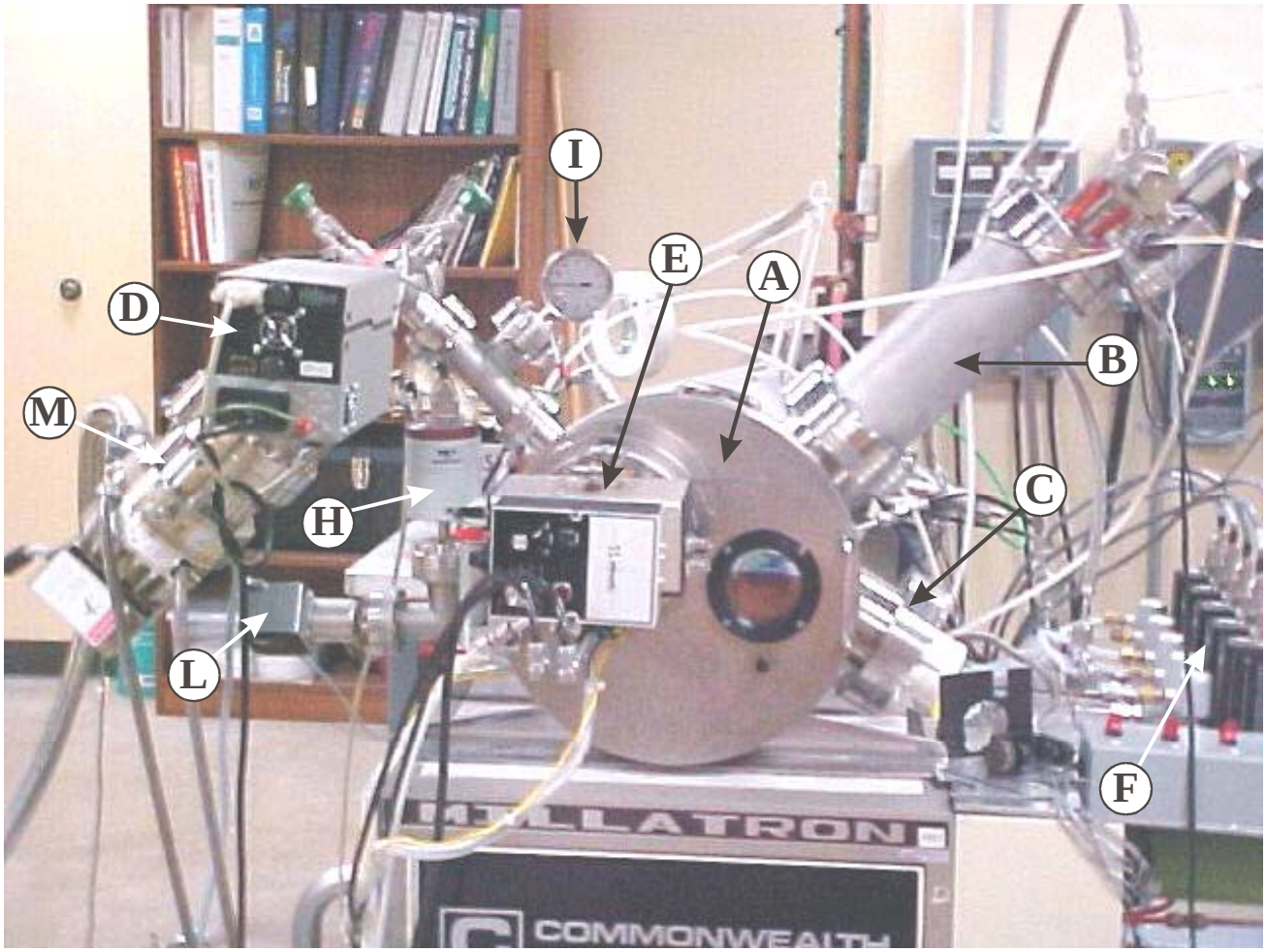
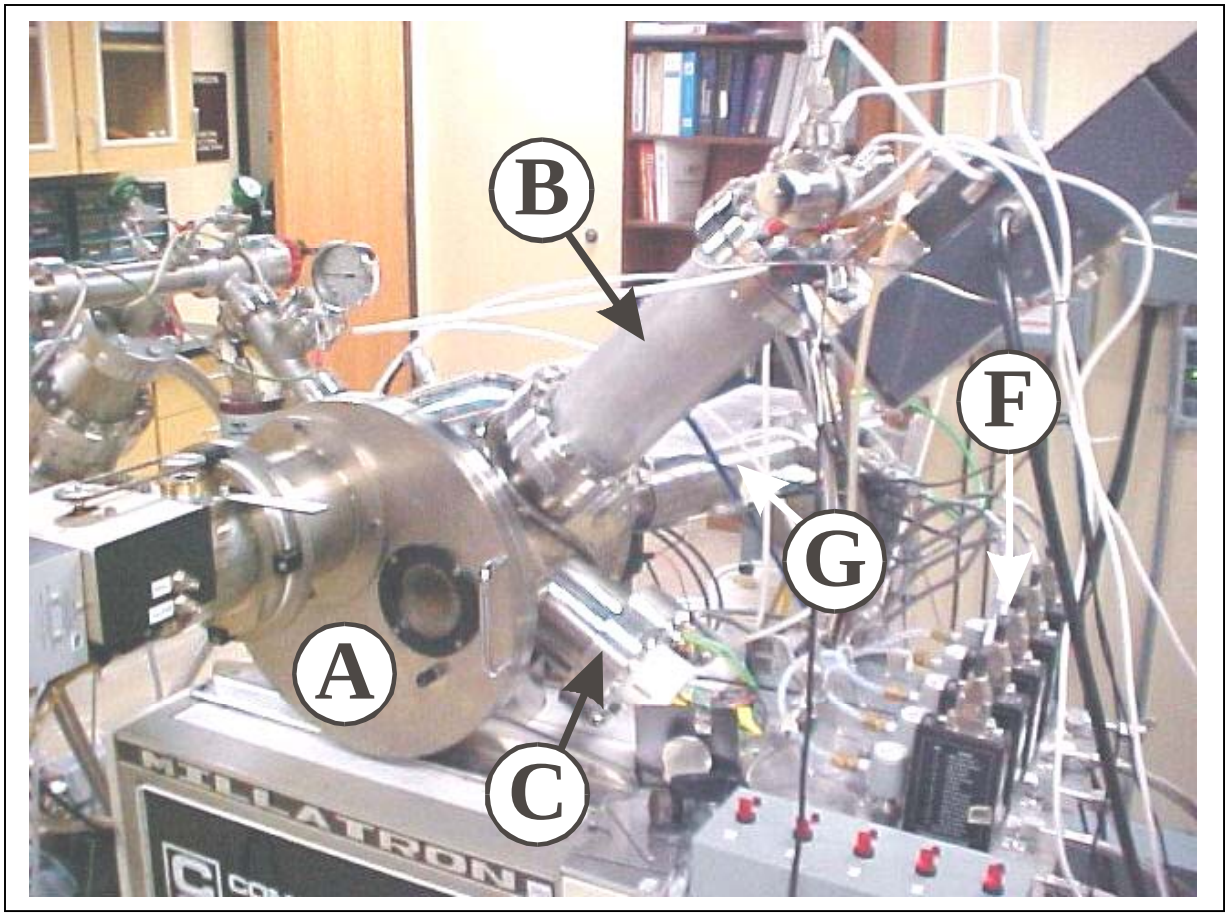
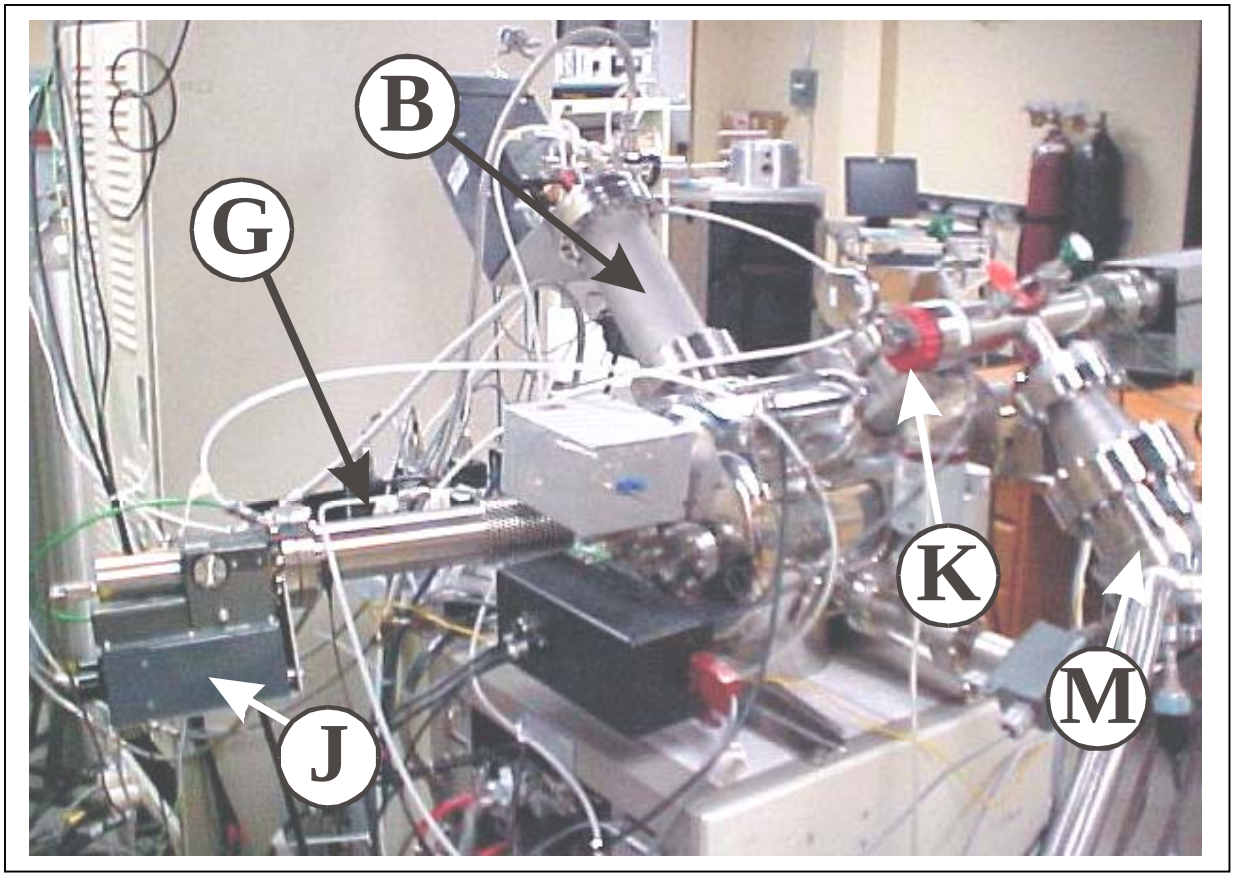
Ion Beam Sputtering System

