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Hoffmann Group – ESB 165
SOP for AJA Sputter Deposition Tool

Must-Do Procedures Before Deposition

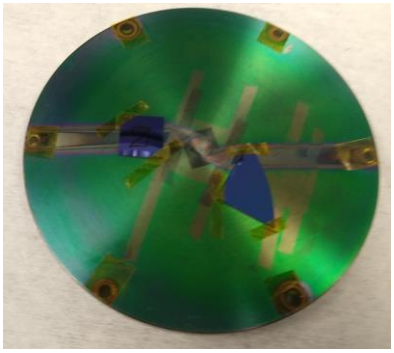
Before you start:

Check the cryo readout on the front of the equipment. It should read somewhere around 14 Kelvin. Temperatures higher than that indicate that the cryopump needs to be recycled.

Check the ion gauge to ensure that the chamber is at a suitably low pressure. You may need to turn it on using the I/O button. Record the base pressure in the log book.

Loading a Sample

1. Prepare your sample (You may wish to clean it with acetone and isopropanol and dry it with nitrogen. If you do, please change your gloves after to avoid getting water/acetone/IPA onto the sample holder unnecessarily) by mounting it onto the appropriate sample holder. The sample holders are stored in the fume hood. Use the high temperature sample holder if you are planning on heating your sample up (sample affixes with clips) or the ordinary sample holder otherwise (sample affixes with kapton tape). Please check that the holes on the side of the sample holder are covered, either with kapton tape for the low temperature sample holder, or by having screws in all of them for the high temperature sample holder. Only use tellurium if trained. If your sample holder is in the load lock already, you may need to vent in order to get it out.

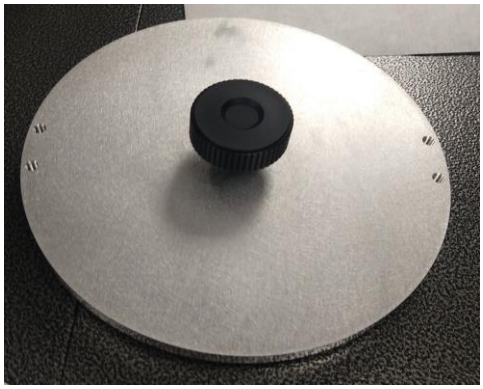


2. Ensure that the transfer arm is fully retracted (completely inside the load lock).

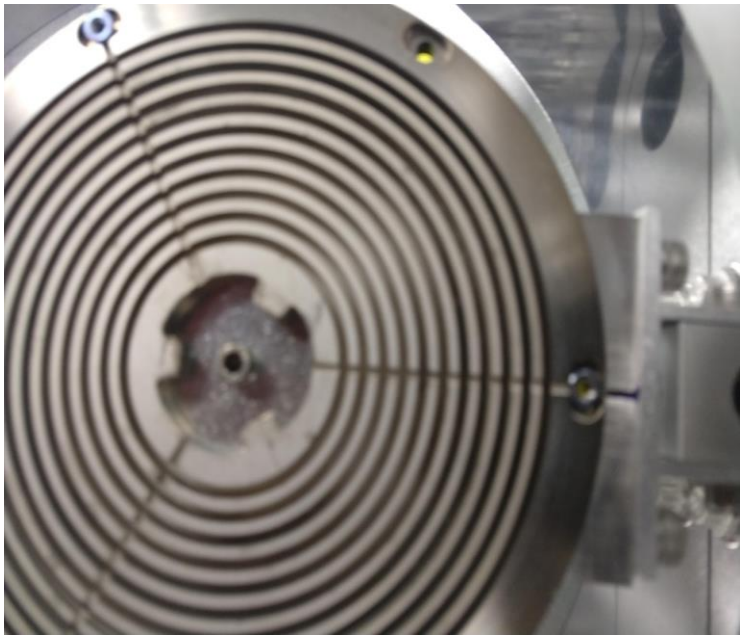
3. Ensure that the transfer valve between the main chamber and the load lock is closed.

4. Turn off the load lock vacuum pumps, initiating a vent.

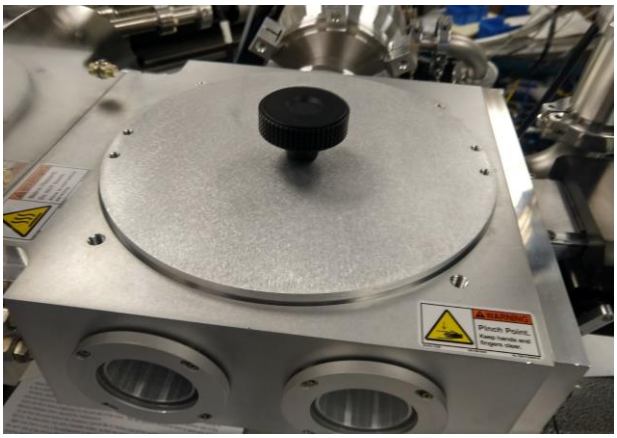
5. Once the load lock is at atmosphere, remove the load lock cover and place it face down on the stand composed of three small rubber pieces.



6. Place the sample holder face down on the transfer arm, lining up one of the three lines on the back of the sample holder with the line to the right of it on the transfer arm. If you are using the high temperature sample holder, you must also ensure that the washers are not in the way of the sample holder properly sitting flat on the arm (thus only one of the three lines on the sample holder will work).

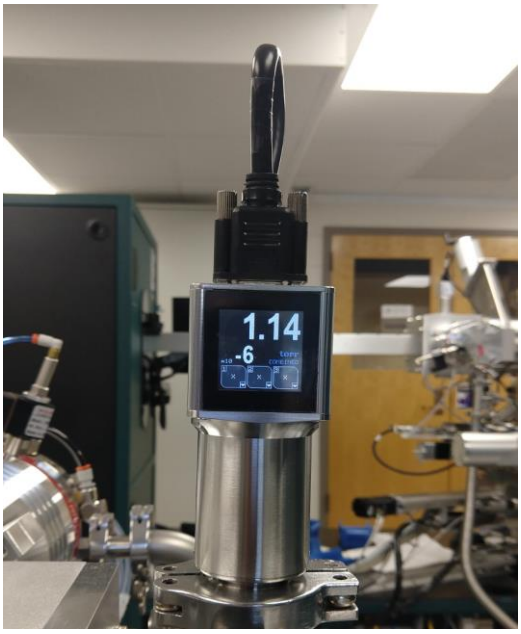


7. Replace the cover on the load lock.



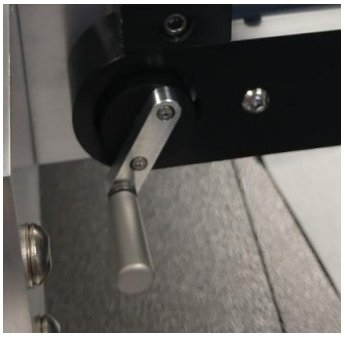
8. Turn on the load lock vacuum pumps. The pressure should start falling.

9. Wait for the pressure to reach somewhere around 1E-6 torr (about 20-30 minutes).



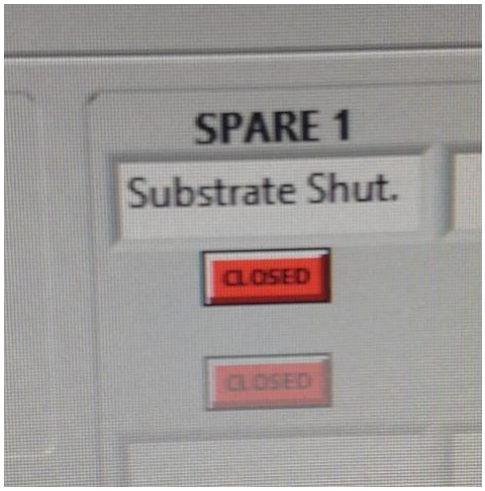
10. Open the transfer valve between the load lock and the main chamber.

11. Extend the transfer arm all the way into the chamber, watching to be sure that it does not collide with anything as it enters.



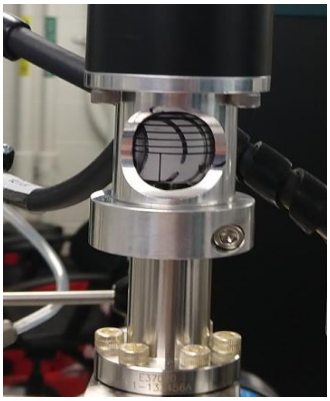
12. Ensure that the rotation of the substrate holder is in the load/unload position (the furthest left circle is aligned with the window).

13. Check whether the substrate shutter is open. If it is closed, click the red button to open it and wait for the shutter to open.



14. Lower the substrate holder with the crank at the top of the chamber until the second black line appears (around _46__). As you do this, watch to be sure that the substrate holder properly interfaces with the sample holder.

15. Rotate the substrate holder rotation to the left until the furthest right circle is centered in the view and the substrate holder no longer easily rotates (locked position).



