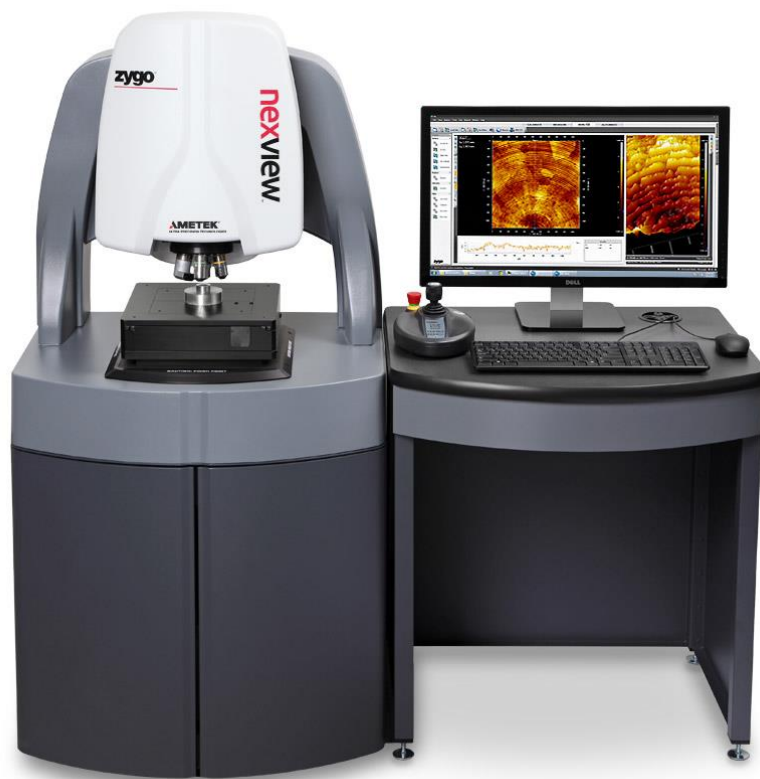


Standard Operating Procedure

UHV E Beam Evaporator



Yale West Campus Cleanroom
ywccleanroom.yale.edu

100 Cleanroom Core Facility
300 Heffernan Drive
West Haven, CT 06516

Version 2.0 June 2024

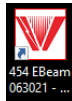
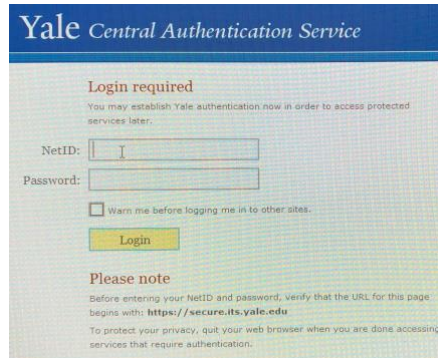
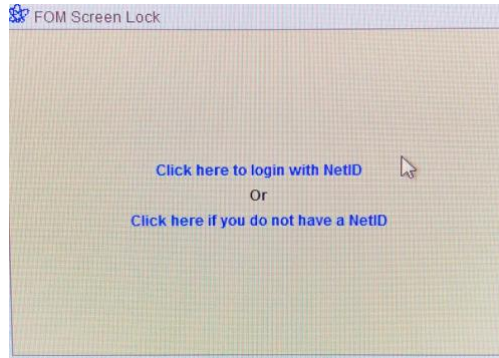
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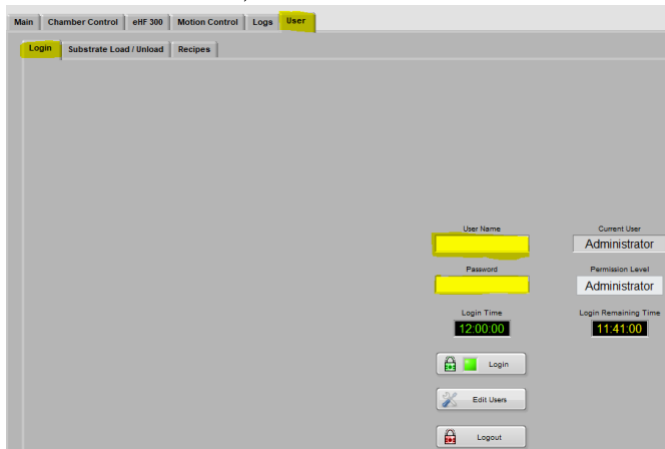
UHV Electron Beam Evaporator SOP

1. Sign-In

- 1) All users are requested sign in the logbook first. Log into your **FOM** account and reserve your time for the E Beam Evaporator.



- 2) Turn on 454 EBeam.vi software if it is not on.
- 3) In **User** → **Login** screen, type in User name and password.
User name: Manual, Password: manual

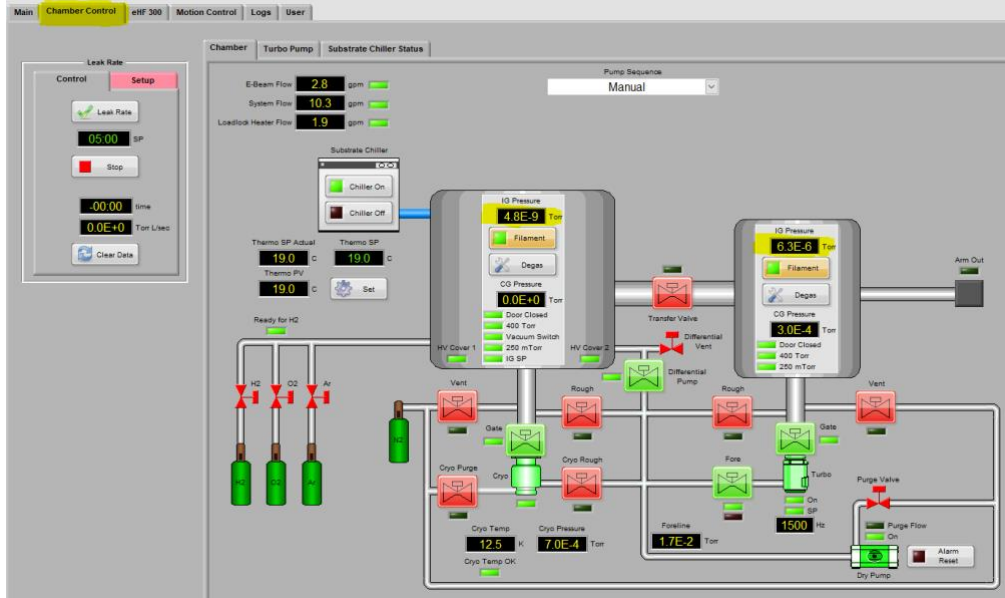


2. System check

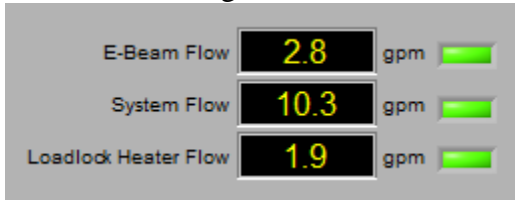
- 1) Check Cryopump Temperature is around 12.3K ~ 12.8K. Report to manager if there is any issue.