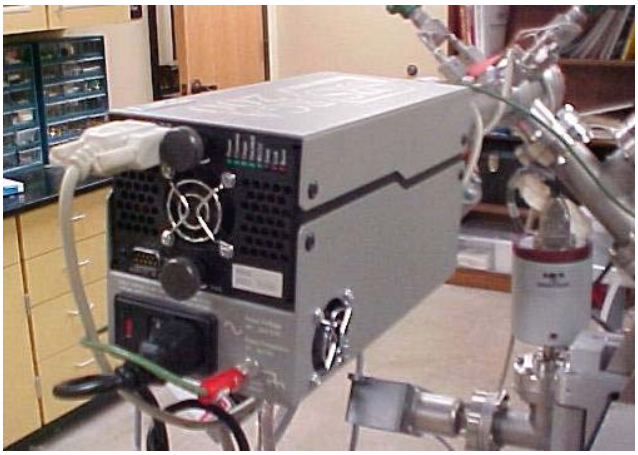
System

A. Process Chamber
B. Primary Ion Beam Source (RF ion source - Oxford)
C. Secondary Ion Beam Source (Assist source - Kaufman)
D. Residual Gas Analyzer (RGA)
E. Substrate Motor Controller
F. Mass Flow Controllers (MFC)
G. RF Atom Source
H. Baratron Pressure Gauge
I. Bourdon Pressure Gauge
J. RF Atom Source Tuner (Load-left knob, Tuner-right knob)
K. Turbo Pump Valve
L. Thermocouple
M. Turbo Pump

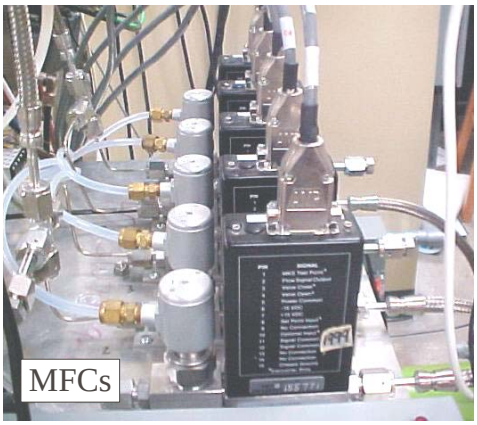


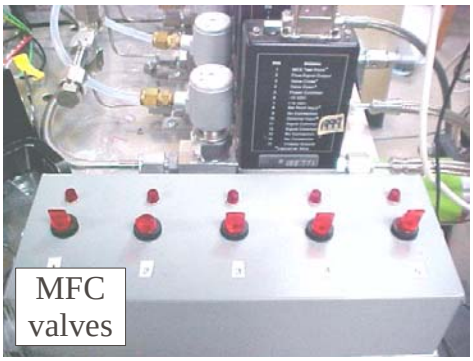

B
F
G
A
C


B
G
K
M
J



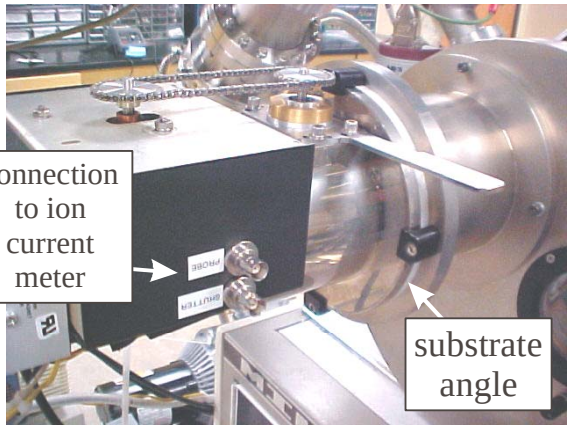
Residual Gas Analyzer (RGA)



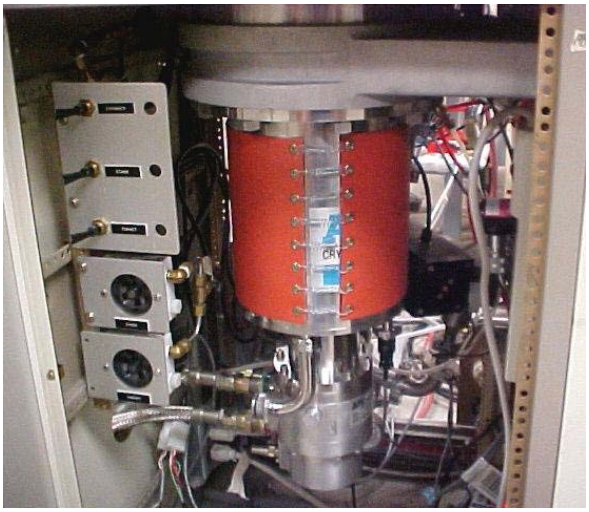


Mass Flow Controllers (MFC)