16. Raise the substrate holder, ensuring that the sample holder is correctly lifted off of the transfer arm.

17. With the transfer arm still under the substrate holder, rotate the substrate holder to ensure that the sample holder is firmly affixed.

18. Remove the transfer arm completely from the main chamber.

19. Close the transfer valve between the main chamber and the load lock.

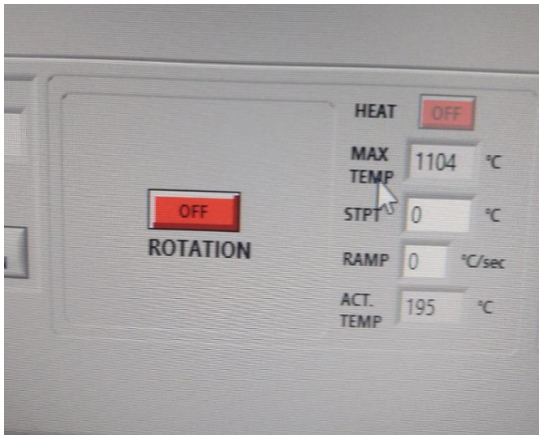
20. Raise the substrate holder to the maximum height.

21. Begin your deposition process using the manual deposition instructions below.

RF Bias and Reactive Ion Etching

1. Connect the RF bias cable to the back of the substrate holder.

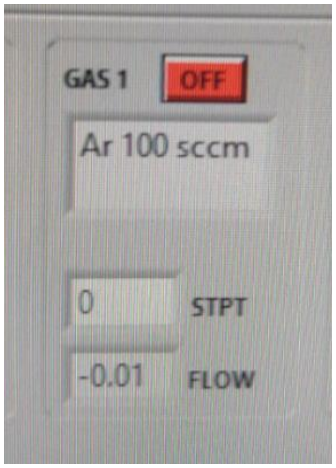
2. Load the sample following **Loading a Sample**. Turn on the sample rotation.



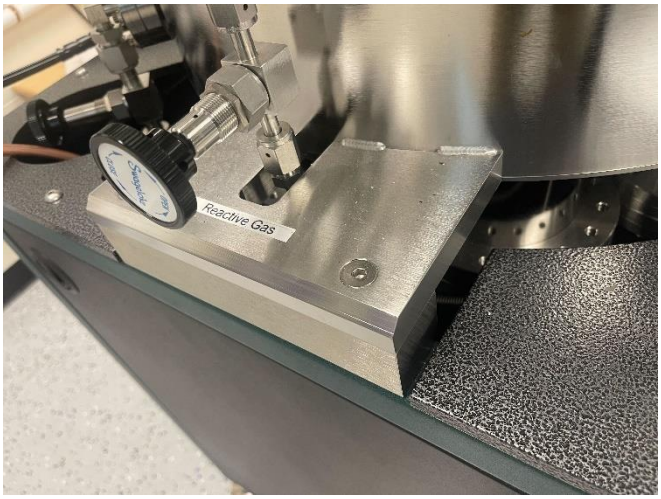
3. Close the shutters covering the view ports to avoid sputtering on them.

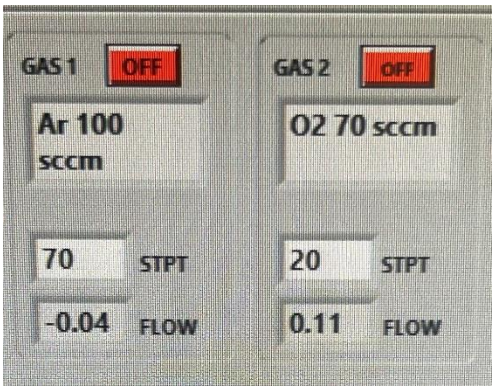
4. Turn off the ion gauge using the I/O button.

5. If you just want to remove surface contaminants, native oxides, and improve adhesion before film deposition, just turn on Ar gas with 70 sccm flow.

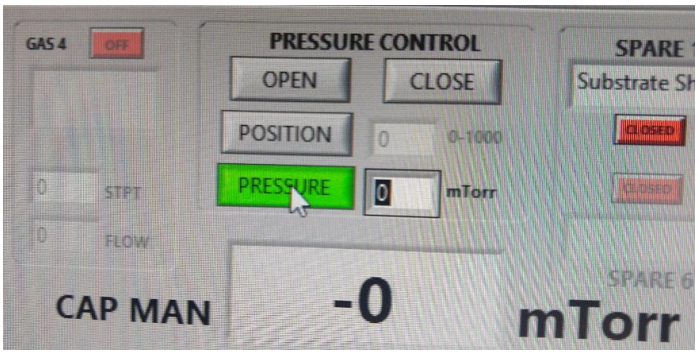


If you want to **chemically react** with contaminants on the surface, especially organic residues (like oils or leftover photoresist), you are using **reactive ion etching(RIE)**, turn on both Ar and O_2 in this case. You might want to sue 20 sccm O_2, but depending on your need, you can adjust the flow rate of O_2 accordingly.

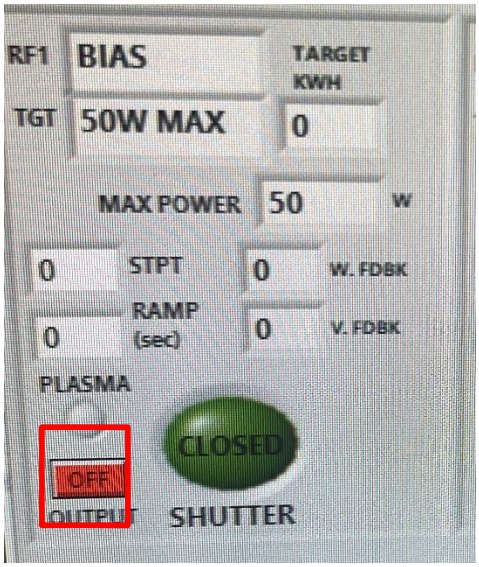




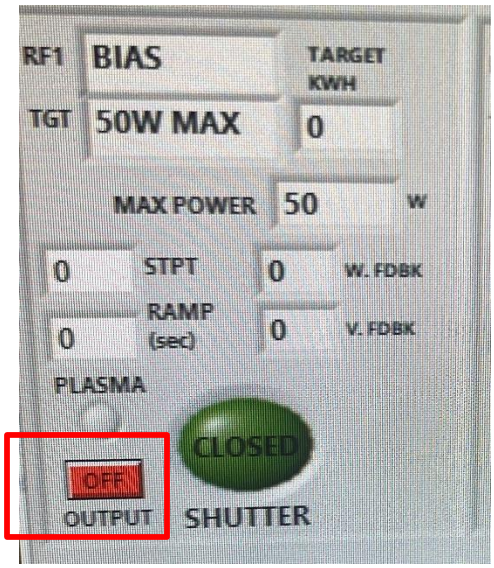
6. Switch the gate valve into target pressure mode. You may want to use 30 mTorr for igniting the gun.



7. Turn on the power of **BIAS** gun.



8. Ramp the gun power to your desired power by entering the ramp time first in the RAMP section and ensure that the gun lights (plasma light turns on in the software). Maximum RF power is 50 W for RF bias!!!

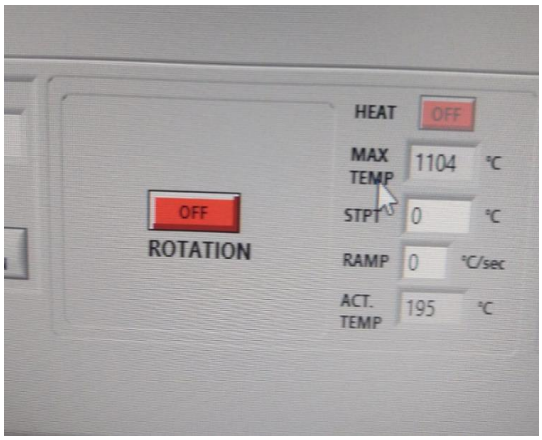


9. Reduce the chamber pressure to your desired deposition pressure. This is most likely 3 mTorr.

10. Ensure that your gun remains lit. If it does not, you may need higher pressure. If this doesn't work, you may need higher power.