- 2) Click **Chamber Control** panel, Check the main chamber pressure is below $5E-7$ Torr.



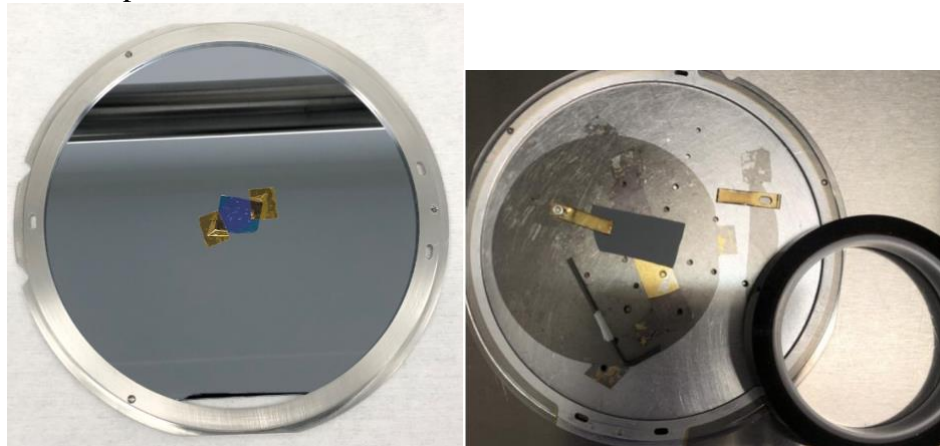
- 3) Check the cooling water flow rates as follows, The bars should be in green.



- 4) Check small load lock vacuum below $E-6$ Torr.

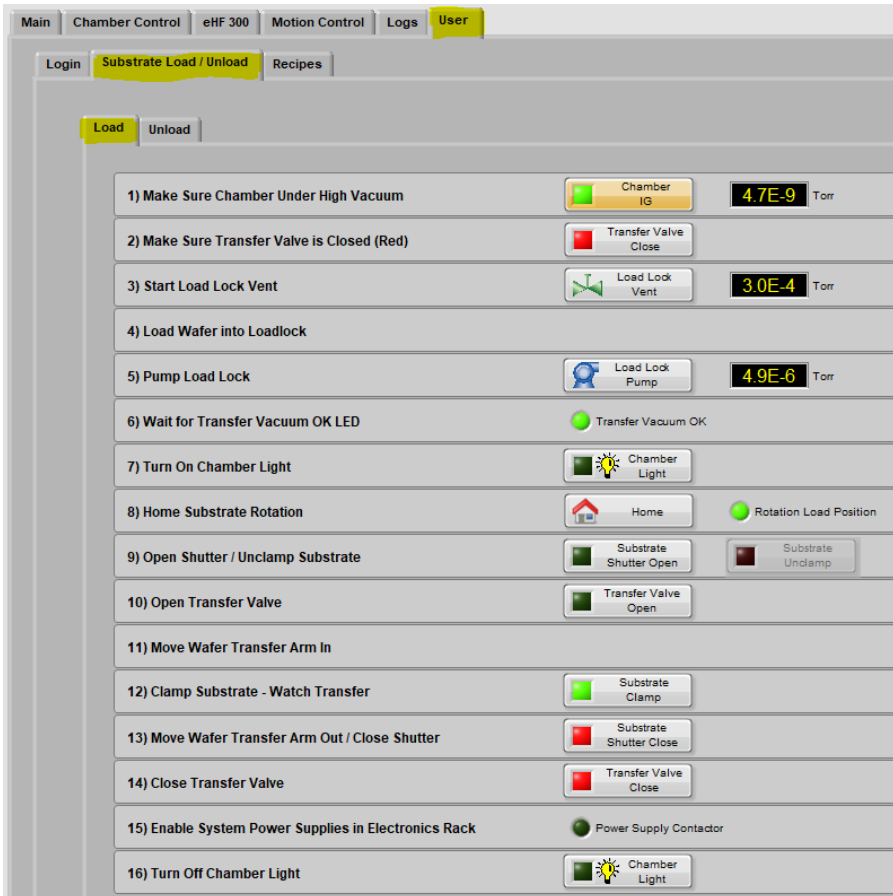
3. Mount Sample to Holder

- 1) There are two methods to mount your sample: Screws or Kapton tape.
- 2) Put your samples on substrate, prefer in the center region for better film uniformity.
- 3) If your sample is non-conductive, you can tight your samples using L-Key Screwdriver.
- 4) Mount your samples using Kapton tape. Please make sure to use as less tape as possible. If too much air is trapped by the tape, loadlock pumping time will be much longer.
- 5) Test whether samples can fall off or not.

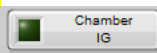
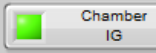


4. Load Substrate

First: Click User → Substrate Load/ Unload → Load.



- 1) Make Sure Chamber Under High Vacuum.

If  **1.0E+3 Torr** is in dark, Click it  to see the vacuum level.
 If the Chamber IG is not turn on, click it and wait for 30 sec, and then click again.
 ➤ Vacuum level should be better than 5E-7 Torr, wait until the vacuum is ready.

- 2) Make Sure Transfer Valve is Closed and in Red Color. Click the icon .

- 3) Start **Load Lock Vent** by clicking .

➤ You should hear the sound of pneumatic valve.

➤ Check whether the vacuum value  **7.2E+2 Torr** is increased.

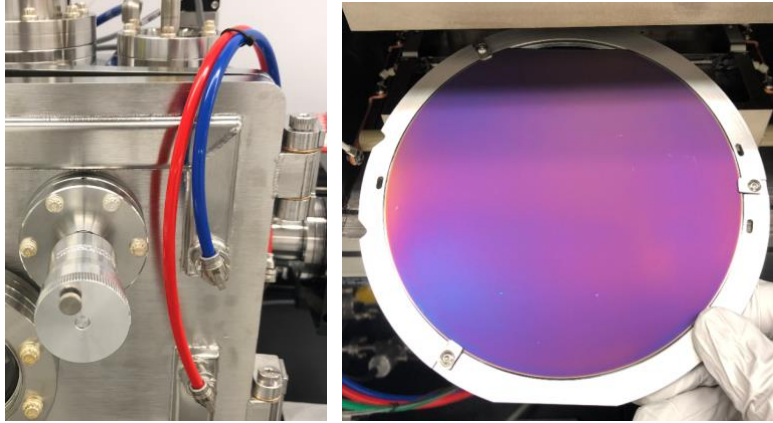
➤ The door should open automatically after 2 mins, and you can hear the leakage sound.

- 4) Load wafer into Loadlock.

