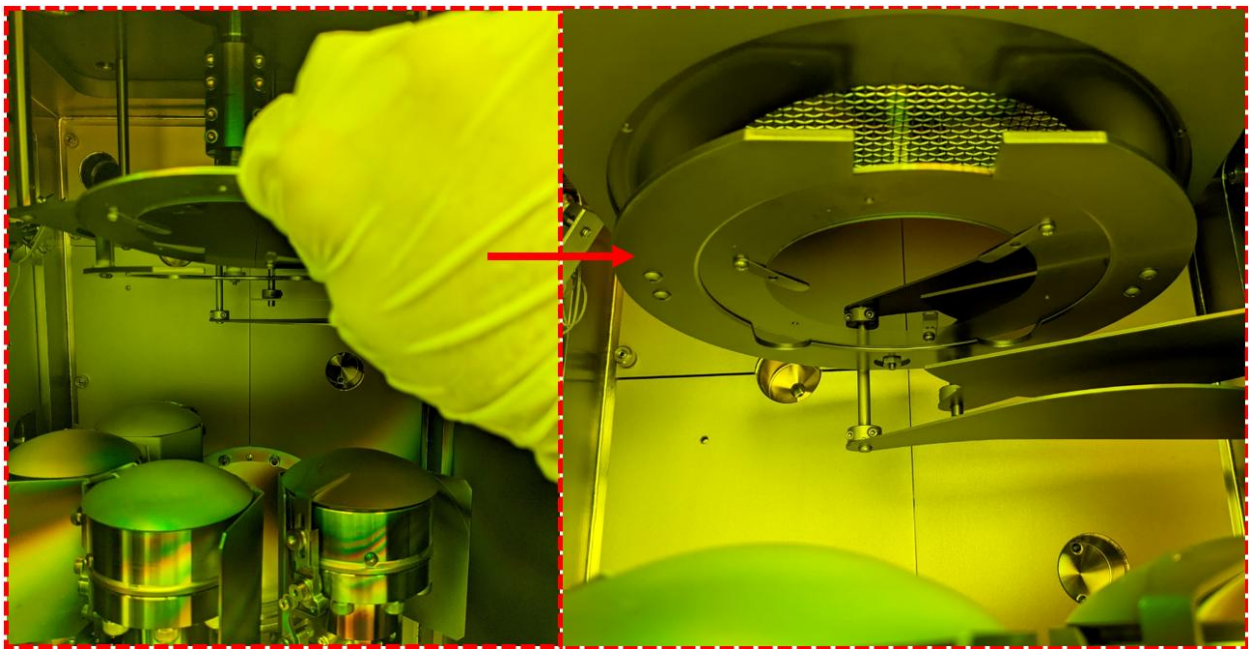
1. Log in to the Sputterer computer (if necessary), and vent the chamber.
2. Get the sample holder from the dry box, and place it on a KimWipe on the table near the sputterer.
3. Secure your sample to the sample holder using the clips on the holder and the screwdriver on the table. Ensure it is secured by flipping the substrate holder upside down over the table and shaking it gently.



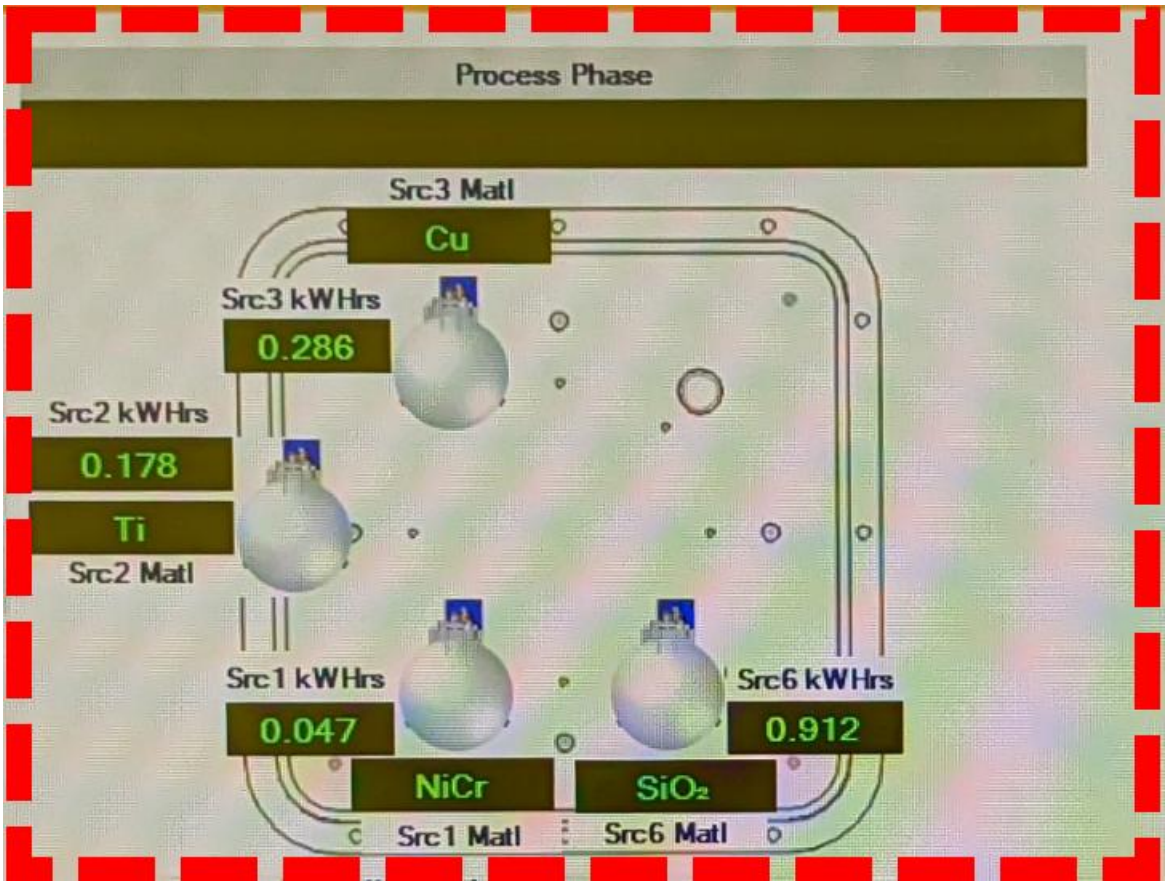
4. When the chamber is vented, return the rotation value to the “Transfer” station, open the substrate shutters, and extend the lift head.