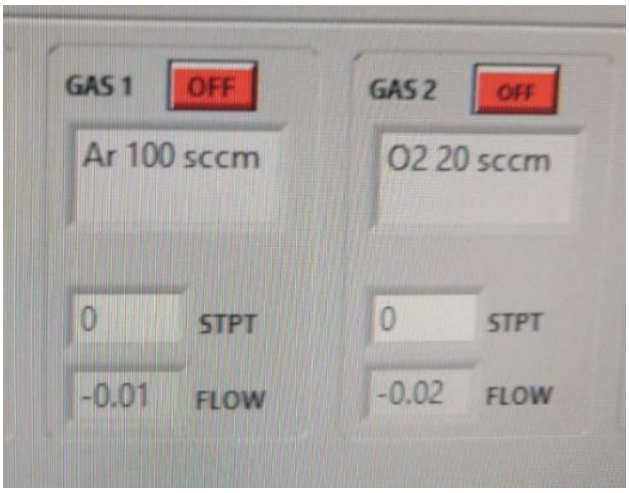
Manual Deposition

1. Turn on the sample rotation.

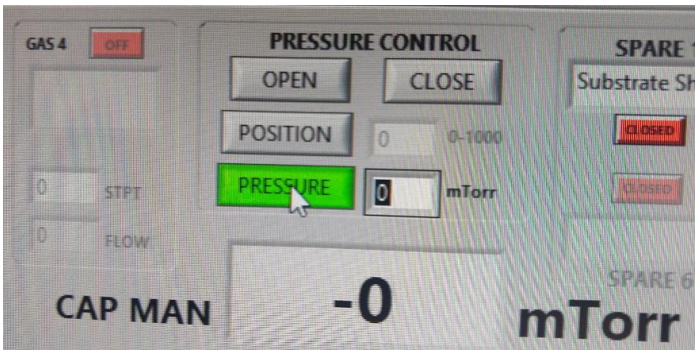


2. Close the shutters covering the view ports to avoid sputtering on them.

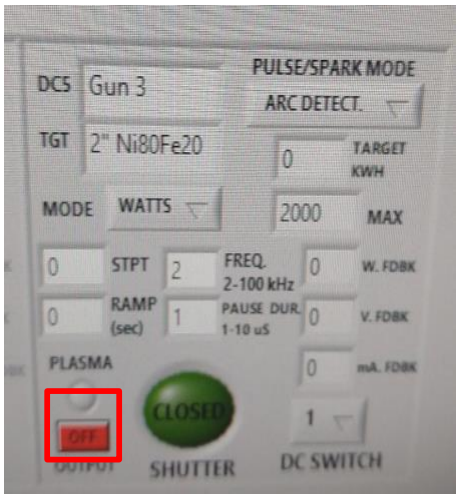
3. Turn off the ion gauge using the I/O button. Turn on the argon gas to the system. You may choose to change the flow rate, but an appropriate rate of 70 sccm should already be entered.



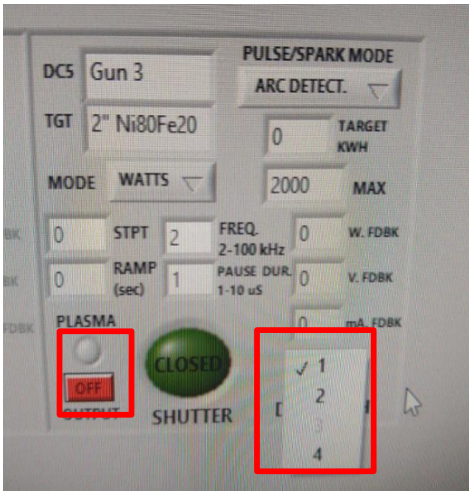
4. Switch the gate valve into target pressure mode. You may want to use 30 mTorr for igniting the gun.



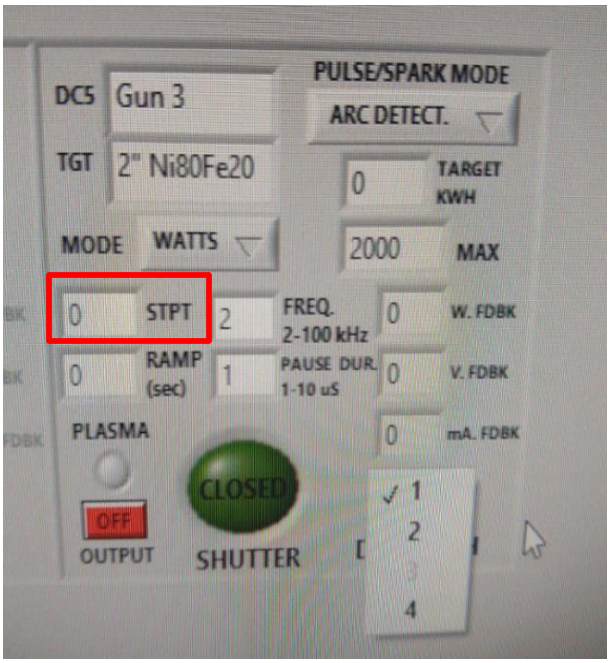
5. Turn on the power to your desired gun.



6. If your desired gun is not currently visible, you may need to change one of the power switches so that power reaches the gun.



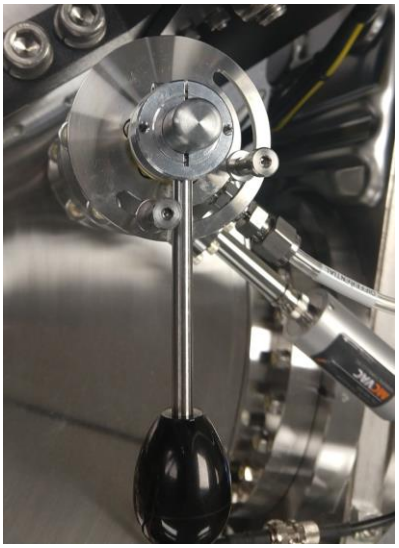
7. Ramp the gun power to your desired power by entering the ramp time first in the RAMP section and ensure that the gun lights (plasma light turns on in the software). If you use a high power, also use an appropriate ramp time.



8. Reduce the chamber pressure to your desired deposition pressure. This is most likely 3 mTorr.

9. Ensure that your gun remains lit. If it does not, you may need higher pressure. If this doesn't work, you may need higher power.

10. If you wish to check the deposition rate with the crystal monitor, move the crystal in front of the substrate by rotating the black handle on the reverse of the system.



- 10a. If you are using the crystal monitor, select your desired material on the deposition monitor controller.

- 10b. With the gun lit, open the gun shutter and check the deposition rate. Aside from looking at the displayed rate, it is good practice to measure the deposited thickness for a fixed duration of time e.g., (15 or 30 seconds).

- 10c. Close the gun shutter.
- 10d. Move the crystal back from covering the substrate.

11. Lower the sample holder to your desired deposition height (around 36, marked with a black line).

12. Open the gun shutter.

13. Open the substrate shutter and deposit for your desired amount of time.

14. Close the substrate shutter.

15. Close the gun shutter.

16. Enter the time needed to ramp the power down to 0 in the RAMP section first, then enter 0 in the STPT section. Tap ‘Enter’ on the keyboard.

17. Turn off the gun power.

18. Open the cryo valve fully.

19. Turn off the gas to the system.

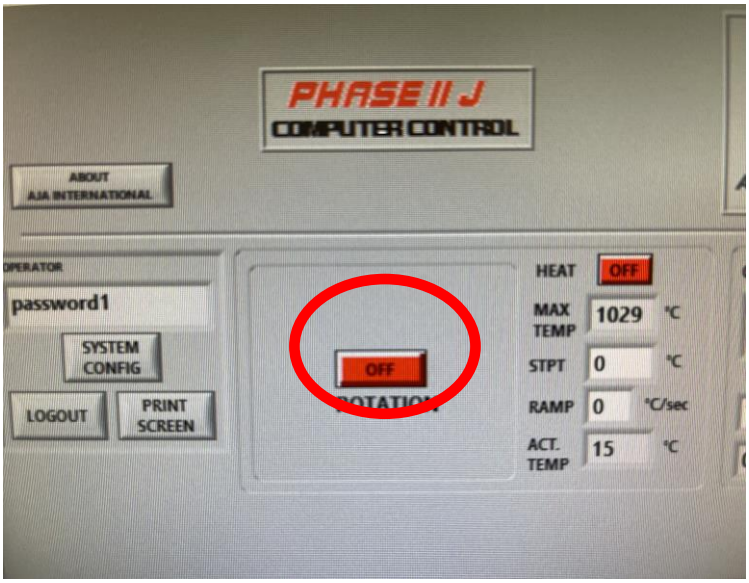
20. Stop sample rotation.

