DENTON VACUUM

DISCOVERY™-18 DEPOSITION SYSTEM
OPERATING MANUAL

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1. INTRODUCTION

The Denton Vacuum Discovery™-18 Deposition System is designed for either thin film production or research. The Discovery™-18 configuration provides easy access to substrates, sources, and instrumentation while maintaining excellent pumping characteristics. This system is designed to simplify the geometries necessary for the coordination of multiple source depositions.

Because Denton uses the finest available subsystems and components, the system is highly reliable and durable. The system's inherent flexibility allows for the operation of three sputter sources and the ability to heat, RF bias, and rotate the substrate. The Discovery™-18 is semi-automatic; controlled by a General Electric 90-30 Programmable Logic Controller (PLC). The system's power supplies and instrumentation are installed in a control cabinet conveniently located next to the chamber for easy observation and operation.

The system offers the user a myriad of thin film process possibilities. However, it is important to note that with all of this system's potential there exists safety considerations. **Individuals who are to operate, service or maintain this system should familiarize themselves with this manual.**

2. SAFETY WARNINGS

This vacuum deposition system is comprised of a number of complex subsystems.

LETHAL VOLTAGES, HIGH TEMPERATURES, HIGH PRESSURES AND POWERFUL MECHANICAL DRIVE MECHANISMS ARE PRESENT THROUGHOUT THE SYSTEM.

Every attempt has been made to safeguard operating and maintenance personnel. Interlocking of sub systems provides a high degree of operator safety.

SYSTEM/SOFTWARE INTERLOCKS SHOULD NEVER BE DEFEATED UNLESS SERVICING OF THE SYSTEM REQUIRES TEMPORARY INTERLOCK OVERRIDES. HARDWIRED SAFETY INTERLOCKS MUST NEVER BE DEFEATED.

All safety/software interlocks should be returned to operational status when problems have been corrected.

Operating and maintenance manuals have been provided and should be thoroughly understood before any operations are contemplated.

THE SYSTEM SHOULD BE OPERATED ONLY BY PERSONNEL WITH PROPER TRAINING AND PROCESS EXPERIENCE.

3. SYSTEM SPECIFICATIONS

3.1 DEPOSITION CHAMBER

- 304L stainless steel chamber, measuring approximately 18″ (diameter) x 13.5″ (deep).

- Full-diameter, top-opening access flange, mounted via articulating hinges to the deposition chamber. Access flange is supported by two gas-pressurized struts to facilitate loading and unloading operations.

- Viewports: (1) optically shielded 4.00″ diameter viewport (chamber sidewall) to permit unrestricted viewing of all installed deposition sources and substrate fixturing.

- Bottom mounted pumping plenum (off chamber baseplate).

- The following chamber penetrations will be provided:
  - **Baseplate**:
    a) (1) 8.00″ (pumping plenum)
    b) (15) 1.00″ (instrumentation, gas, spares)
    c) (1) 3.38″ CF (substrate rotation)

  - **Sidewall**:
    a) (1) 4.00″ viewport (optically shielded)
    b) (2) 2.75″ CF
    c) (1) 1.33 mini-CF
    d) (1) 10.0″ CF (rotatable, loadlock expansion)

  - **Top-plate**:
    a) (3) 1.12″ compression seal (sputter cathodes)
    b) (3) 0.25″ (shutter rotary feedthroughs)

  - **Pumping Plenum**:
    a) (1) NW100 (high vacuum pump)
    b) (1) 0.75″ compression seal (vacuum gauge)
    c) (1) NW25 (roughing valve))
    d) (1) NW16 (vent valve/vacuum safety)
    e) (1) 3.50″ (high vacuum bellows valve actuator)

3.2 LOADLOCK CHAMBER

- 304L stainless steel chamber, electro-polished, measuring approximately 8.0″ (diameter) x 10.5″ (long).

- 8.0″ electro-pneumatic, hivac gate valve (CF flanging).