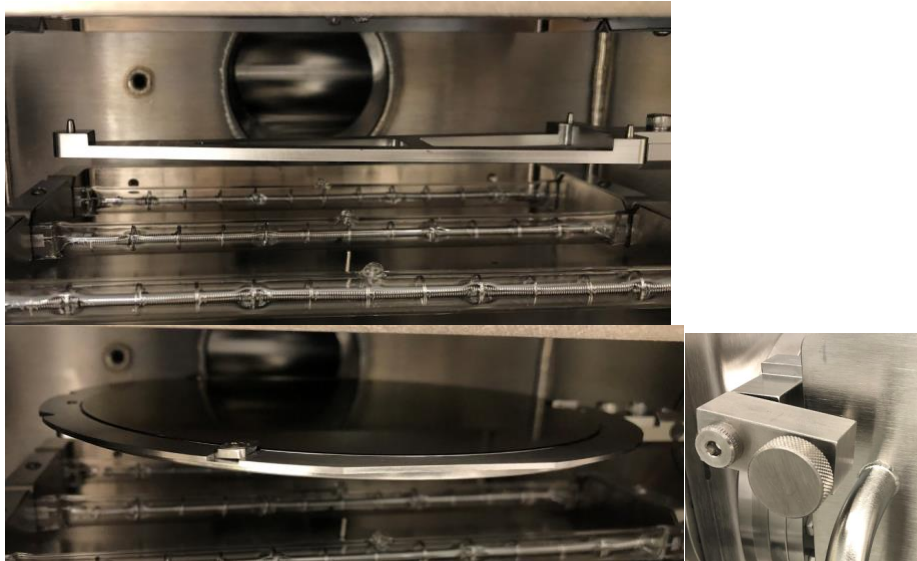
➤ Slowly open the door. Do Not bend the tubing.

➤ Flip the substrate holder with your sample facing down.

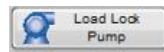
➤ Hold the substrate holder as following orientation: The end with One hole at left, the other end with two holes at right.



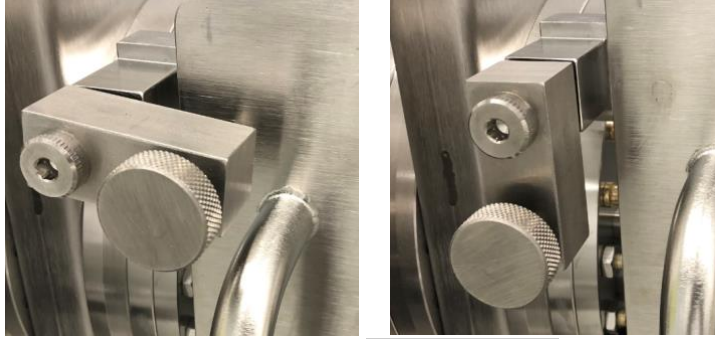
- Put substrate holder on transfer arm with left side first.
- Slowly move the right side to find the two pins.
Do not hit any lamp. Do not push the holder down.
- Double check the holder is properly load With all three pins in the holes.
- Close the door.
- Tight screw gently. Never too tight.

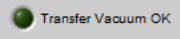


5) Pump Load lock by clicking [Load Lock Pump](#)



- You should hear the sound of pump started.
- The locker will fall off.
- The vacuum should drop quickly.
- Double check whether there is a gap in the window and chamber. Push the window to make sure it seals very well.



6) Wait for Transfer Vacuum OK,  LED should become green

 after 15 minutes.

7) Turn on Chamber light by clicking



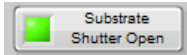
8) Home Substrate Rotation by clicking

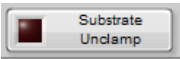
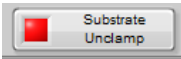


. It Should be green.

9) Open shutter/unclamp substrate.

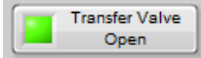
➤ Click  to open substrate shutter, this icon should become green



➤ Click  to unclamp substrate. This icon should be in Red 

➤ You can check the shuttle and clamp from the front window and left window.

10) Open Transfer Valve by clicking . The icon should become green



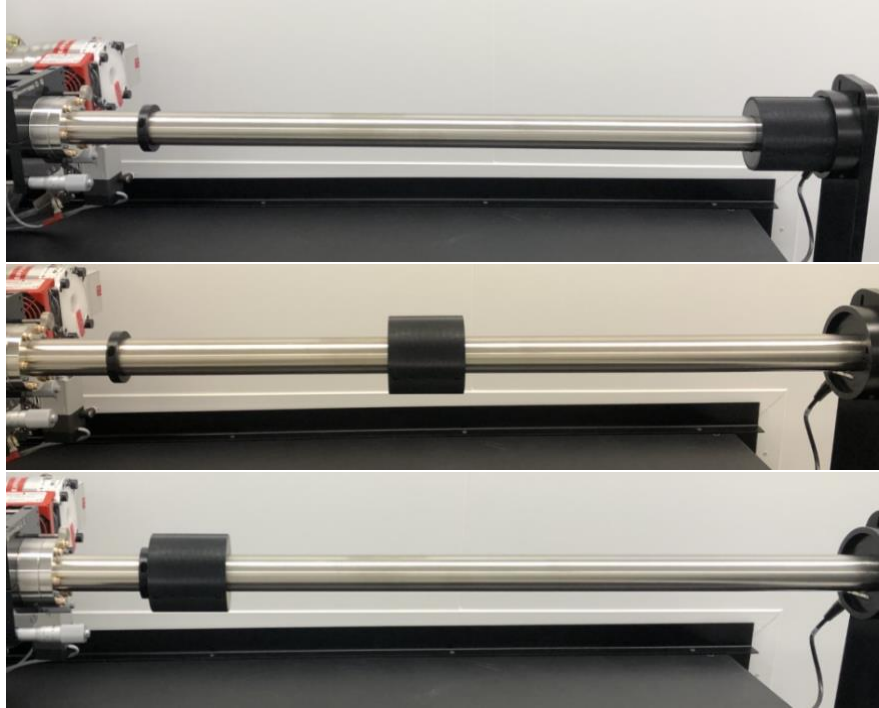
. You should hear the sound of pneumatic valve open.

Note: If the  is not turn green. Please check whether the black knob is at right end.



11) Move Wafer Transfer Arm In.

- Slowly move the black knob to middle point.
- Check the location of your substrate from chamber front window and left-side window.
- Continue move the black knob to the end of arm where the stopper located.
- Check the location of your substrate from chamber front window and left-side window.



12) Clam Substrate – Watch Transfer. Click  , the clamp should push the substrate to stage.


13) Move Wafer Transfer Arm Out/Close shutter.

➤ Slowly move the black knob out till the end. Make sure the black knob touch the end. Otherwise the Transfer Valve won't close.

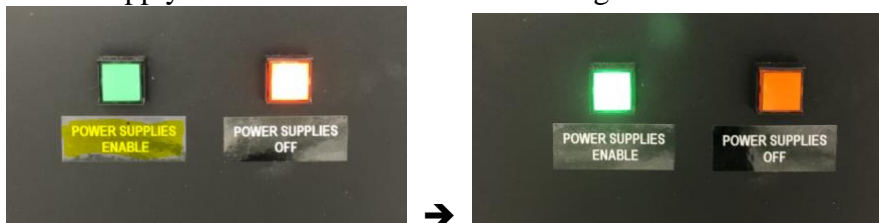
➤ Click  , it should become red.


14) Close Transfer Valve by clicking  . The icon should become red.

Note: If the  is not turn green. Please check whether the black knob is at right end.