21. If you need to further anneal your sample, follow **Annealing After Deposition**.

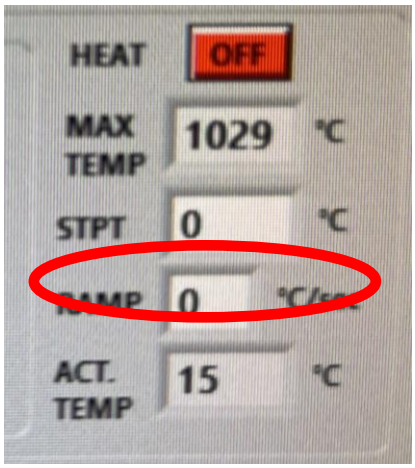
High Temperature Growth

1. Make sure that the substrate holder is loaded and locked safely inside the chamber by following **Loading a Sample**.

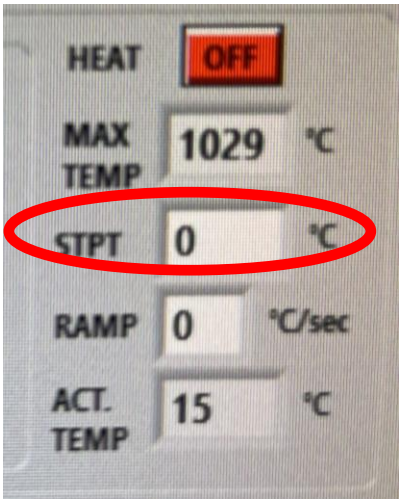
2. Click the Rotation button on the software.
(Note: Do not turn on heating before turning on rotation, the heating will be automatically turned off when you turn on the rotation after you turn on heating)



3. To grow films above room temperature, first enter the desired ramp rate (between 0.1 to 1°C/s) in the RAMP section.
(Note: 0°C/s makes the temperature increase fast and will result the actual temperature to exceed the set temperature by a noticeable amount for a while before it drops down to the set temperature, so enter some value in between 0.1 to 1°C/s in order to control the temperature efficiently.)

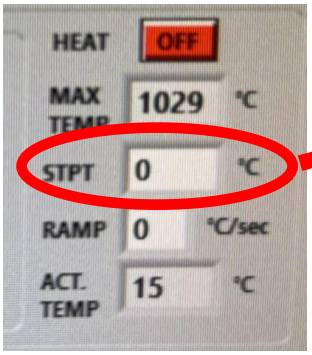


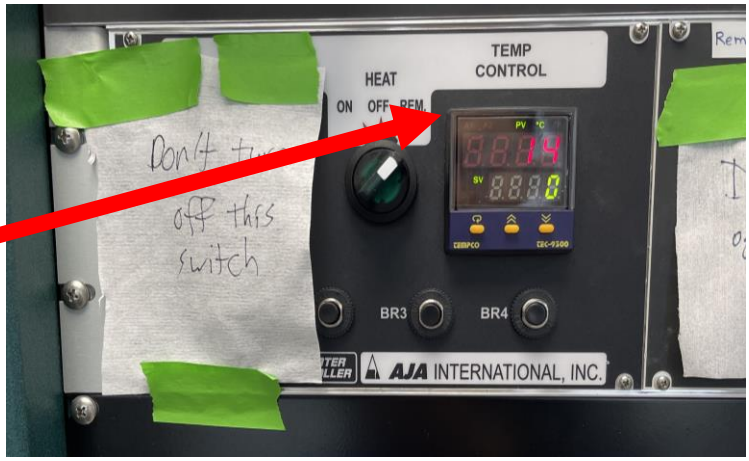
4. Then in the STPT section, enter the deposition temperature you want to use for thin film growth. Click the HEAT button to turn on heating.



5. You will notice that the temperature shown on the screen will increase and eventually reach the set temperature. At the meantime, keep an eye on the

temperature sensor, and make sure that the temperature shown on the sensor matches the temperature shown on the computer screen always.





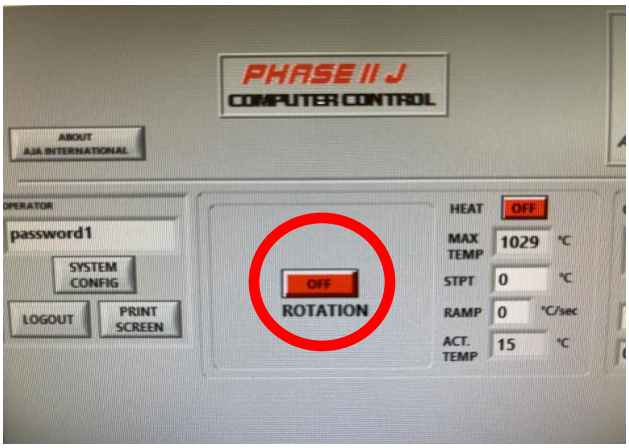
6. When the temperature reaches the STPT value, wait for 20 minutes for the temperature to be stable before proceeding to deposition.
(Note: For temperature below 400 °C, it takes longer for the temperature to be stable (30mins-1h).)

7. Follow **Manual Deposition** to grow your sample.

8. Finally, after you finish thin film growth, simply turn off the rotation by clicking the Rotation button, the heating will be automatically turned off as mentioned in STEP 2. Warning: wait for a few hours for the sample to be cooled down to 14°C/s as shown on the temperature sensor before taking it outside the main chamber by following **Unloading a Sample**.

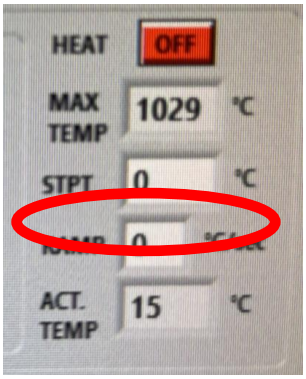
Annealing After Deposition

1. Make sure that the sample rotation is on. If not, turn it on.

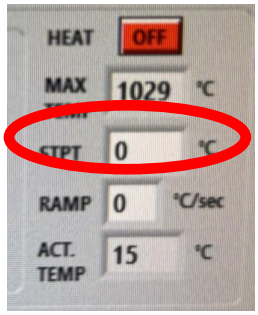


2. First enter the desired ramp rate (between 0.1 to 1°C/s) in the RAMP section.

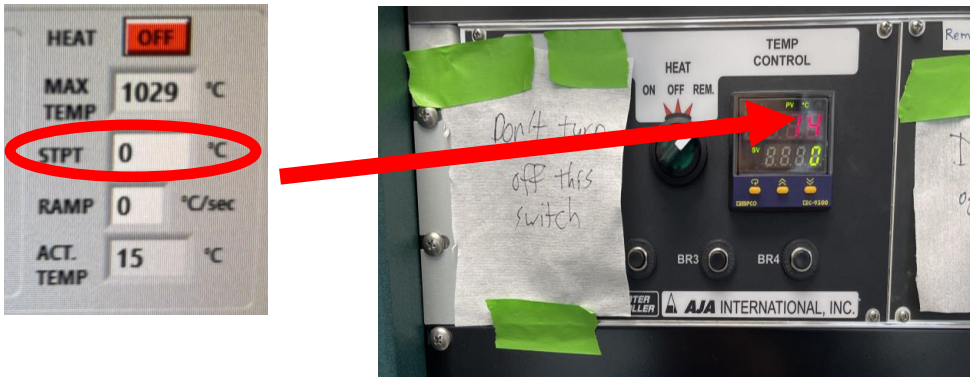
(Note: 0°C/s makes the temperature increase fast and will result the actual temperature to exceed the set temperature by a noticeable amount for a while before it drops down to the set temperature, so enter some value in between 0.1 to 1°C/s in order to control the temperature efficiently.)



3. Then in the STPT section, enter the annealing temperature you want. Click the HEAT button to turn on heating.



4. You will notice that the temperature shown on the screen will increase and eventually reach the set temperature. At the meantime, keep an eye on the temperature sensor, and make sure that the temperature shown on the sensor matches the temperature shown on the computer screen always.



5. When the temperature reaches the STPT value, start time recording on your phone in order to control the annealing time.