- 8.0 ″ diameter, side-loading door, electric transfer drive

- The following loadlock penetrations will be provided:
  a) (1) 2.75″ CF
  b) (1) 1.33 mini-CF (vacuum gauge)
  c) (1) NW25 (loadlock roughing)
  d) (1) VCO-4 stub (vent valve)

3.3 DEPOSITION CHAMBER PUMPING SYSTEM

- Alcatel ATP5150 turbomolecular pump (NW100 inlet flange, particulate screen, air-cooled) with Alcatel CFF450 frequency convertor.

- Alcatel 2021 two-stage, rotary vane pump (14.6 CFM).

- NW25 foreline filter

- DVI 5.0″ electro-pneumatic, internal hivac poppet valve.

- NW25 bellows-sealed, electro-pneumatic, roughing valve.

- NW25 bellows-sealed, electro-pneumatic, turbo backing valve.

- 0.25″ VCO, bellows-sealed, electro-pneumatic vent valve.

- 0.25″ electric, mechanical pump vent valve (slaved to mechanical pump status).

- KF-25 manual valve (leak checking), mounted on foreline.

3.4 LOADLOCK PUMPING SYSTEM

- Utilization of deposition chamber mechanical pump to achieve crossover pressure of approximately 2.0E-1 torr.

- 1.0" bellows-sealed, electro-pneumatic, roughing valve.

- VCO-4 bellows-sealed, electro-pneumatic, vent valve.

3.5 VACUUM GAUGING/PROCESS GAS AND PRESSURE CONTROL

- Varian SenTorr CC2 cold cathode/thermocouple gauge controller:
  - Cold cathode gauge #1 (deposition chamber, gauge setpoint relay interfaced to system controller).
  - Thermocouple gauge #1 (deposition chamber, gauge setpoint relay interfaced to system controller).
  - Thermocouple gauge #2 (turbomolecular pump foreline, gauge setpoint relay interfaced to system controller).

- Granville Phillips Model 275 mini-Convectron vacuum sensor pressure switch (P/N: 275803) for loadlock chamber crossover (2.0E-1) indication.

- MKS Instruments 127A (100 mtorr FS) capacitance manometer with MKS Instruments PDR-C-1C power supply/readout.

- MKS Instruments 247C four-channel power supply/readout interfaced to (2) MKS 2259C mass flow controllers (100 sccm and 50 sccm full scale):
  - each MKS 2259C supplied with close-coupled, bellows-sealed, electro-pneumatic, isolation valve,
  - each MKS 2259C isolation valve controlled by system controller, and
  - each MKS 2259C outfitted with dual gas-inlet capability (manual toggle-type isolation valves).

3.6 SPUTTER SOURCES

- (3) DVI 3.0" diameter, internal "stalk-mount", planar magnetron sputter sources:
  - RF/DC capability,
  - Variable source to substrate distance, and
  - Clamp/bond target compatibility.

- (3) independent, electro-pneumatic source shutters (cylinder mounted air flowrate control), each dedicated to a delivered planar magnetron, interfaced to system PLC for remote open/close operation.

- Cooling water flow sense on each cathode's dedicated cooling water circuit (safety interlock).

- Quick-disconnect cooling water lines.

3.7 SPUTTER POWER SUPPLIES

- (1) Advanced Energy MDX1.5K (Low Z; 700 volt) power supply:
  - Hardwired safety interlock (chamber door, vacuum bellows safety switch, cathode water),

- (1) manual DC power switchbox, to shunt output of MDX supply to any of the three installed cathodes:
  - (2) Advanced Energy RF blocking filters (P/N 3155018)

- (2) Advanced Energy RFX600 RF power supplies, each coupled to an Advanced Energy ATX600 automatic match network:
  - Hardwired safety interlock (chamber door, vacuum bellows safety switch, cathode or Bias-Stage water),
  - Twin power output lead from match network to minimize cable heating, and
  - Matching network configured for discrete DC power input.

3.8 RF-BIAS SUBSTRATE STAGE

- (1) RF-bias substrate stage (confocal source mode):
  - (2) 10" substrate platens; one pre-machined to accept DVI's sample transfer holder and the other "blank" to support Utah's TBD substrate requirements.

- (2) DVI sample transfer holders: one pre-machined to accept a 150 mm diameter substrate and the other "blank" to support Utah's TBD substrate requirements.

- (1) DVI high performance, RF-biasable rotary motion feedthrough, 3.38" CF flanging.