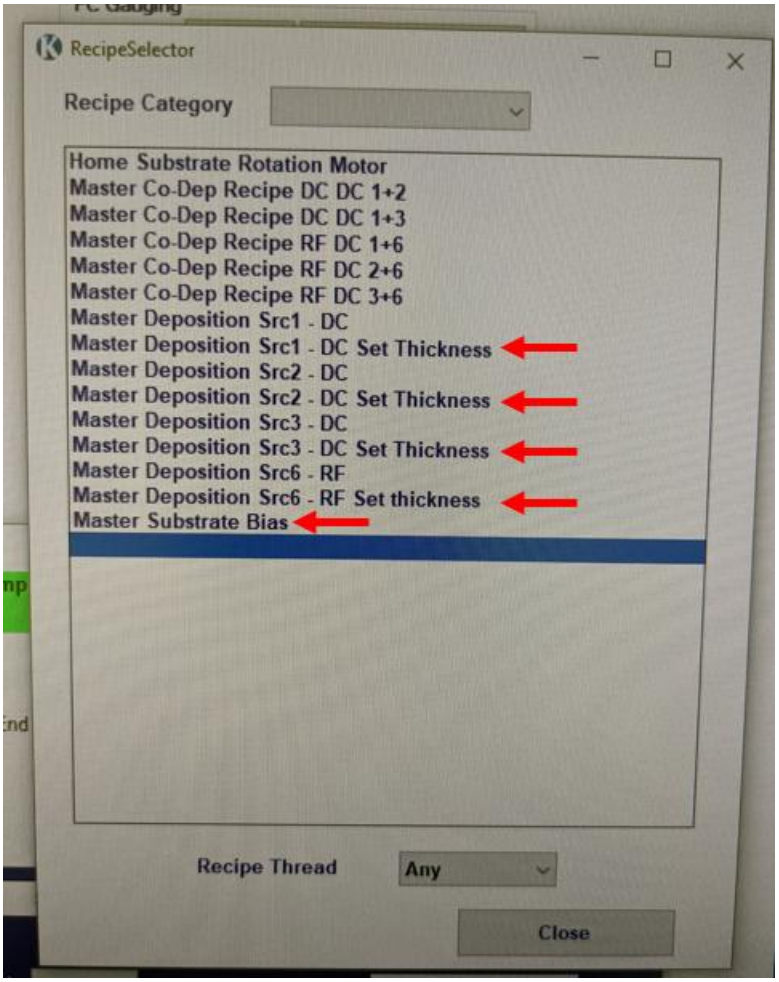
5. Place the sample holder with your secured sample upside down onto the lip of the extended lift head. Keep one hand on the sample holder and jiggle it gently to ensure it is secured in the lift head properly.



6. Retract the lift head, close the substrate shutters, and then pump down the system.
7. Once pump down is complete and the system status window is highlighted green, move the GUI to the “Deposition” tab to verify which material is loaded into each source.



8. Click “Load Recipe” and then select either “Source ___ Deposition – Set Thickness” to run the source with your material of choice, or “Source Substrate Bias” to run a pre-sputter clean.



9. If you selected a deposition recipe, set your desired thickness into the bottom right field of the last step in the recipe that pops up (1kA = 100nm), while leaving all other steps of the recipe unchanged.
10. Observe the system as it progresses through the various stages of the recipe you chose. If it fails for whatever reason, the recipe will abort and the system status light (on top of the machine) will change to yellow or red. Contact NFF staff if this happens, do NOT attempt to fix the issue yourself!

11. When you are finished processing your sample, vent the chamber. Once it is vented, return the subtrate holder to the “Transfer” station, open the substrate shutters, extend the substrate lift, then reach into the chamber to remove your sample.
12. If you have another sample to run depositions on, you can now load it and start again from step 1. Otherwise, remove your first sample from the substrate holder, return the substrate holder to the dry box, and pump the chamber down.