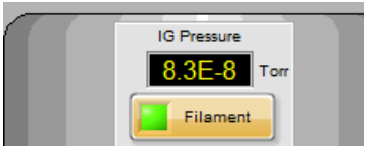
15) Enable System Power Supplies in Electronics Rack by pressing the switch  on PLC Control Chassis panel.

➤ Power supply Contactor LED should become green.




16) Turn off Chamber light by clicking  .

5. Ar Cleaning

Please make sure IG pressure  is ON.
Otherwise  is not ON.

- 1) Make sure Power Supplies Enable  on PLC Control Chassis panel is in **Green**.
- 2) Click **eHF 300** button to check the Ion Clean programs. **No action is needed, just explanation.**

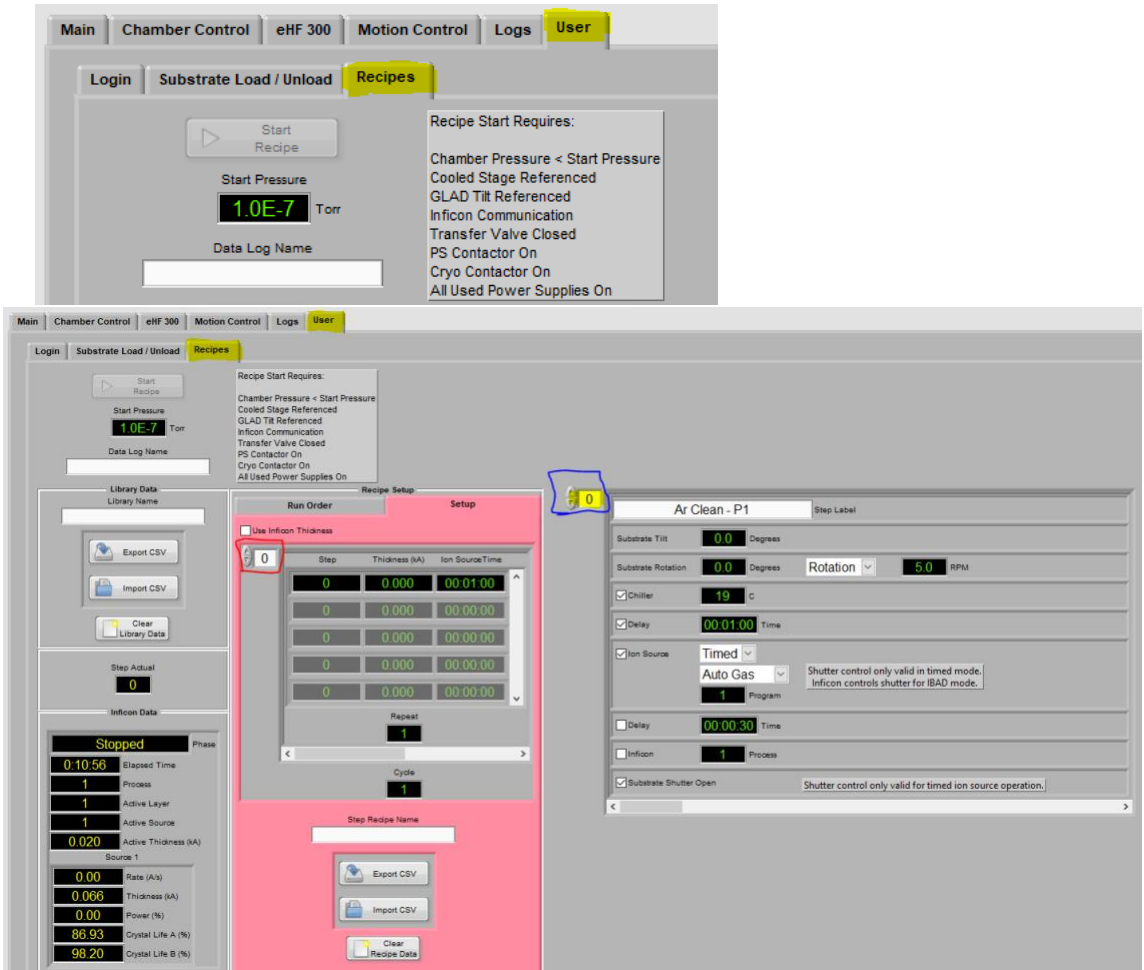


The screenshot shows the 'eHF 300' control interface with the following data:


Program	Gas 1 (H2)	Gas 2 (O2)	Gas 3 (Ar)	Discharge Volts	Discharge Amps	Emission Amps
Program 1	0.0	0.0	40.0	50.0	2.00	2.00
Program 2	0.0	0.0	20.0	100.0	2.00	2.00
Program 3	0.0	0.0	40.0	50.0	2.00	2.00
Program 4	0.0	0.0	30.0	0.0	0.00	0.00

Additional interface elements include: 'Auto Gas' dropdown menu, 'Set Gas Mode' button, 'Run' button, 'Stop' button, 'Help' button, and 'Remote Control' button.

- (a) There are only 4 Ion Clean programs, users are not able to edit these parameters.
 - (b) You can choose the best matched program and then optimize the etching time.
 - (c) Program 1 is Ar etching, with 50V as Discharge Volts, 2A as Discharge Current, 40sccm Ar flow rate. (recommended)
 - (d) Program 2 is Ar etching, with 100V as Discharge Volts, 2A as Discharge Current, 20sccm Ar flow rate.
 - (e) Program 3 and 4 are for other gas etching.
 - (f) Here Auto Gas is selected. This will adjust flow rate to reach Discharge Volts and Current.
- 3) Click **User** → **Recipes** to find the program.





4) In the right side, you see the auto program of Ion Cleaning.

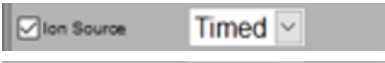
5) Click up or down arrow  to select the one you need.

6) Here **0 Ar Clean-P1** is recommended for Ar cleaning. These parameters are not editable.


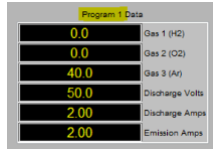
(a)  Substrate Rotation is in 5 RPM.


(b)  Chiller is running at 19C to cool the stage.

(c)  1 min delay before Ar etching.

(d)  You can edit etching time on Recipe Setup shortly.

(e)  Auto gas mode is on to tune flow rate.

(f)  Program 1 is used, which is 

(g)  The second delay. 30 Sec of Ar cleaning before shutter to open.

- (h)  Substrate shutter will open.

7) Recipe Setup. **(Your action starts from this step)**

- (a) Click **Setup** in **Recipe Setup**.

- (b) Click .