- (1) direct-drive, compact, gear motor.
  - Rotation speed adjust (0-20 RPM) via front panel potentiometer.

3.9 SUBSTRATE HEAT

- (1) 3.0 kW, backside quartz heater array with reflector and deposition shield.
- 208/110 VAC step-down/isolation transformer to minimize possibility of spurious glow discharges and feedback from sputter power supplies.
- 3.0 kW PI temperature control system (Omega CN76000 temperature controller, interfaced to system PLC for remote on/off operation.
- Manual setpoint.
- (1) sheathed thermocouple positioned internally in chamber.

3.10 SYSTEM CONTROL AND AUTOMATION

- GE-Fanuc 90-30 programmable logic controller (PLC) with membrane-type operator interface.
- EEPROM memory backup.
- Valve control/sequencing, pump operation, and "soft" system interlocks (i.e., non-safety related) controlled by the PLC.
- The following operating modes provided:
  - AUTOPUMP (automatic loadlock and chamber pumpdown to high vacuum conditions),
  - AUTOVENT (automatic loadlock and chamber venting to atmospheric pressure),
  - MANUAL (permits manual (front panel) system operation and interruption of in-process automatic system sequences), and
  - MAINTENANCE MODE (key-switch selectable from MANUAL mode; permits all MANUAL MODE functionality, "soft" system valve interlocks disabled. All "hard" safety interlocks remain operational).

3.11 UTILITIES

- Electrical: 208 VAC, 60 Hz, 1 phase, 4 wire (60 A)

- Cooling water: 30-35 l/min, 15-25 degrees Centigrade, 3-4 bar differential between supply and return (6 bar maximum inlet pressure):
  - Four-circuit water manifold (metering on supply and return side); circuit designation follows:
    1.) Sputter cathode #1 (flow sense/interlock)
    2.) Sputter cathode #2 (flow sense/interlock)
    3.) Sputter cathode #3 (flow sense/interlock)
    4.) RF Bias Stage (flow sense/interlock)

- Compressed air: 10-20 l/hr, normal dry shop air, 6-7 bar (system valve operation):
  - dew point: maximum of 2 degrees Centigrade
  - oil content: 1-5 mg/m^3
  - foreign particles, size: maximum of 5 microns
  - foreign particles, concentration: maximum of 5 mg/m^3

- Nitrogen: (preferentially evaporated from liquid N_2)
  - 0.5 bar (chamber venting, 100 l/cycle, optional)
  - 0.5 bar (loadlock venting, 10 l/cycle, optional)

- Process gas: 5N purity
  - 0.5 bar (customer supplied)

3.12 SYSTEM DOCUMENTATION

- Three complete sets of operating instruction manuals; instruction manuals to include preventive maintenance procedures/timetable, troubleshooting guides, and fully-costed spare parts listing.

- One complete set of sub-assembly vendor manuals.

- Three complete sets of electrical schematics (B-size).

- One complete set of electrical schematics (AUTOCAD.DWG format).

- Three complete sets of mechanical drawings necessary for system maintenance and repair (D-size).

3.13 SPUTTER TARGETS

- 3.0″ diameter x 0.062″ thick; gold target (4N purity).
- 3.0″ diameter x 0.062″ thick; platinum target (4N purity).
- 3.0″ diameter x 0.125″ thick; copper target (5N purity).
- 3.0″ diameter x 0.125″ thick; aluminum target (5N purity).
- 3.625″ diameter x 0.125″ thick; SiO_2 target (4N5 purity) solder bonded to DVI 3.0″ backing plate (backing plate included).
- 3.625″ diameter x 0.125″ thick; Si_3N_4 target (3N5 purity) solder bonded to DVI 3.0″ backing plate (backing plate included).

4. SYSTEM OPERATION

4.1 COLD START

1. Turn ON main system disconnect located on rear of system instrumentation cabinet; ensure that all utilities and process gases are installed and operational.

2. Push the green START button located near the top of rack cabinet. At this point, power to the system and the system PLC will be applied.