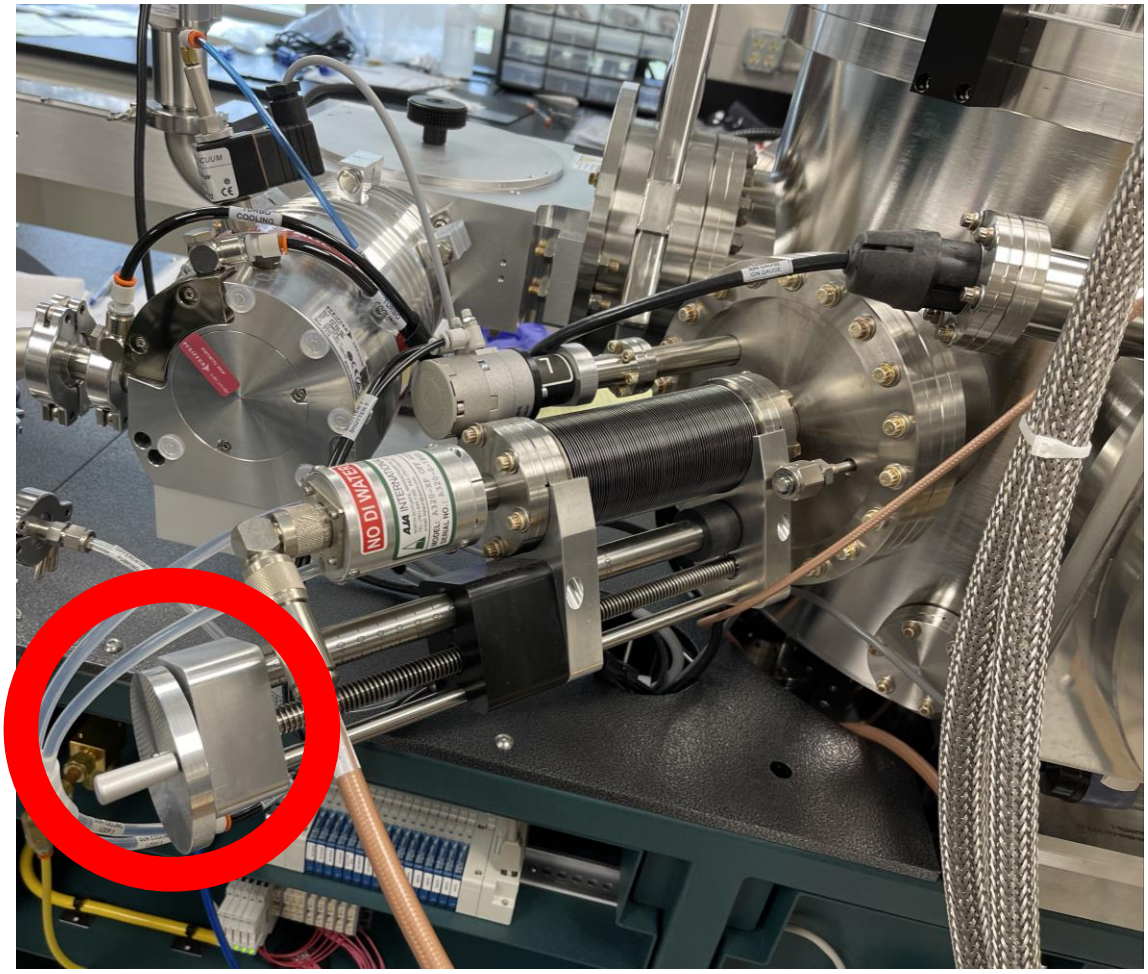
6. After you finish annealing, simply turn off the rotation, the heating will be automatically turned off as well. Warning: wait for a few hours for the sample to be cooled down to 14°C/s as shown on the temperature sensor before taking it outside the main chamber by following **Unloading a Sample**.

Using Side Guns for Sputtering

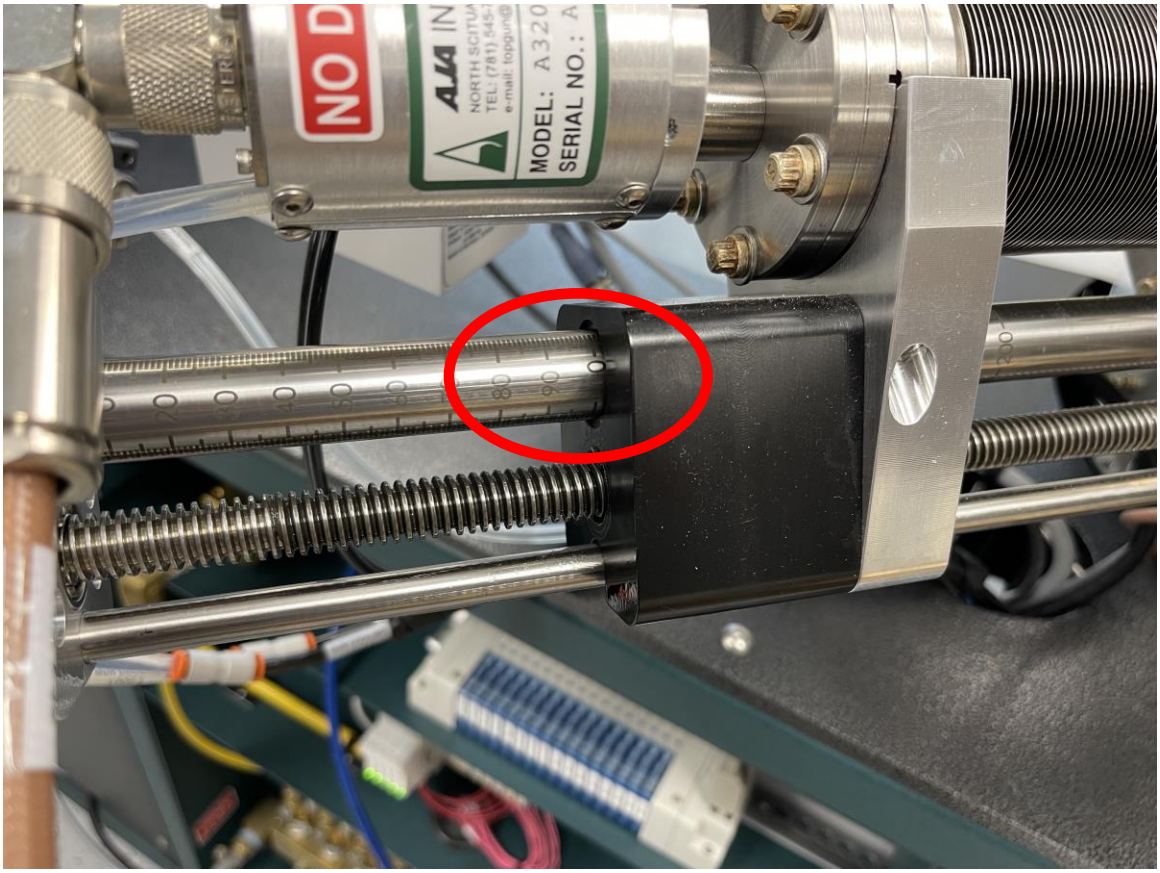
1. Load the sample correctly by following the **Loading a Sample**.

2. To use the side gun ***7 (or 8)*** for MgO (or YIG) deposition, first raise the substrate holder inside the chamber to the highest position, and close the substrate shutter.

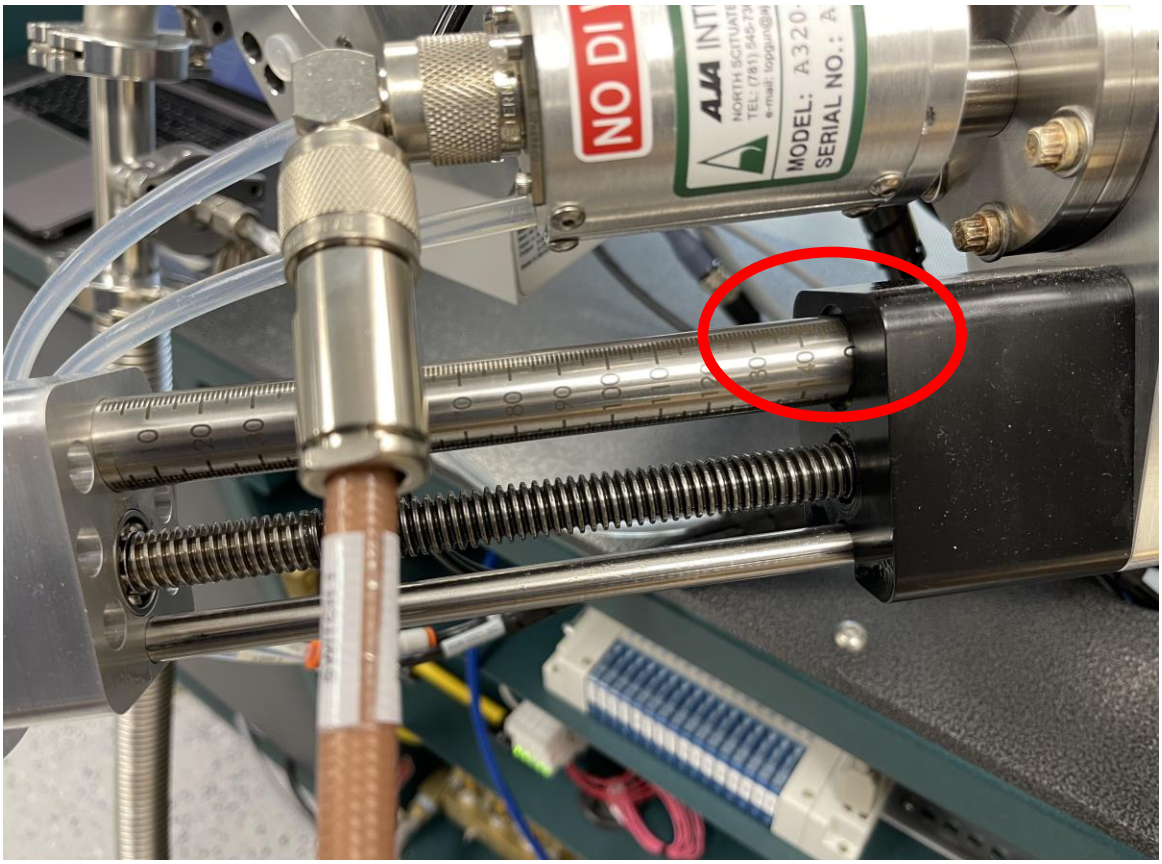
3. Find the rotation knob on the side gun ***7 (or 8)***, and gently rotate the knob counterclockwise so that the gun will extend inside the chamber.