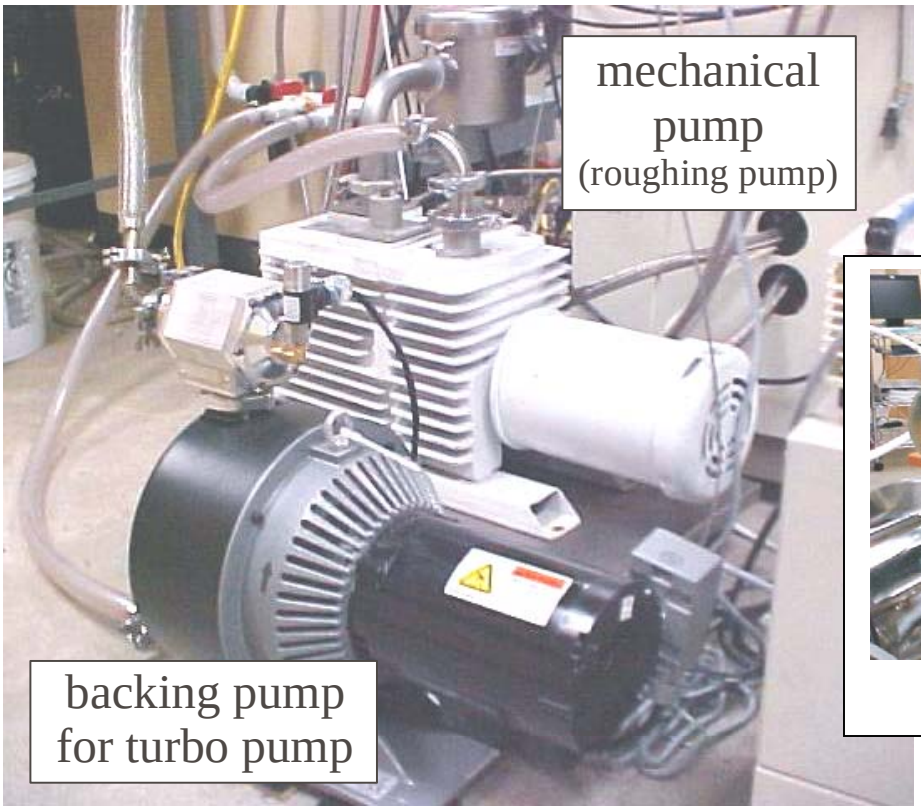
Shutter Housing Pump



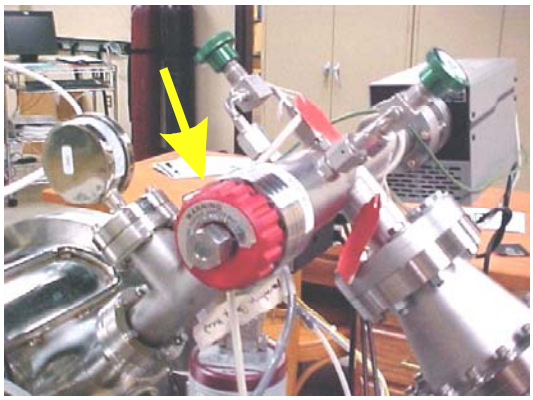
Substrate Motor Controller



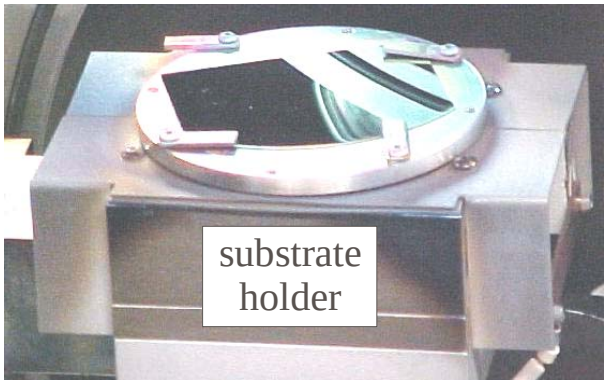
Cryo Pump (High Vacuum Pump)