- (c) Click Step and type program you need. Here for Ar Cleaning type 0. This will use

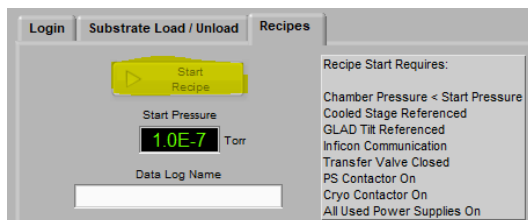
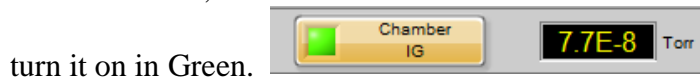


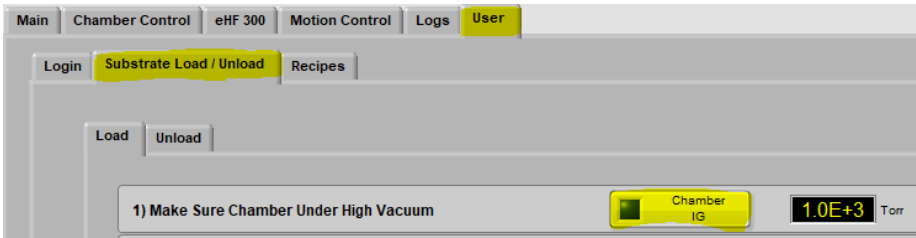
- (d) Click Ion Source Time and type in etching time, here shows 00:01:00. (60 sec)



8) Start Etching.

- Check **Start Recipe**.
- If this is not on, click **User** → **Substrate Load/ Unload**, then click **Chamber IG** to

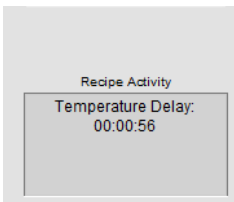




9) Turn off Chamber Light if it is on.

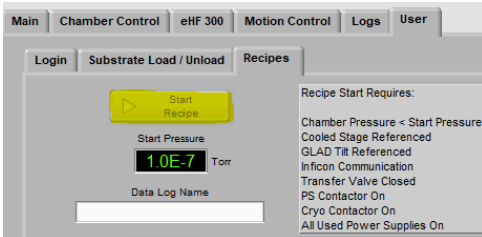


10) Watch the etching or Recipe Activity shown at bottom left window.



11) Watch the Ion process from the front window of main chamber.

12) When the process ends, the icon of Start Recipe becomes grey again because the vacuum level was above 1.0E-7 Torr. You need to wait for a better vacuum for next step.



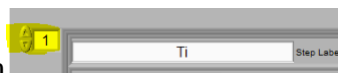
6. Metal Deposition (Auto Mode)

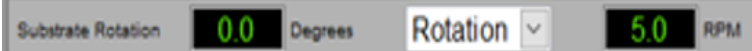


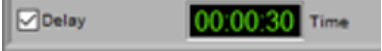

The deposition process is using an auto program. The program has been set at a constant deposition rate; User only needs to type in the thickness.

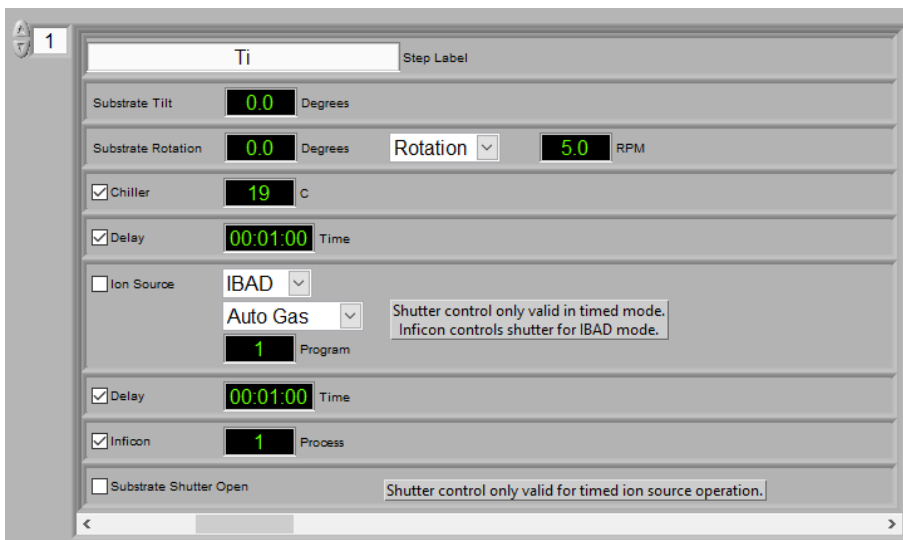
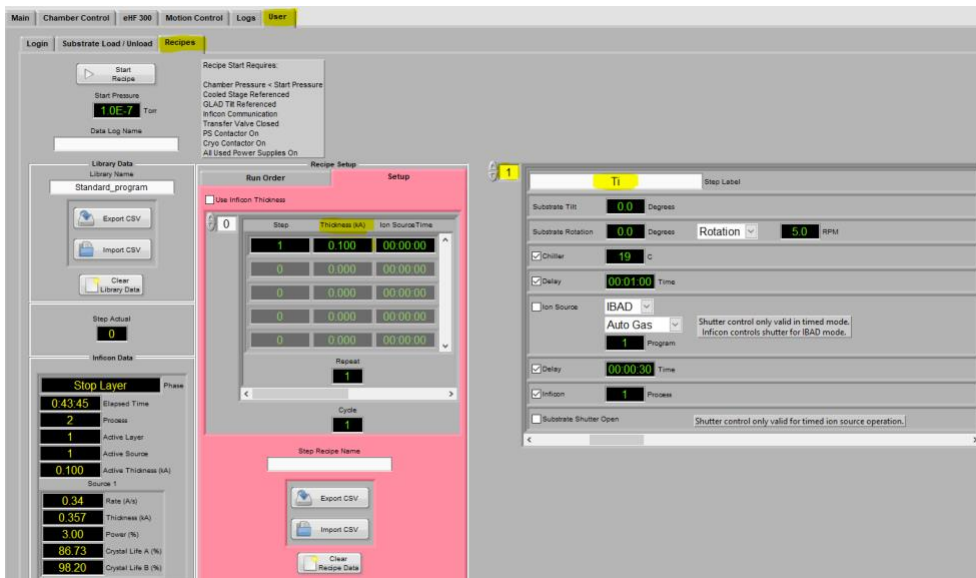
1) Click **User** → **Recipe**.

2) Click Up or Down arrow to select program

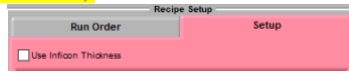
Here we take Ti deposition as an example: **(No action is needed)**



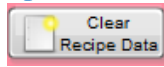
- (a)  Substrate Rotation is in 5 RPM.
- (b)  Chiller is running at 19C to cool the stage.
- (c)  1 min delay before deposition.
- (d)  The second delay. 30 Sec before shutter to open.
- (e) . Here 1 refers to the INFICON Deposition Controller program. Which has set all the parameters for Ti, including power range, ramp time, pocket number and so on.



3) Recipe Setup (Your action starts from here)



- Click Setup in Recipe Setup
- Click Clear Recipe Data
- Type 1 in Step, which will use the program 1 of Ti. Similar to other metal deposition.
- Type the Thickness value, here is 0.100 kA.
- Leave Ion Source Time as 0.



4) Change INFICON Deposition Controller to the corresponding program.