4. Slowly rotate the knob till it reaches 100 labelling. Stop and observe the side gun through the glass window to make sure that it will not hit the substrate shutter with further extension.

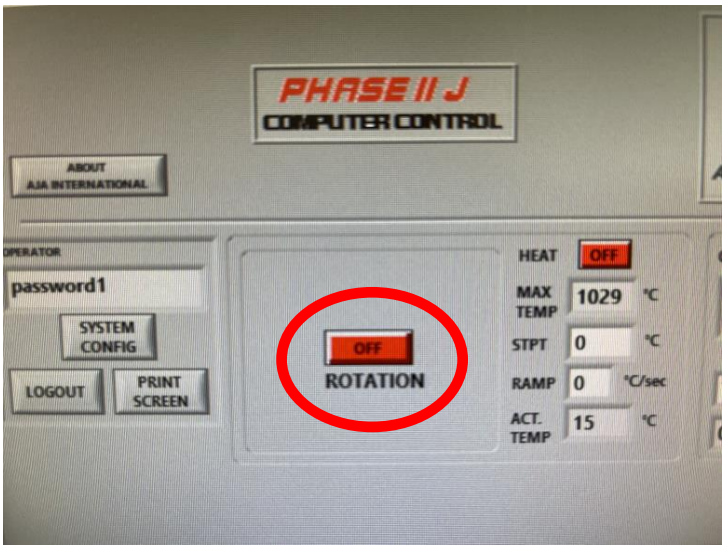


5. Continue to rotate the knob till it reaches 150 labelling. Stop and observe again that the side gun does not hit the substrate shutter. If everything looks safe, you can proceed to MgO (or YIG) deposition.

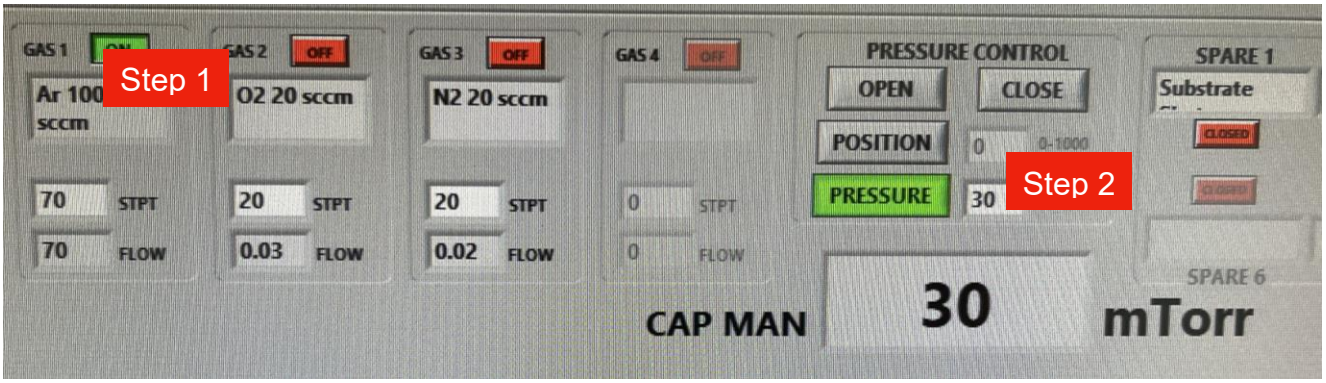


6. Turn off the ion gauge first.

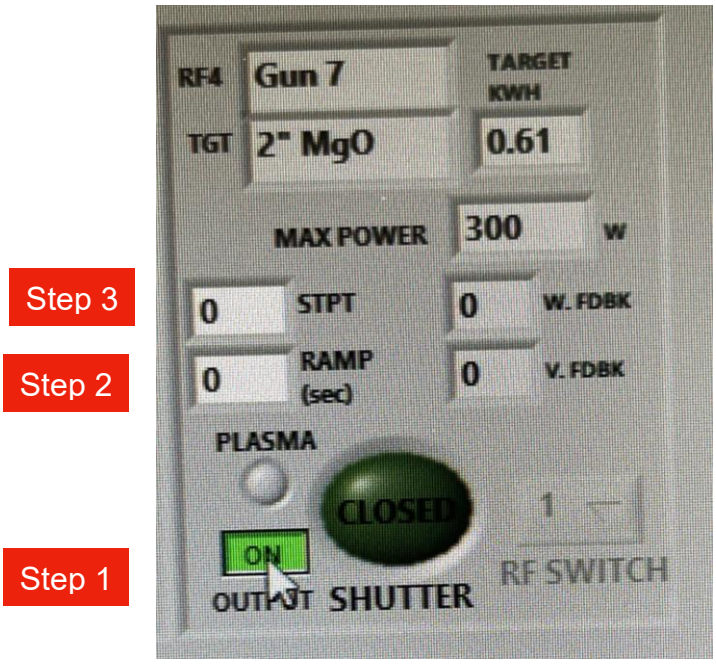
7. Click the Rotation button to turn on rotation.



8. Turn on Gas 1 Ar gas flow, and click PRESSURE and set the pressure in the pressure control section to be 30 mTorr.

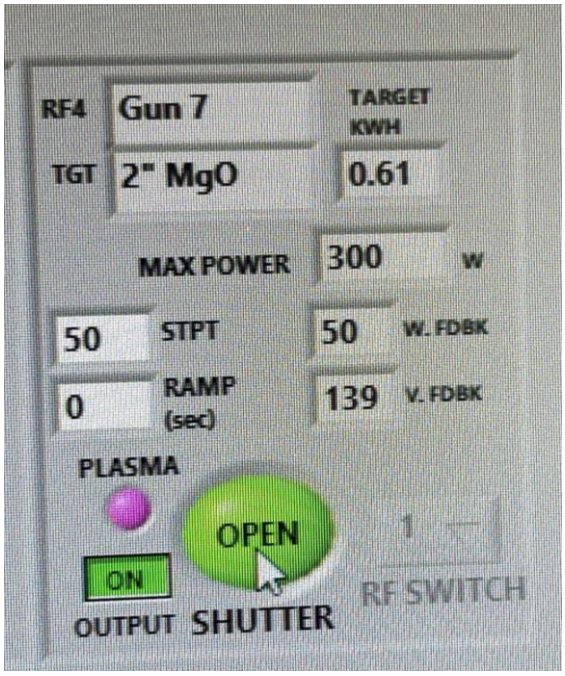


9. Turn on gun 7, enter 20 in the RAMP section as the ramp time, and enter 50 in the STPT section as the power of the gun.

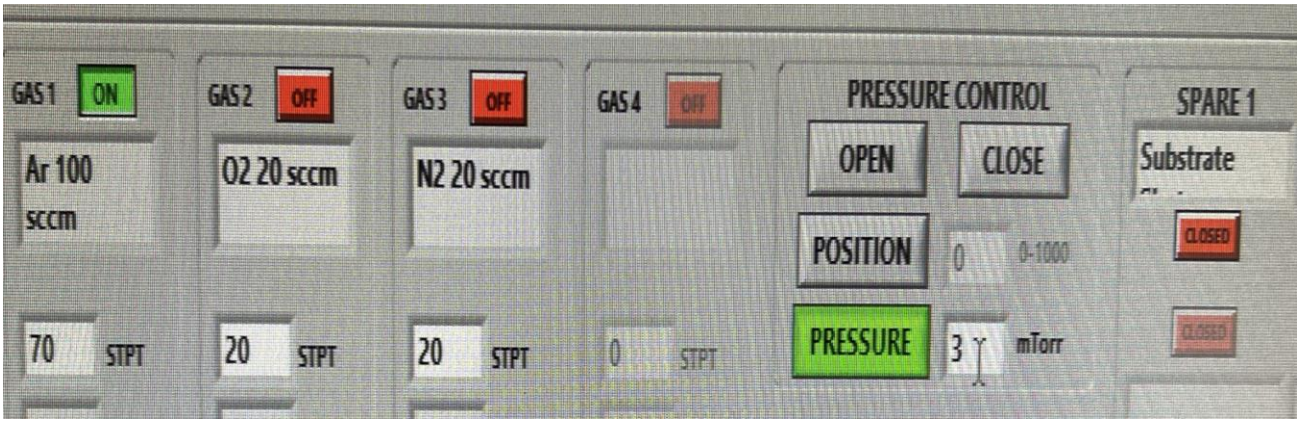


10. Skip this step if the gun is successfully excited. Wait for 20s till the power of the gun reaches 50W. If the gun is not lit as the PLASMA is grey instead of pink shown on the software screen, open the gun ***7 (or 8)*** shutter and wait for a few seconds (Note: make sure the substrate shutter is closed when doing

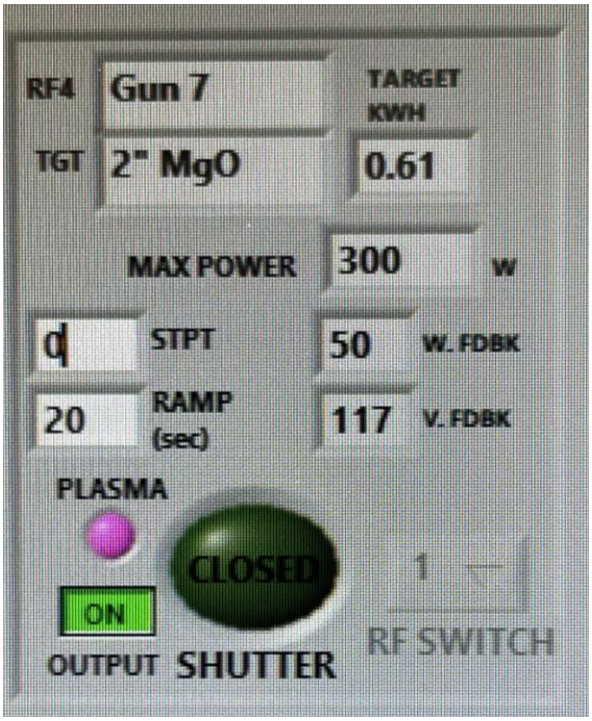
this). The gun should be excited and lit after that. Reduce the Ar gas pressure to 3 mTorr.