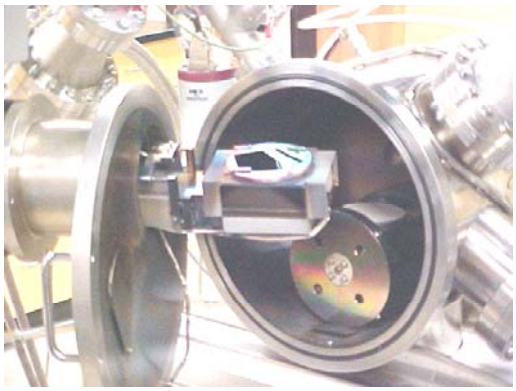


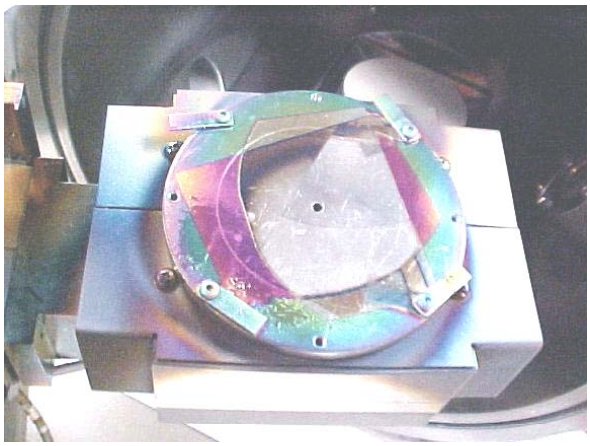
Pumps

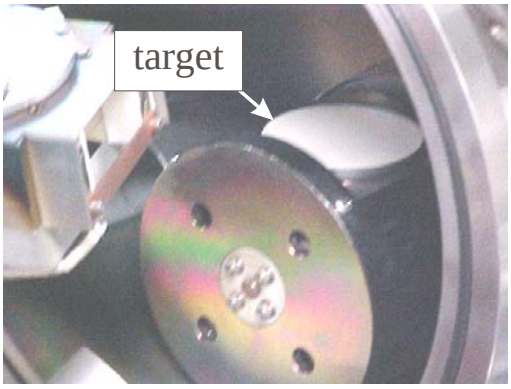


Turbo Pump Valve





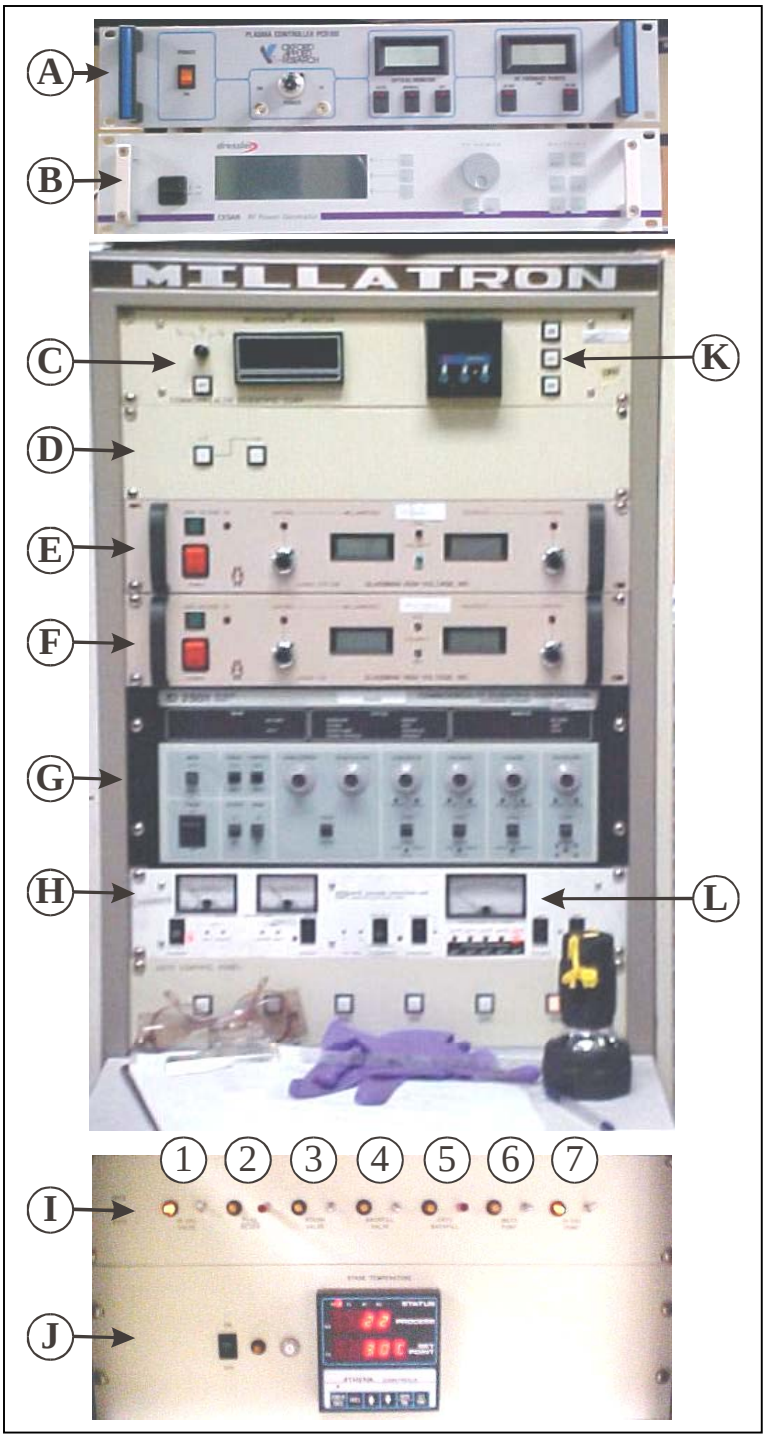




Chamber Open

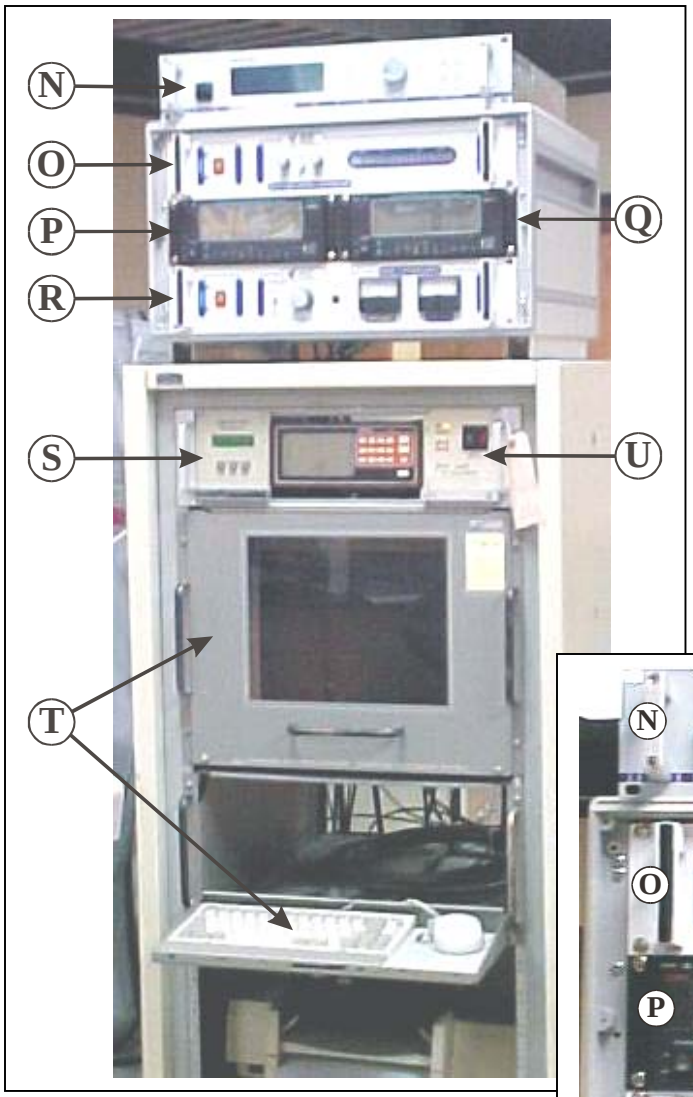
Control Rack 1

A. Atomic Source Power Supply Controller
B. Atomic Source Power Generator
C. Ion Current Meter (connected to Substrate Motor Controller)
D. Safety Interlocks
E. Accelerator Power Supply
F. Beam/Source Power Supply
G. Assist Beam Drive
H. Chamber/Cryo Pump Pressure Gauge
I. Valve/Pump Switch Panel
   1. High Vacuum Valve
   2. Fore/Regen
   3. Rough Valve
   4. Backfill Valve
   5. Cryo Backfill
   6. Mechanical Pump
   7. High Vacuum Pump
J. Chamber Temperature
K. Timer
L. Chamber High Vacuum Pressure Gauge



Control Rack 2

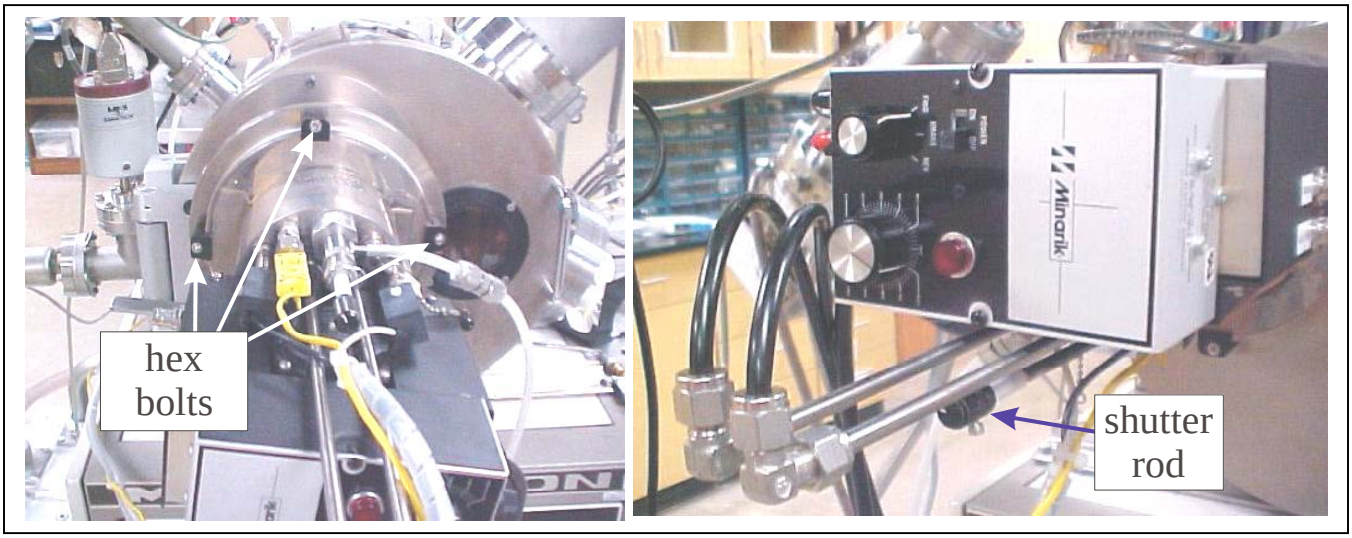
N. Primary Source Power Supply Controller
O. Automatic Tuner for Primary Source
P. Controller for MFC1, MFC2, MFC3
Q. Controller for Baratron Pressure Gauge, MFC4, MFC5
R. Filament Power/Gas Pulser
S. Cryo Head Temperature
T. PC for RGA software
U. Target Motor Controller