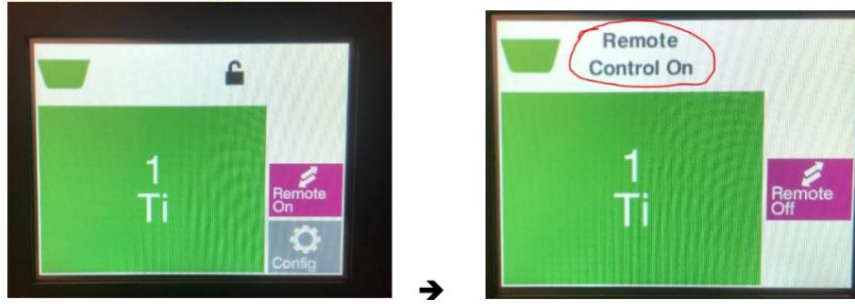
- Click Next Menu.
- Click Process Menu.
- Select process you need by scrolling the knob.
- Then click Select.
- Click Main Screen to go back. Your layer such as Cr: Layer 1 of 1 must be shown on screen.
- Click Next Menu again.
- Click Manual/ Auto button to change to Auto/Manual. This will change to Auto mode. This is very important.



5) Set Pocket Indexer Controller.

- Touch the screen of Pocket Indexer Controller if it is dark.
- Click Remote On button to switch to Remote mode.
- Remote Control On should be shown. The final status is displayed as the right picture.

Note: Here the pocket in screen may be not the one you want, the program will automatically rotate when you start the deposition.

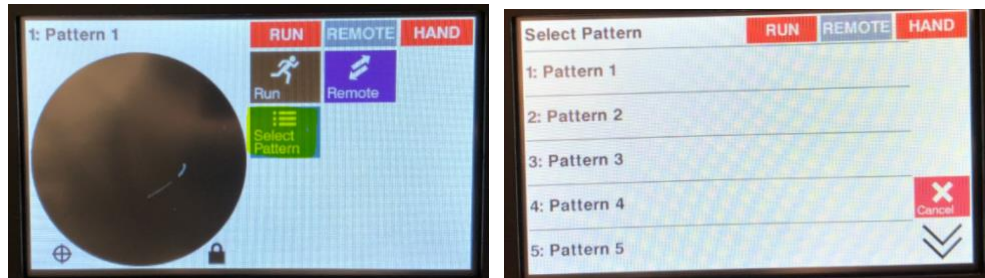


6) Choose correct pattern in Programmable Sweep panel.

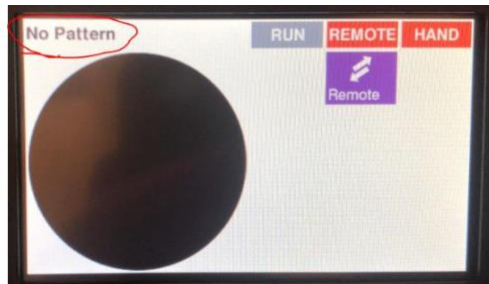
a) Touch the screen if it is dark.

b) Click **Select Pattern** . Click Remote first if you didn't see .

c) Click the correct Pattern.



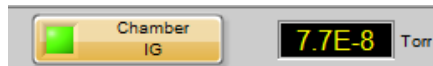
d) One pattern is select, click **Remote**. The final status is shown below. It shows **No Pattern**.



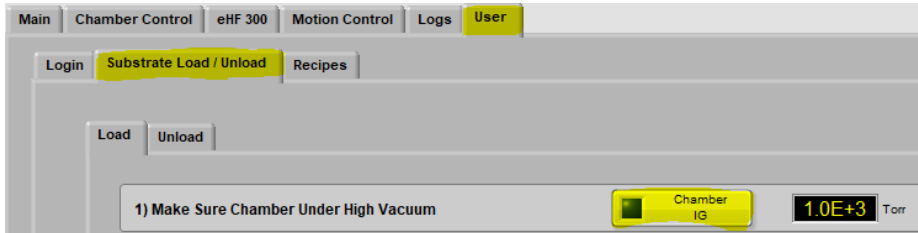
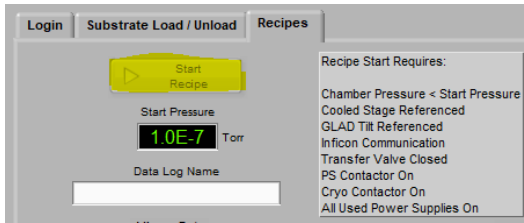
7) Start Deposition.

➤ Check **Start Recipe**.

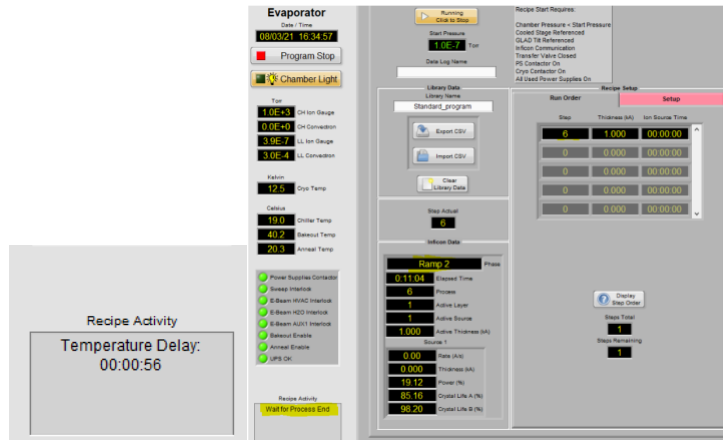
➤ If this is not on, click **User** ➔ **Substrate Load/ Unload**, then click **Chamber IG** to turn it on in Green.



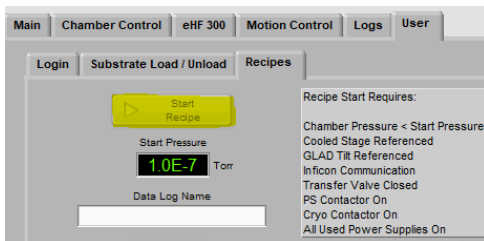
➤ In addition, the vacuum level must be better than 1.0E-7 Torr.



- 8) Watch the Recipe Activity shown at bottom left window.
- During the process, the power will increase to set point, but the source shutter is not open so we cannot see any rate.
 - The source shutter is open after soak 1 or 2, then the substrate shutter is open after 5 sec.



- 9) Click Next Menu → Next Graph → Next Graph → Next Graph to switch to big power window.
- 10) Watch the deposition process from the front window of main chamber.
- 11) When the process ends, the icon of Start Recipe becomes grey again because the vacuum level was above 1.0E-7 Torr. You need to wait for a better vacuum for next step.



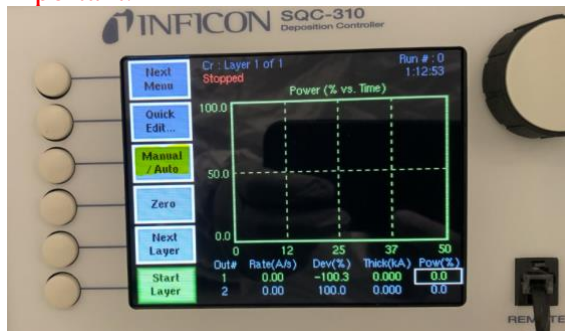
7. Metal Deposition - Manual Mode (Recommended)

1) Change INFICON Deposition Controller to the corresponding program.