11. If the gun is successfully lit as shown on the software, reduce the Ar gas pressure to 3 mTorr, you can start MgO deposition by opening the substrate shutter. (Note: Generally, it takes 3mins and 30s to grow 2nm MgO at 50W and 3mTorr.)

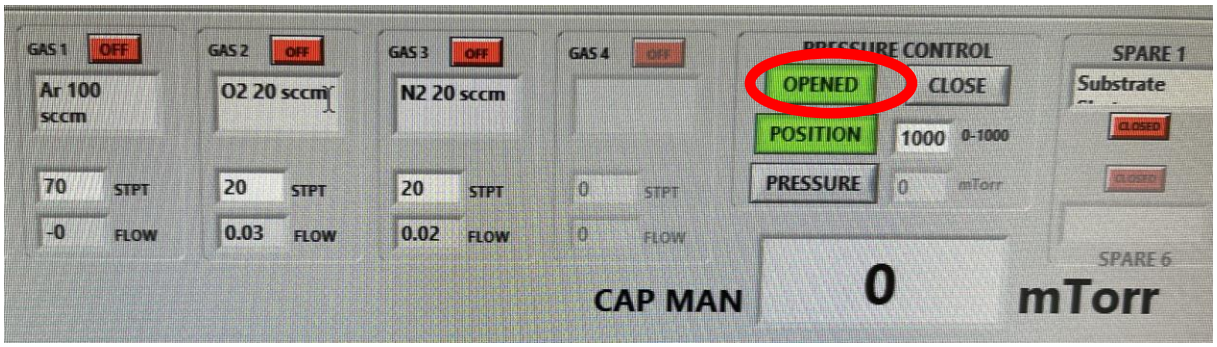


12. After you finish the deposition, enter 20 in the RAMP section as the ramp time, and enter 0 in the STPT section. After the gun is ramped down to 0, turn off the OUTPUT.



13. You will have to move the side gun ***7 (or 8)*** to the home position now. Gently and slowly rotate the knob on the gun ***7 (or 8)*** clockwise till it reaches 0 position as labelled.

14. Open the Cryo by clicking OPEN in the Pressure Control section. Then turn off the Gas1 Ar gas flow and turn off the sample rotation.
15. Take your sample out by following **Unloading a Sample**.



Unloading a Sample

1. Wait for a few minutes after deposition for the argon to be pumped out of the chamber.

2. Turn on the ion gauge and ensure that the pressure in the main chamber has fallen to a pressure that is similar to or lower than that in the load lock.

3. Open the transfer valve.

4. Extend the transfer arm all the way into the chamber, watching to be sure that it does not collide with anything as it enters.

5. Rotate the substrate holder until it is at the locked position (the rightmost circle).

6. Ensure that the substrate shutter is open.

7. Lower the substrate holder until it reaches the second line and the sample holder is resting on the transfer arm.

8. Rotate the substrate holder to the right until it reaches the unlock position and no longer rotates easily.

9. Raise the substrate holder to the maximum height, ensuring that the sample holder disengages and remains on the arm.

10. Remove the transfer arm fully from the chamber.

11. Close the transfer valve.

12. Vent the load lock by turning off the load lock pumps.

13. Once the load lock is at atmosphere, remove the lid from the load lock and retrieve the sample holder.

14. Remove your sample from the sample holder. If you are using clips to affix your sample, either remove them or make sure they are tightened so that they will not become loose and fall out.

15. Leave the sample holder back in the hood where you got it.

16. Place the cover back onto the load lock.

17. Turn the load lock pumps back on, pumping down the load lock.

18. Once the pressure begins to fall, you may leave the tool as is.

Maintenance

List of Regular Maintenance Parts

- **Cooling waterlines**
- **CTI 8200 compressor adsorber change**
- **Cryo pump helium circuit decontamination**
- **Water filters**

Maintenance records can be found in the '*Maintenance* ' folder in the '*Safety* ' folder

I. CTI 8200 Compressor Adsorber Replacement

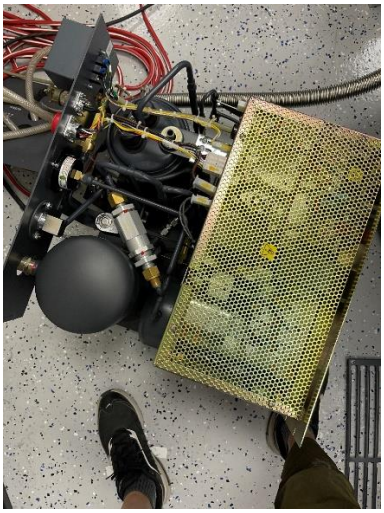
Remove the old adsorber:

1. Shut down the compressor.

2. Disconnect the compressor input power cable from its electrical power source.

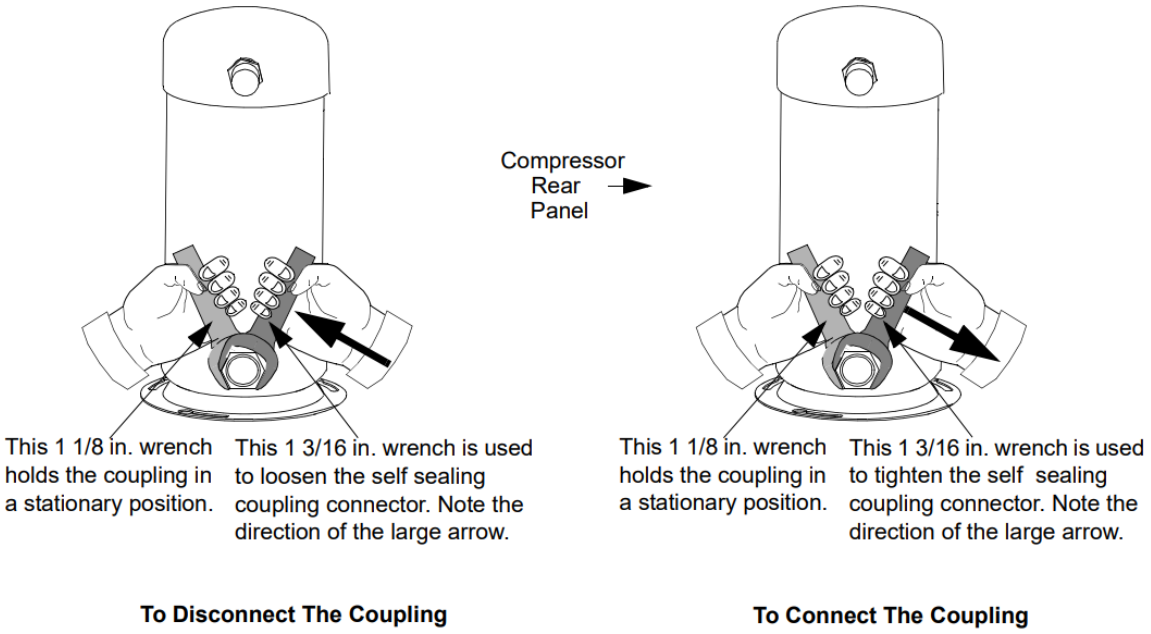
3. Disconnect the flex lines from the gas-return and gas-supply connectors at the rear of the compressor.

4. Remove the screws holding the compressor rear grille, rear panel, front panel and cover. Front and rear panels remain in place.