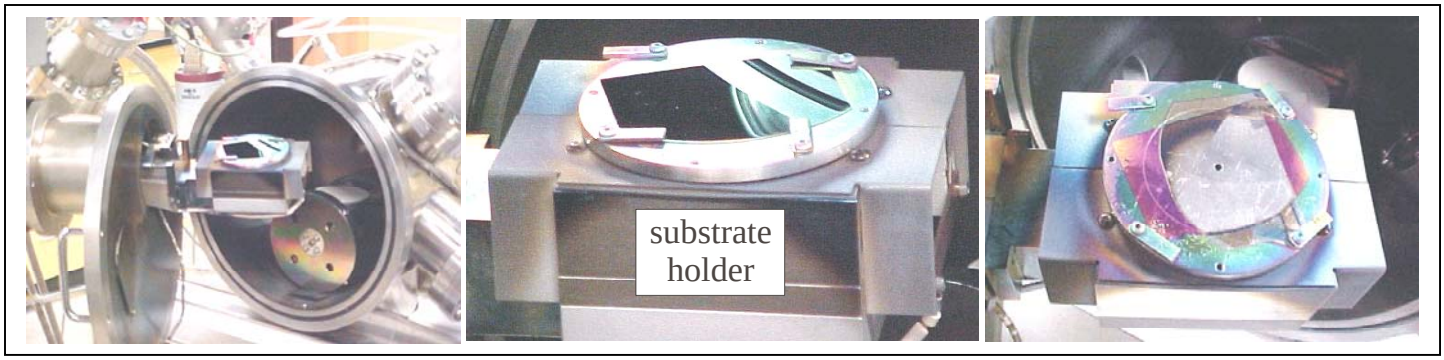
Controller		Address	
P	MFC 1	171	Argon
P	MFC 2	172	Oxygen
P	MFC 3	173	Nitrogen
Q	Baratron Pressure Gauge	171	
Q	MFC 4	172	Argon (primary ion beam source)
Q	MFC 5	173	Oxygen (primary ion beam source)

Attaching / Removing Sputtering Substrate

1. Ensure that the chamber pressure gauge (Bourdan gauge) is at 0.
2. Loosen the 3 hex bolts so that the substrate motor controller can rotate.

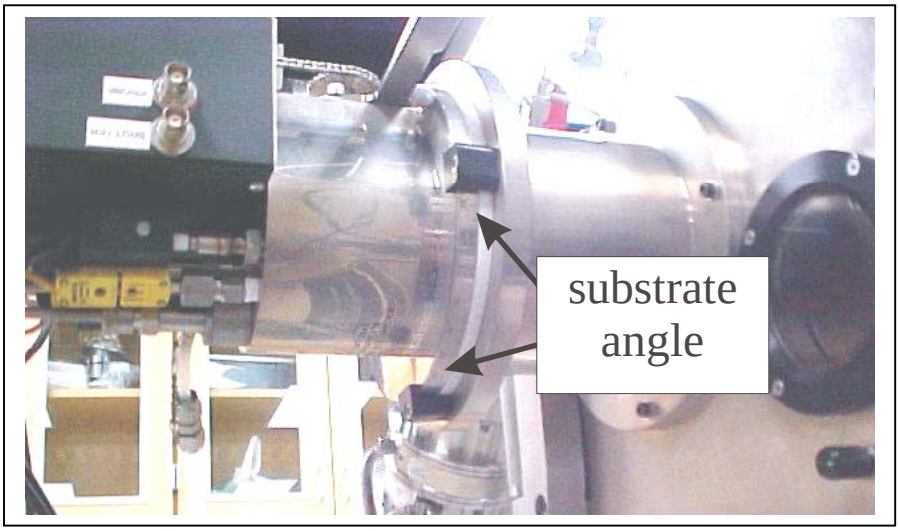


3. Open chamber lid about 6 – 8 inches.
4. Open the shutter completely and secure by tightening the shutter knob.
5. Begin rotating the substrate motor controller while opening up the lid until the substrate holding platform is parallel to the floor and the clips are readily accessible. Move the cables as necessary so that the substrate motor controller does not catch any.
6. Loosen the substrate clips using a hex wrench



7. If a substrate is already in place, use tweezers to remove the substrate and place it in a plastic container (i.e. single wafer carrier).
8. Place the substrate on the substrate holder and secure the substrate to the platform by using the clips. Make sure that at least 2 clips are used. Do not overtighten the hex bolts holding the clips, causing the substrate to fracture.
9. Ensure that the chamber o-ring is free of dirt and in the o-ring groove located on the chamber body. Do not touch the o-ring with bare hands.

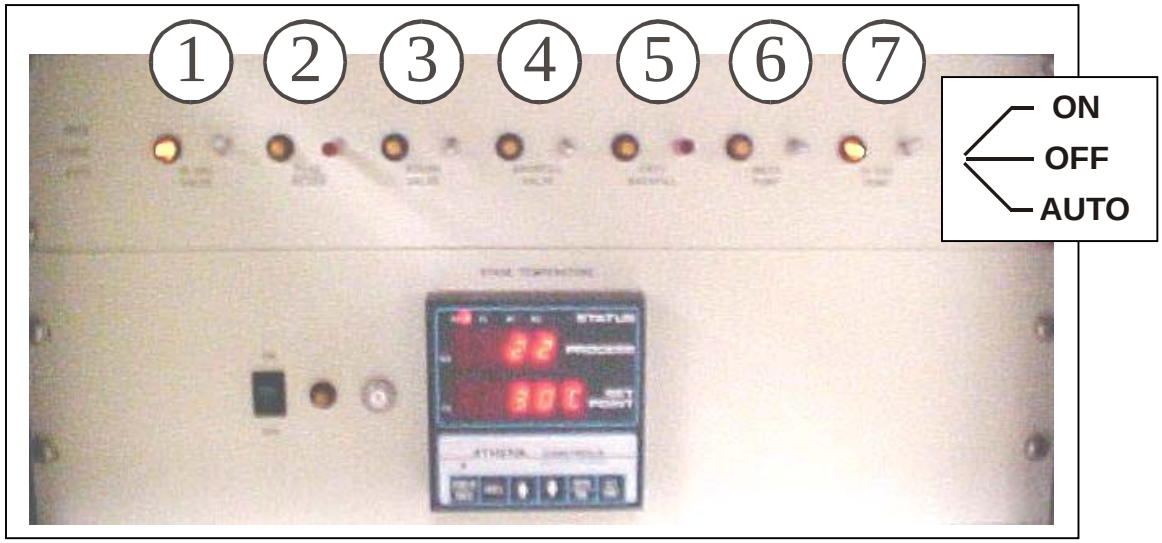
10. Once the substrate is secured, rotate the substrate motor controller back to an angle of 85^{o} and tighten the hex bolts to hold the controller in place.



11. Close the chamber door slowly making sure the substrate platform is clear of any obstacles in the chamber and no wires are entangled on the substrate motor controller.
12. Close the shutter and secure by tightening the shutter knob.
13. Press the chamber lid as close to the chamber body as possible.

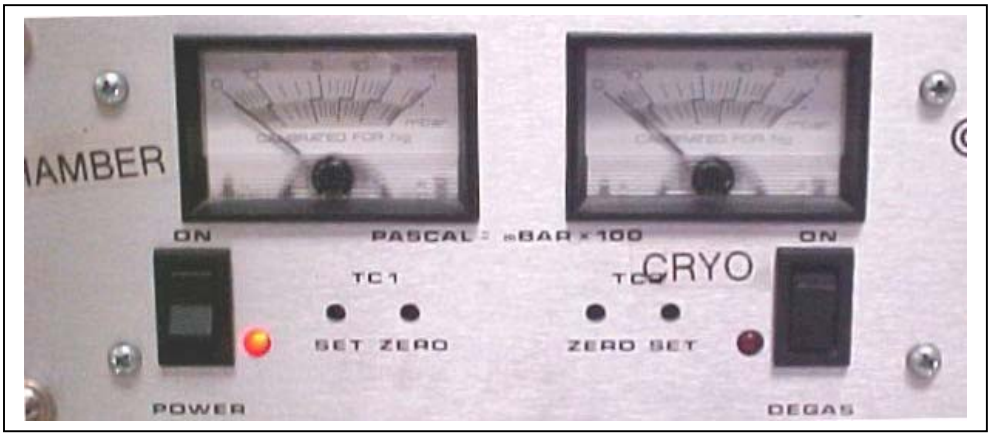
<u>Pumping Down the Chamber</u>

1. Turn on the mechanical pump using the switch located on the Valve/Pump Switch Panel (switch 6) on Control Rack 1 by gently pulling the switch out and moving the switch to the up position. The LED to the left of the switch will come **on**.