3. Power-up the following subsystems and instrumentation:
   - Varian CC2 cold cathode/thermocouple gauge controller (power is applied by toggling the front panel STANDBY key),
   - MKS PDR-C-1C capacitance manometer power supply/readout,
   - MKS 247C mass flow controller power supply,
   - Turn ON channels 1 and 2,
   - Advanced Energy MDX1.5K 1.5 kW DC power supply,
   - both Advanced Energy RFX 600 W RF power supplies, and
   - both Advanced Energy ATX automatic matching networks.

4. Select (instrument front panel) the following configuration on the following subsystems and instrumentation:
   - "AUTO ON" and "TORR" display units on the Varian CC2 cold cathode/thermocouple gauge controller,
   - "FLOW" mode for each channel (1-4) on the MKS 247C flow controller,
   - "MM HG" display units on the PDR-C-1C power supply,
   - "LOCAL SIGNAL", "LOCAL CONTROL", and "FWD POWER REGULATION" mode for each RFX600 RF power supply (Ensure that the left display is indicating "FORWARD PWR" and the right display is indicating "REFLECTED POWER"),
   - "AUTO" mode for each ATX600 RF matching network controller (Ensure that the bar graphs are set up to read capacitor position).
   - "POWER REGULATION" on the MDX1.5K DC power supply

5. Ensure that the following setpoints and limits are entered into the Varian CC2 cold cathode/thermocouple gauge controller:
   - TC_1 (Chamber): 2.0E-1 torr (Isolation Valve Crossover), and
   - TC_2 (Turbo foreline): 5.0E-1 torr (Hivac Valve Crossover).

Please refer to the Varian Sentorr manual on the proper procedure to display and alter setpoints.

6. Ensure that the following setpoints are entered (rear input) into the MKS 247C power supply/readout:
   - Channel 1 display: (Full scale flowmeter rating)(GCF), and
   - Channel 2 display: (Full scale flowmeter rating)(GCF).

Please refer to the MKS 247C manual on the proper procedure to display and alter gas correction factors and setpoints.

7. Ensure that the following limits are entered into the Advanced Energy RFX600 power supplies:
   - RFX #1: 600 W maximum RF power, and
   - RFX #2: 600 W maximum RF power.

8. Ensure that the loadlock transfer arm is fully retracted.

9. Ensure that the system keyswitch is set in the Manual Mode position.

10. Ensure that the loadlock lid is in place and that the loadlock isolation valve is fully closed.

11. Ensure that the chamber lid is lowered, the latch is engaged, and positive contact has been made with the lid sensor switch.

12. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is not flashing .

13. Turn on the mechanical pump; wait 60 seconds.

14. Open the turbopump backing valve; wait until the pressure indicated on TC_2 is less than 50 millitorr (the turbopump can be started once it is backed by the mechanical pump; waiting until the "stub" pressures approached the mechanical pump's blank off value ensures that there are no major leaks below the high vacuum valve).

15. Turn on the turbomolecular pump.

16. Wait until the turbopump has completed its' acceleration and has attained full rotational speed (indicated on the CFF450 frequency by a change in the status LED's color from yellow to green).

Note: ***If the CFF450 frequency convertor LED is red then a fault is present and the user should immediately contact Denton Vacuum or Alcatel Vacuum Products!***

17. Add LN_2 to the cold trap (optional). A full charge of LN_2 will keep the trap cold for approximately 2-4 hours.

18. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is flashing.

19. Depress the "Chamber Autopump" keyswitch to initiate the automatic chamber pumping process. At the completion of this automatic pumping sequence the "Chamber Autopump" LED indicator will be extinguished and the chamber will be in high vacuum status.

Note: ***If the "CHAMBER AUTOPUMP" softkey is depressed before the completion of the automatic cycle (i.e., the autocycle LED is still flashing when the key is depressed) then the automatic cycle will be terminated and the machine will remain in the valve state at which the termination was initiated!***

4.2 SYSTEM PUMPING AND VENTING

4.2.1 MAIN CHAMBER PUMPING - AUTOMATIC MODE

1. Ensure that steps 1 through 17 of the Cold Start Procedure (Section 4.1) have been successfully completed.

2. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is flashing.

3. Depress the "Chamber Autopump" keyswitch to initiate the automatic chamber pumping process. At the completion of this automatic pumping sequence the "Chamber Autopump" LED indicator will be extinguished and the chamber will be in high vacuum status.