- a) Click Next Menu and Next Menu.
- b) Click Process Menu.

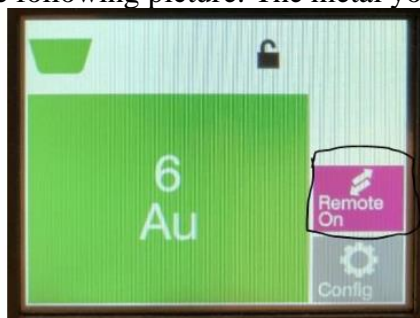


- c) Select process you need by scrolling the knob.
- d) Then click Select or press the knob.
- e) Click Main Screen to go back. Your layer such as Au: Layer 1 of 1 must be shown on screen.
- f) Click Next Menu again.
- g) Click Auto/Manual button to change to Manual/Auto. This will change to manual mode. **This is very important.**




2) Set up Pocket Indexer Controller.

- a) Touch the screen if it is dark.
- b) If it is in Remote Control On mode, click 
- c) Click the green region of panel.
- d) Select the metal pocket, for example 6 Au pocket.
- e) Wait until the pocket is done with rotation.
- f) You should see the following picture. The metal you need must be shown.



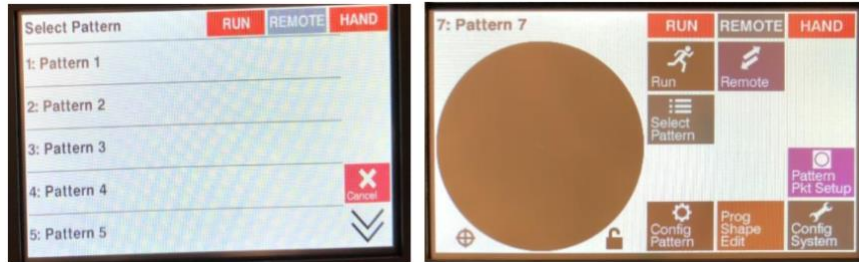
3) Choose the correct pattern in Programmable Sweep panel.

a) Touch the screen if it is dark.

b) Click **Remote** if you did not see .

c) Click **Select Pattern** .

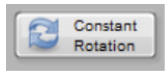
d) Click the correct Pattern by name.

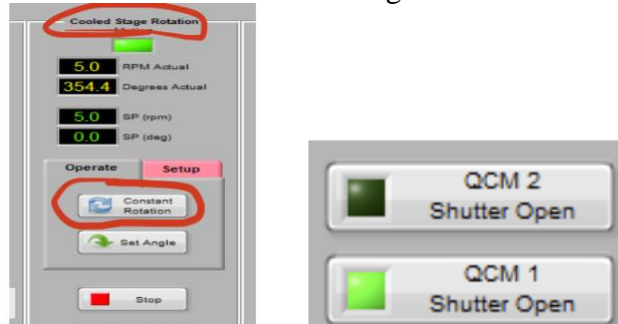


4) Set Rotation for Cooled Stage.

a) Click **Main**



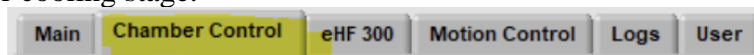
b) Click  to start stage rotation in Cooled Stage Rotation



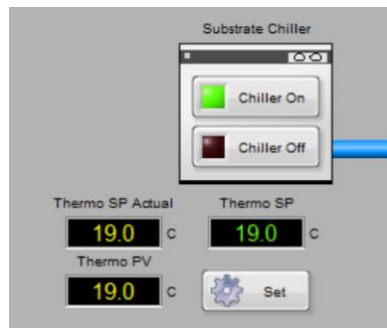
5) Quartz Crystal Setup. Double check Quartz Crystal 1 QCM1 is in green.

6) Check **Chiller On** for cooling stage.

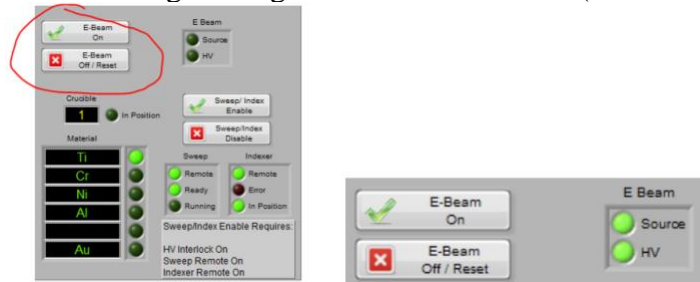
In **Chamber Control**



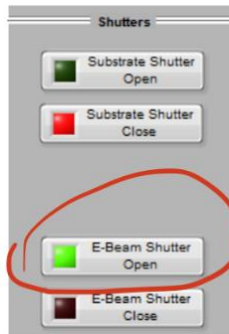
Check **Chiller On** is in green and the Thermo SP Actual is 19C, shown below.



- 7) Turn on E Beam voltage.
 - a) Click the **Main** menu window (right side)
 - b) In the right side, Clicking **E-Beam On** button to turn on 10kV.
 - c) Check the high voltage is increased to 10kV (or 9.99kV).



- 8) Open E-Beam Shutter (In Main menu window, bottom left side) by clicking **E-Beam Shutter** open.



- 9) Manually increase power by pressing PWR Up button.
 - a) The power for gold at 1A/sec is around 7 ~ 9%, it may change depending on the volume of gold in crucible.
 - b) Slowly increase the power to 7% in 6min, **2~3 sec for 0.1% power increase.**
Note: Never increase power without any pause, big particles may spill out.
 - c) Check the beam spot during the power increase. Make sure it hits the center of gold pocket.
 - d) Maintain the 1A/sec deposition rate by tuning the power. Power should be no more than 25%.

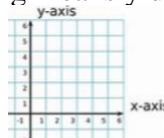
- 10) Adjust e beam spot location and amplitude.

- a) Check the e beam spot during the deposition, make sure it is in the center of crucible liner. **Have to make sure the e beam hits the center of gold pellet, not on the bottom or sidewall of crucible.**



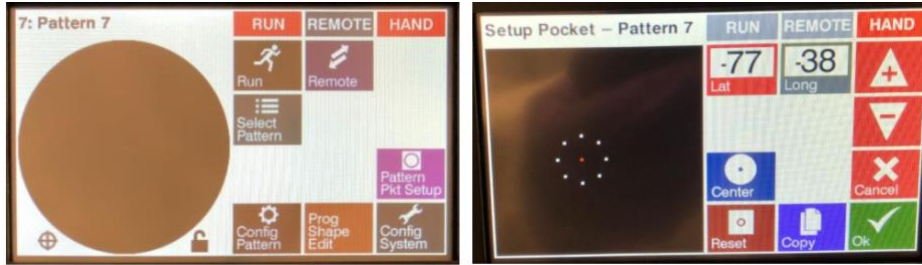
- b) Adjust the location if needed by clicking **Pattern Pkt Setup**
Password: 1234
- c) Select **Lat** first, then click + to move right, or – to move left.
- d) Select **Long**, Click + to move beam up, or – to move beam down.