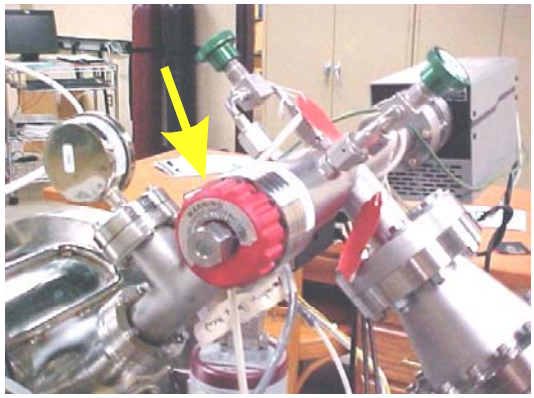


2. Open the rough line valve using the switch located on the Valve/Pump Switch Panel (switch 3) on Control Rack 1 by gently pulling the switch out and moving the switch to the up position. The LED to the left of the switch will come **on**.

3. Press the chamber lid as close to the chamber body as possible.
4. Wait until the chamber pressure is down to 0.3T. The chamber gauge is located on the Control Rack 1.

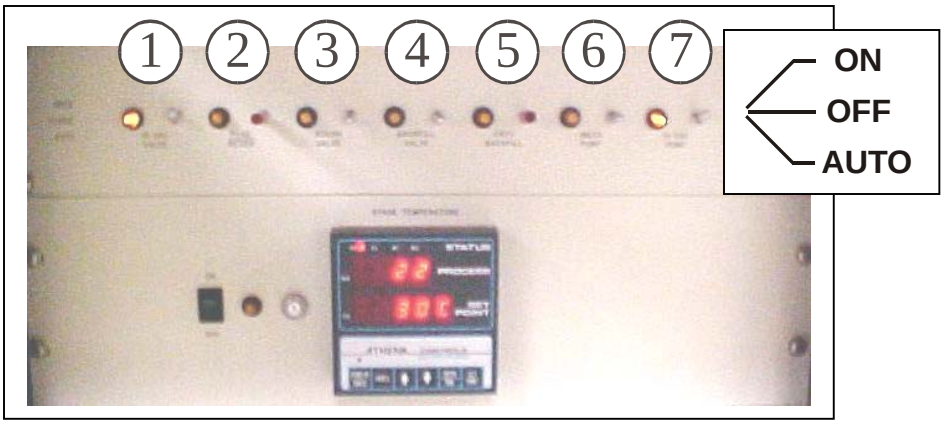


5. Open the Turbo Pump valve by using the torque wrench located near the tool. The torque wrench (set to 24 ft-lbs) should be turned counter clockwise to the turbo pump valve. When the torque wrench clicks, it is safe to hand turn the knob until it is 4 – 6 inches away from the knob housing.



Turbo Pump Valve

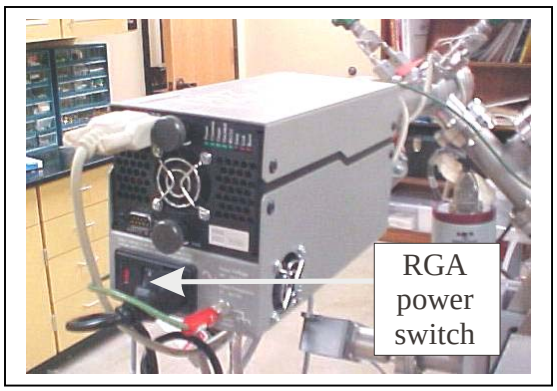
6. Close the rough pump valve located on the Valve/Pump Switch Panel (switch 3) on Control Rack 1 by gently pulling the switch out and moving the switch to the middle position. The LED to the left of the switch will come **off**.



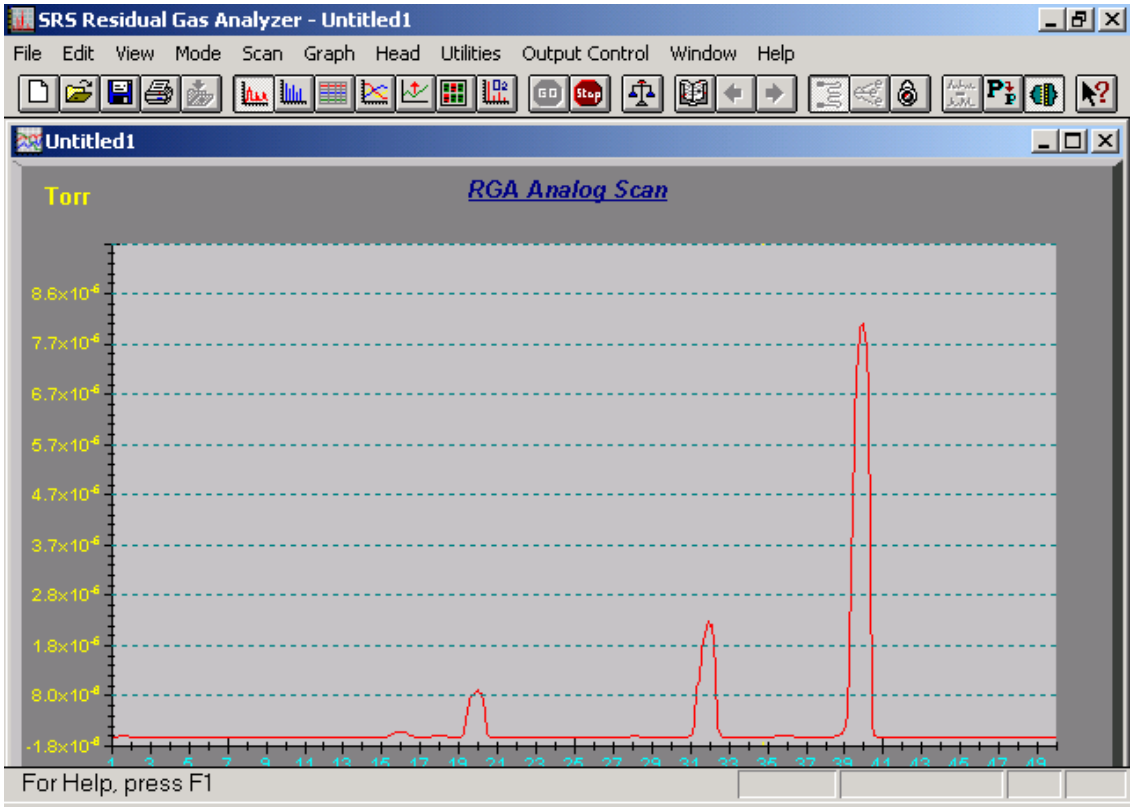
7. Turn off the mechanical pump using the switch located on the Valve/Pump Switch Panel (switch 6) on Control Rack 1 by gently pulling the switch out and moving the switch to the middle position. The LED to the left of the switch will come **off**.
8. Wait for chamber pressure to fall to 10^{-3} Torr. Use the same gauge as in step 4.
9. Open the High Vacuum Valve by using the switch located on the Valve/Pump Switch Panel (switch 1) on Control Rack 1. Gently pull the switch out and move it to the up position. The LED to the left of the switch will come **on**. The high vacuum pump (switch 7) should already be on.