5. Use the two wrenches (supplied) to avoid loosening the body of the coupling from its adapter.

6. Unscrew the two self-sealing coupling halves quickly to minimize gas leakage as shown in the figure below.

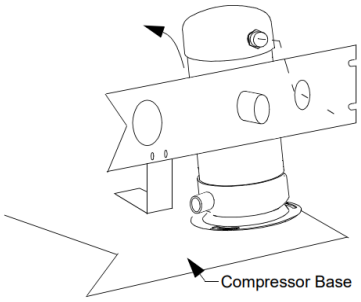


To Disconnect The Coupling **To Connect The Coupling**

7. Disconnect the adsorber-inlet self-sealing coupling as shown in Figure 4-1 (circled in red).

8. Remove the bolts, nuts, and washers that secure the adsorber to the base of the compressor. Save all nuts, bolts, and washers for installing the replacement adsorber.
   Note that the second nut is hard to unscrew, and it is recommended to unscrew it from the red arrow direction shown in the figure.

9. Carefully lift the adsorber inward until the outlet self-sealing coupling clears the rear panel and remove the adsorber as shown in Figure 4-2.

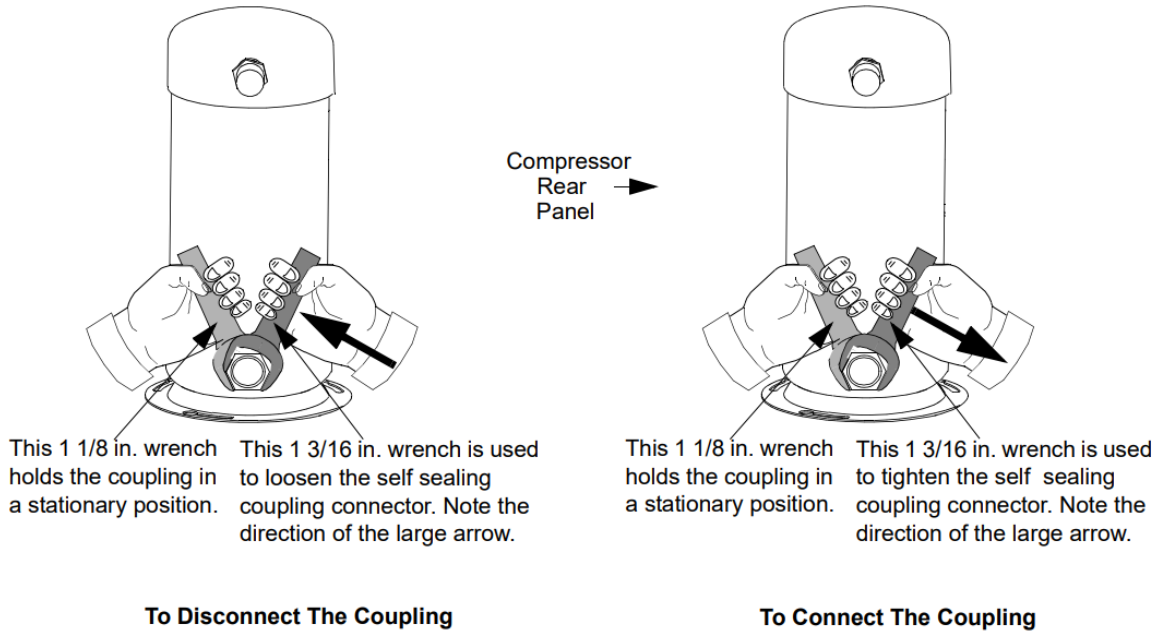


Install the new adsorber:

1. Install the replacement adsorber as follows:
   a. Remove the dust caps from the self-sealing coupling halves at each end of the replacement adsorber.

b. Write installation date on the adsorber decal.
c. Install the replacement adsorber following the steps for compressor adsorber removal in reverse order.
Use the hardware saved in step 5 above.

2. Connect the adsorber to the compressor internal piping shown in the figure below.



To Disconnect The Coupling **To Connect The Coupling**

a. Check the self-sealing connector flat rubber gasket to make sure that it is clean and properly positioned.
b. Make the first turns by hand and then firmly seal the connection using the two wrenches until the fittings “bottom”.

Caution: Make sure to hold fast on the left coupling nut while tightening the right coupling nut

3. Replace the cover and the front and rear grilles and secure them.

4. Ensure that the pressure gauge reads 245-250 psig (1690-1725 kPa). If additional gas pressure is required, follow the instructions, Adding Helium Gas.

5. Reconnect the return and supply flex lines to the compressor.

6. Connect the compressor input power cable to the electrical power source.

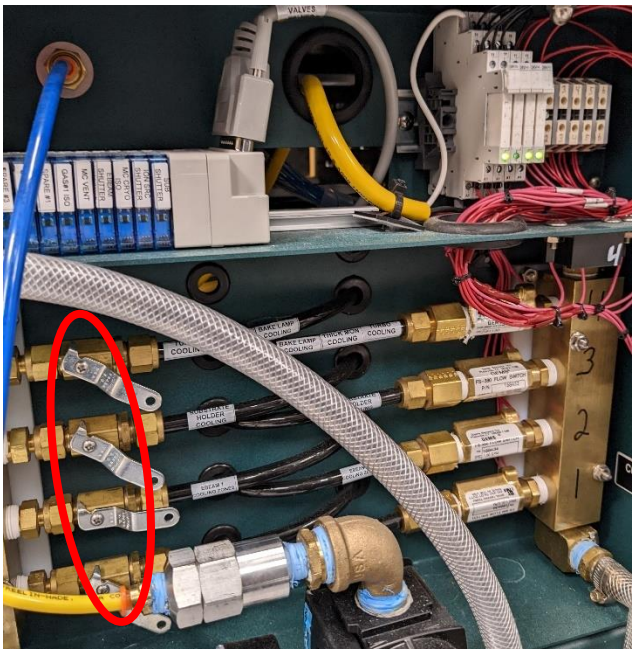
II. Turn on the system after water interlock triggered

1. Push the blue button to reset the water interlock. Then turn the Mains switch clockwise to turn the system back on.

If turning the switch does not turn the system on, the water flow is not sufficient. In that case you can check the water flow switches and valves in the back of the system. If all lights are on the system should turn back on. If one or more lights are off, try adjusting the water valves to turn all lights on.

2. Turn on the computer.

3. Turn on the ion gauge and check if the pressure is around $2x10^{-6}$ Torr. If it is higher or the ion gauge won't turn on due to overpressure, wait for the turbo pump to pump down the loadlock chamber to the approximate pressure of the main chamber. Then open the loadlock gate between the loadlock chamber and the main chamber and let the turbo pump down the main chamber to around $2x10^{-6}$ Torr.



4. Open the PHASEII software. The password is apex.
5. If the pressure in the main chamber is below $2x10^{-6}$ Torr, open the gate valve between the cryo pump and the main chamber.

6. Close the gate between the load lock and the main chamber.

III. CHANGING QUARTZ CRYSTALS

1. Follow the instructions for venting the chamber.
2. Once the chamber is vented turn the hoist switch to the right to move it up

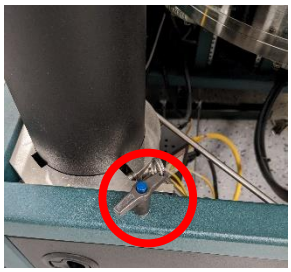
3. Push the pin through the hole in the hoist support

4. Pull the crystal down by its front plate to remove it.

5. Remove the old crystal and replace it with a new one.

6. Put the crystal with its front plate back into the assembly.

7. Clean the edge of the chamber and the camber lid with IPA to get a good vacuum seal.
8. Remove the pin from the hole in the hoist support and put it back into the hole next to the hoist.



9. Turn the hoist switch to the left to move it all the way down.

10. Follow the instructions for pumping down the chamber in the venting the chamber section.

Troubleshooting

1. Software Shutdown
You may need to restart the software if it is closed for some reason. To do, this, double click on the software's icon on the desktop. You will then be asked for a password.
Password: apex

2. Deposition Guns
If a power supply is not properly outputting power, and you are sure that it is the power supply that is not working, this can sometimes be fixed by power cycling the power supply, if you know how to do this. If you do not know how to do this, contact Jonathan or another tool manager.

3. Alignment Issues
It should be easy to transfer the sample into and out of the chamber. If it is not working smoothly, contact Shuchen or another tool manager.

4. Deposition rate
If the deposition rate is not accurate and deviates a lot from previously recorded rate on the logbook, check the crystal monitor and check if it is at the end of its life.

5.Reverse bias
When you are trying to clean the substrate by reversing the bias, if the ignition light is not on and you cannot see any plasma from the main chamber, check if the substrate rotation is turned on.

Shuchen's Contact Info:
(217)-898-3445
sl117@illinois.edu

Training documentation

Name (Printed)	Name (Signed)	Trainer	Date
Zhaoxuan Ge		Shuchen Li	08/12/2022
Ruihao Liu		Shuchen Li	09/15/2022
Zhixin Zhang		Shuchen Li	11/24/2022
Effie Gong		Shuchen Li	05/15/2023
Xiangrui Li		Shuchen Li	07/16/2024
Weiqi Du		Shuchen Li	07/16/2024
Mark Cheng		Shuchen Li	10/30/2024
Solona Chiu		Shuchen Li	11/16/2024
Chan Lee		Shuchen Li	09/10/2025