Note: Lat means x direction, Long means y direction. Highlight Lat or Long, then

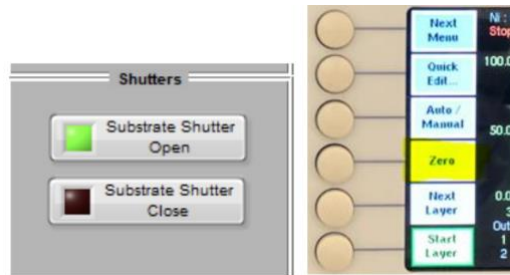


click + or -to change the value,

- e) Click **Ok**. Check whether the e beam moves as you expected. Repeat again if needed.



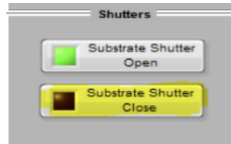
- 11) Click **Substrate Shutter Open** and click **Zero** to start deposition.
- Click **Substrate Shutter Open** button to open the substrate shutter.
 - Click **Next Menu** → **Next Menu** → **Zero** on INFICON Controller to set thickness to zero.



Wait for the deposition.....

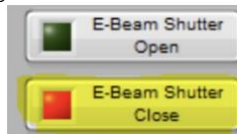
When deposition is done, take the following actions:

- 12) Click **Substrate Shutter Close** when the thickness is reached to your value.

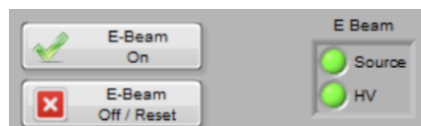


- 13) Lower the Power relatively quick to Rate is ~0%, then slowly lower the power to 0% using **PWR Down** button. Every 3 sec for 0.1% down.

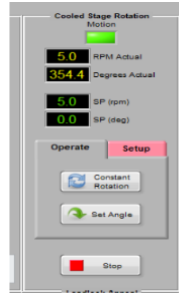
- 14) Close E-Beam Shutter by clicking **E-Beam Shutter Close**.



- 15) Turn off 10kV by clicking **E-Beam off/Reset** button. You should see the high voltage is decreased to 0 kV.



- 16) Turn off stage rotation by clicking **Stop** in Cooled Stage Rotation.



8. Unload Sample

- Before unloading the sample, check the load lock chamber, make sure it is empty inside.
- Click Power Supplies OFF on PLC Control Chassis panel to turn off power. Power supplies OFF LED should become red.


1) Make Sure Chamber Under High Vacuum. Click  to see the vacuum level.
 ➤ Vacuum level should be better than E-8 Torr, wait until the vacuum is ready.

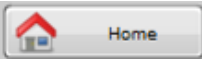
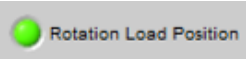
2) Make Sure Transfer Valve is Closed and in Red Color. Click the icon  if not red.

3) Make sure Transfer Arm is Empty and Pump Loadlock.

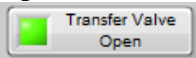
Note: If transfer Arm is not empty, jump to step 13 to vent the load lock.

4) Wait for Transfer Vacuum OK,  LED should be in green.

5) Turn on Chamber light by clicking .

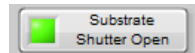
6) Home Substrate Rotation by clicking  . It Should be in green.

7) Open Transfer Valve by clicking . The icon should become green

. You should hear the sound of pneumatic valve to open.

8) Open shutter and Move Wafer Transfer Arm In.

➤ Click  to open substrate shutter, this icon should become green



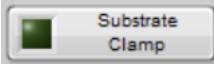
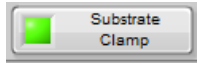
- Slowly move the black knob to middle point,
- Check the location of your substrate from chamber front window and left-side window.
- Continue move the black knob to the end of arm where the stopper located.
- Check the location of your substrate from chamber front window and left-side window.

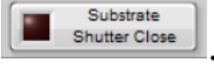
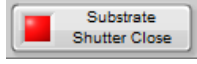
9) Unclamp Substrate – Watch Transfer. Click  , the clamp should release the substrate to transfer arm.

10) Move Wafer Transfer Arm Out.

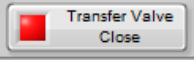
- Slowly move the black knob out till the end. Make sure the black knob to touch the end. Otherwise the Transfer Valve won't close.

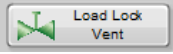
11) Clamp Substrate/Close Shutter.

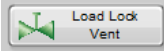
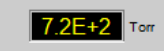
- Click  , the icon should become green  , the clamp should move up to stage.

- Click  , the icon should become red  to close substrate shutter.

12) Close Transfer Valve by clicking  . The icon should become red

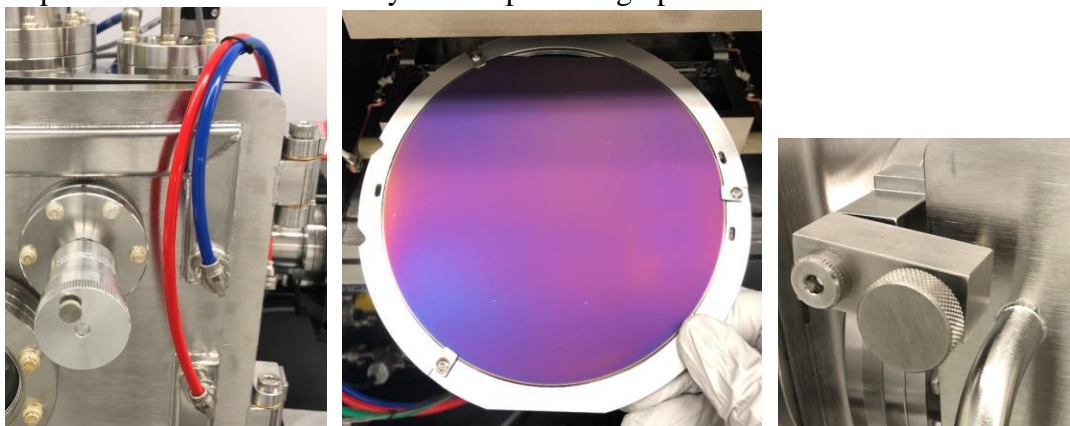
 . You should hear the sound of pneumatic valve to close.

13) Vent Load Lock by clicking  .


- The door should open automatically after 2 mins   , and you can hear the leakage sound.

14) Remove Wafer from Load Lock.

- Slowly open the door. Do Not bend the red and blue tubings.
- Lift the substrate holder a little bit and take out from loadlock chamber.
- Flip the substrate holder with your sample facing up.




- Close the door.
- Tight screw gently. Never too tight.

15) Pump Load lock by clicking  .

- You should hear the sound of pump to start.
- The locker will fall off.



16) Turn off Chamber Light and PS Contractor in Electronics Rack.

➤ Click  to turn off light.

➤ Press the  button to turn off if the power is still on.



9. Log Out System and FOM

- 1) Please check the vacuum level of loadlock, it must be smaller than 10-5 Torr.
- 2) Make sure POWER SUPPLIES OFF.
- 3) Remember to sign in logbook and record your metal thickness and deposition rate.
- 4) Log out FOM and **type the thickness of gold if you used gold.**