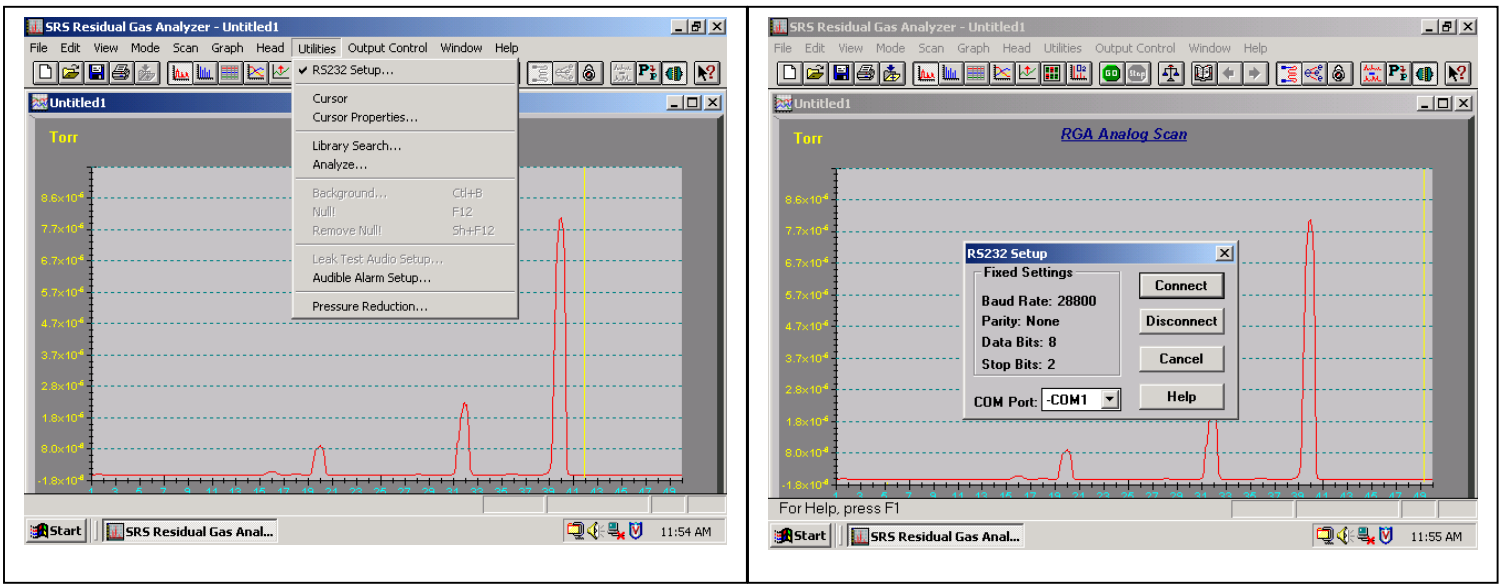
Configuring and Starting the Residual Gas Analyzer

1. Start the computer on the Control Rack 2.
2. Start the Gas Analyzer by hitting the power switch located on the Gas Analyzer.



3. Using the mouse, click Utilities → RS-232 Setup → COM1 → Connect on the pull down menu across the top of the screen. Return to the main screen.





4. Turn the filament head on by clicking Head → Filament on. Return to the main screen.
5. Configure the scan parameters by clicking Scan → Mass Spec Parameters.
   a. Configure the AMU weight to be between 1 and 50 AMU.
   b. Configure the analyzer to make 5 – 6 scans per second.
6. Return to the main screen and hit the Go button.
7. Select Graph → Autoscale or hit Ctrl-k to auto scale the graph.

Mass Numbers commonly seen on RGA

Hydrogen	2	Water	17-18
Carbon	12	Carbon monoxide, CO	28
Nitrogen	14, 28	Argon	20, 40
Methane, CH_4	16	Hydrocarbons (grease,oil, polymer)	Typically > 40
Oxygen	16, 32	Chlorinated compounds	Typically 35 - 37

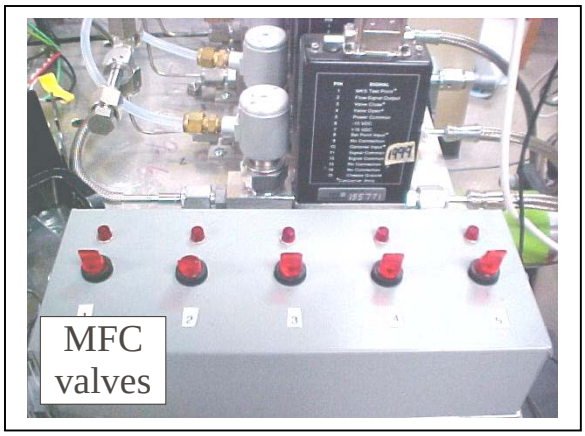
<u>Activating the Atomic Source Ion Beam</u>

This is a secondary source, which is primarily used to clean the substrate.

1. Open the valve on the O_2 tank behind system. The atomic source can use O_2 or N_2.
2. Zero the oxygen flow meter. Using MFC 2 (controller P, 172) on the Control Rack 2, hit the Zero key followed by the number for the MFC (i.e. 2 for MFC 172).
3. Set the oxygen flow rate.
   a. Using MFC 2 (controller P, 172) on the Control Rack 2, hit the Display key until the word Setup is flashing on the LCD display.

b. MFC number will be flashing in the top left corner. Type in 2 to select the 172 MFC that controls the oxygen gas and press the enter key.
c. Type in desired flow rate, and hit enter.

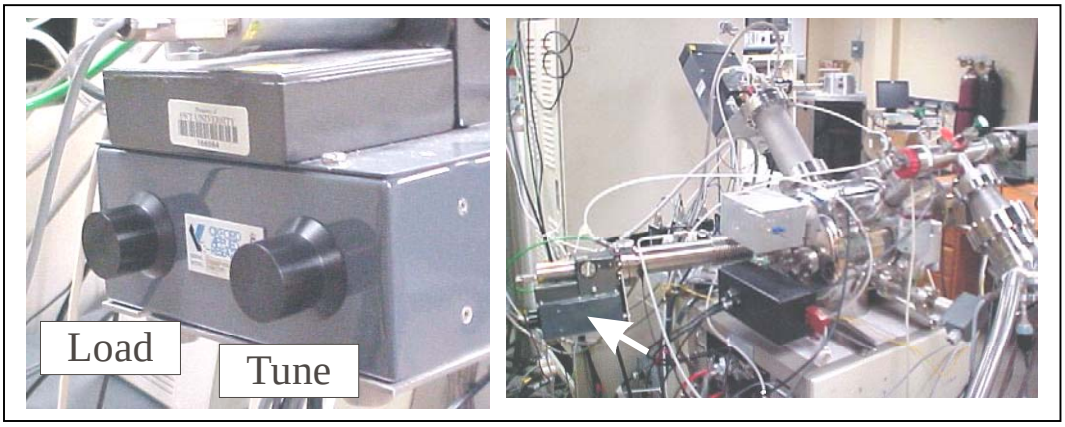
4 Open the red valve on the MFC corresponding to the correct source. The pressure inside the chamber will increase sharply.



5. Once the gas starts flowing turn on the atomic source power on top of Control Rack 1.

6. Set the RF forward power to 150-200 W.
7. Set the Reflected power to 1-5 W.

8. Tune the impedance with the load and tune knobs on the atomic beam source. Both of these knobs should be turned gently.
    a. Slowly turn the load knob until the impedance stops decreasing.
    b. Turn the tune knob until the impedance stops decreasing.
    c. Repeat this process until the Reflected power is less than 5 W.



8. If the plasma is not igniting, reduce the sccm to 1 and then retune the impedance to as low as possible, then increase the sccm to 3 and retune.
9. To switch the RF forward power off turn the RF forward knob to zero.
10. Turn off the main power
11. Reduce the sccm flow to 1 for 10-15 minutes until cool to touch.
12. Set the sccm flow to zero.

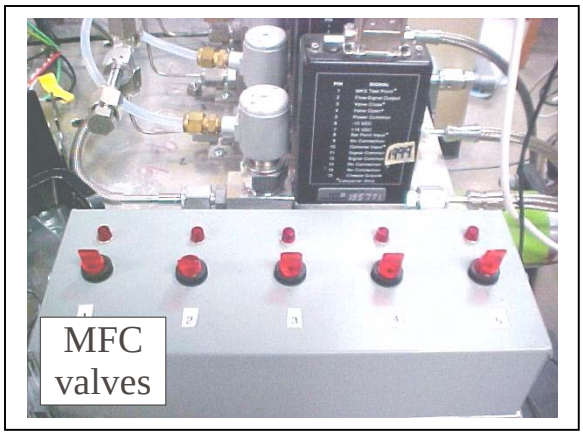
Activating the Primary Source Ion Beam

1. Select target by punching in the number on Target Motor controller on Control Rack 2. Turn on target chiller after you have selected which target you want to sputter.

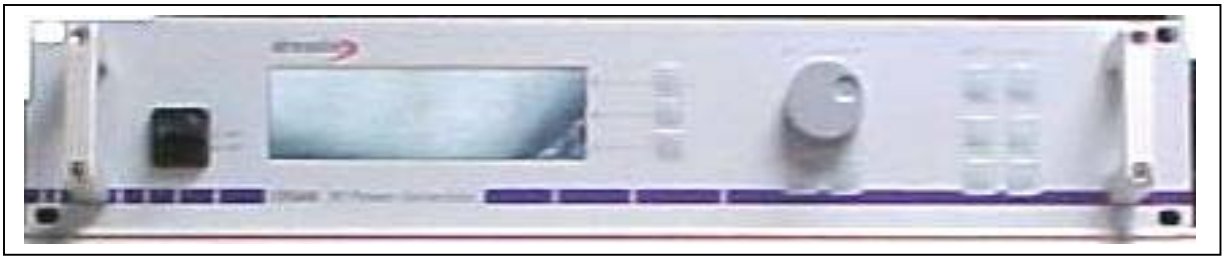
2. Locate the Argon tank behind the Control Racks.
3. Flip the switch so that Argon is flowing.
4. Zero the Argon flow meter. Using MFC 4 (controller Q, 172) on the Control Rack 2, hit the Zero key followed by the number for the MFC (i.e. 2 for MFC 172).

5. Set the Argon flow rate to be 10 – 20 sccm.
   a. Using MFC 4 (controller Q, 172) on the Control Rack 2, hit the Display key until the word Setup is flashing on the LCD display.

   b. MFC number will be flashing in the top left corner. Type in 2 to select the 172 MFC that controls the Argon gas and press the enter key.
   c. Type in desired flow rate, and hit enter.
5. Flip switch 4 on the MFC control box to open the valve.



6. Allow the Argon to flow for 1 – 3 minutes to purge chamber.
7. Enable substrate rotation by flipping the On/Off switch located on the substrate motor controller.
8. Turn on the Primary Source main power. Rotate key and press on button.



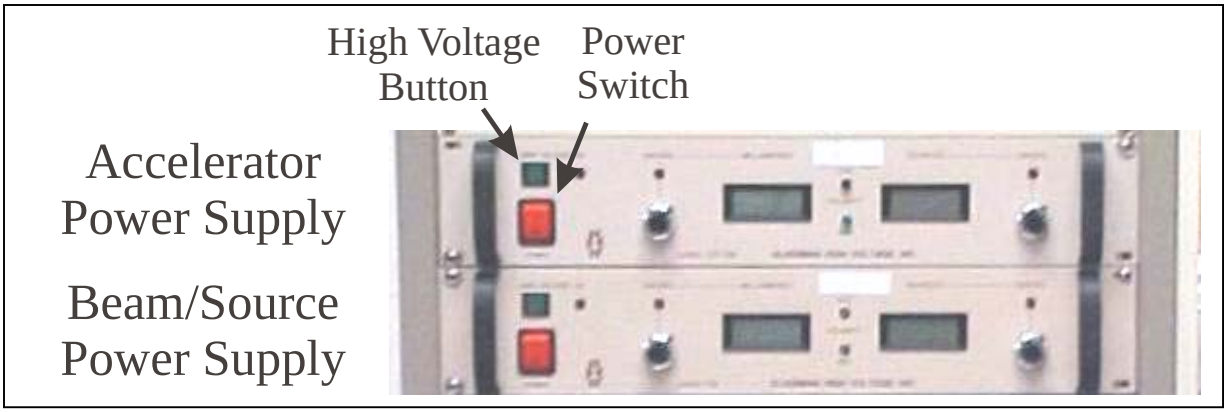
9. Turn on the Automatic Frequency Match Tuner located on Control Rack 2. Press autotune button.

10. Turn on the Filament power and set to 5A.

11. Set RF Forward power (W_F) to be 150W.

Warning: Do not immediately set the power to 150W. Use 50W increments with at least a 1 minute duration between steps.

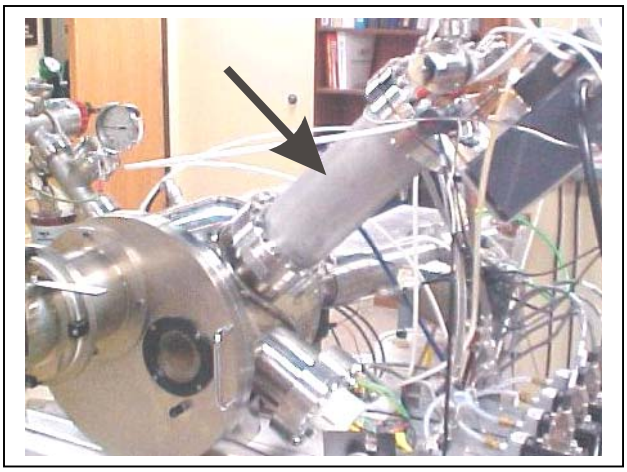
12. Turn on the Accelerator and Beam power supply.
13. Hit the High voltage button on both the Accelerator and Beam supplies.



14. Tune the Beam voltage to 0.84 kV. **Warning: Do not exceed 1kV.**
15. Tune the Beam current to 88 mA.
16. Tune the Accelerator voltage to 126 kV. **Warning: Do not exceed 500V**.
17. If plasma does not strike under these conditions, reduce the Argon gas flow to 10 sccm.
18. Once the plasma has started, adjust the Accelerator voltage until the Beam current is 50mA. (for Ni-Fe 50 mA, for ZnO 60-80 mA)
19. Allow the system to pre-sputter for at least 5 minutes.
20. Turn on substrate rotation motor. Open the shutter all the way and start timing.

Powering down the System

1. Once sputtering is complete, close the shutter.
2. Turn off substrate rotation.
3. Switch off the Beam and Accelerator power supplies.
4. With the Beam and Accelerator power supplies off, turn the voltage and current knobs on both Beam and Accelerator power supplies to 0.
5. Turn off Filament power.
6. Turn the RF Forward power knob to 0.
7. Turn off the RF Forward power.
8. Reduce Argon flow to 5 sccm.
9. Flow 5 sccm of Argon through the Primary Ion Beam until the neck is cool to touch.



10. Turn off the Argon flow (0 sccm) on the MFC Controller.
11. Turn off Argon flow on the MFC gas control box by flipping switch 4.
12. Stop the Residual Gas Analyzer
    a. Hit the Stop Button.
    b. Turn the filament head off by clicking Head -> Filament off.
    c. Bring the Gas Analyzer off line by clicking Utilities -> Disconnect Gas Analyzer.
    d. Turn off the Gas Analyzer main power.
13. Hand tighten the turbo valve. Use the torque wrench to ensure the valve is tightened properly.
14. Close the valve on the Argon tank located behind the control racks.
15. Start Nitrogen flow by opening the valve on the Nitrogen tanks located behind the control racks.
16. Switch off the Ion Gauge
17. Close the High Vacuum valve by operating the switch located on the on the Valve/Pump Switch Panel (switch 1) on Control Rack 1. The LED should be **off**.
18. Turn on the Backfield Nitrogen gas flow by operating the switch located on the on the Valve/Pump Switch Panel (switch 4) on Control Rack 1. The LED should be **on**.
19. Once the chamber pressure has returned to 0, follow the steps located in the Attaching / Removing Substrate section to recover the recently sputtered substrate.

Miscellaneous Safety and Guidelines

1. Do not consume food or drink around the system.
2. Never touch the substrate or inside of the chamber with bare skin. Always wear gloves to prevent the transfer of skin oil and dirt to the inside of the chamber.
3. Always get assistance or use a mechanical device when moving the gas the cylinders. Leave the metal screw-on cover in place over the gas cylinder valve when storing or moving the cylinders.
4. Do not use any lubricants to connect the brass fittings, regulator and hoses on the gas cylinders.
5. The system uses high voltage, be aware of electrical dangers (i.e. bare wires, shorts, spilled liquids)
6. Keep fingers away from pinch points such as the chamber door and chain on substrate motor.
7. Until the sources have cooled down, keep hands away from ion/atom beam sources after use.