4.2.2 MAIN CHAMBER PUMPING - MANUAL MODE

1. Ensure that steps 1 through 17 of the Cold Start Procedure (Section 4.1) have been successfully completed.

2. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is not flashing.

3. Close the turbomolecular pump backing valve.

4. Open the chamber rough valve. Pump the main chamber until the pressure indicated on TC_1 is less than 2.0E-1 torr.

5. Close the chamber rough valve.

6. Open the turbomolecular pump backing valve. Wait until the pressure indicated on TC_2 is less than 1.0E-2 torr.

7. Open the chamber hivac valve.

4.2.3 LOADLOCK PUMPING - AUTOMATIC MODE

1. Ensure that steps 1 through 17 of the Cold Start Procedure (Section 4.1) have been successfully completed.

2. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is flashing.

3. Depress the "Loadlock Autopump" keyswitch to initiate the automatic chamber pumping process. At the completion of this automatic pumping sequence the "Loadlock Autopump" LED indicator will be extinguished and the loadlock will be ready for exposure to the main chamber.

*Note: **If the "LOADLOCK AUTOPUMP" softkey is depressed before the completion of the automatic cycle (i.e., the autocycle LED is still flashing when the key is depressed) then the automatic cycle will be terminated and the machine will remain in the valve state at which the termination was initiated!***

4.2.4 LOADLOCK PUMPING - MANUAL MODE

1. Ensure that steps 1 through 17 of the Cold Start Procedure (Section 4.1) have been successfully completed.

2. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is not flashing.

3. Close the turbomolecular pump backing valve.

4. Open the loadlock rough valve. Pump the loadlock until the "loadlock setpoint" LED is illuminated on the Granville Phillips Model 275 mini-Convectron (the setpoint of the 275 was preset at the factory to 200 mtorr).

5. Wait 20 seconds.

6. Close the loadlock rough valve.

7. Open the turbomolecular pump backing valve.

4.2.5 MAIN CHAMBER VENTING - AUTOMATIC MODE

1. Ensure that the loadlock transfer arm is fully retracted and the "Sample Holder OUT" LED is illuminated.

2. Ensure that the loadlock isolation gate valve is fully closed.

3. Ensure that the system keyswitch is set in the Manual Mode position.

4. Turn off all internal sources of energy (RF power, DC power, and heat).

5. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is flashing.

6. Depress the "Chamber Autovent" keyswitch to initiate the automatic chamber venting process. At the completion of this automatic venting sequence the "Chamber Autovent" LED indicator will be extinguished and the chamber will be vented to atmospheric pressure.

Note: ***If the "CHAMBER AUTOVENT" softkey is depressed before the completion of the automatic cycle (i.e., the autocycle LED is still flashing when the key is depressed) then the automatic cycle will be terminated and the machine will remain in the valve state at which the termination was initiated!***

4.2.6 MAIN CHAMBER VENTING - MANUAL MODE

1. Ensure that the loadlock transfer arm is fully retracted and the "Sample Holder OUT" LED is illuminated.

2. Ensure that the loadlock isolation gate valve is fully closed.

3. Ensure that the system keyswitch is set in the Manual Mode position.

4. Turn off all internal sources of energy (RF power, DC power, and heat).

5. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is not flashing.

6. Close (if open) the hivac valve.

7. Close (if open) the chamber rough valve.

8. Close (if open) the gas #1 and gas #2 isolation valves.

9. Open the chamber vent valve. When chamber is fully vented and the chamber lid seal is broken, close the chamber vent valve.

4.2.7 LOADLOCK VENTING - AUTOMATIC MODE

1. Ensure that the loadlock transfer arm is fully retracted and the "Sample Holder OUT" LED is illuminated.

2. Ensure that the loadlock isolation gate valve is fully closed.

3. Ensure that the system keyswitch is set in the Manual Mode position.

4. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is flashing.

5. Depress the "Loadlock Autovent" keyswitch to initiate the automatic loadlock venting process. At the completion of this automatic venting sequence the "Loadlock Autovent" LED indicator will be extinguished and the loadlock will be vented to atmospheric pressure.

Note: ***If the "LOADLOCK AUTOVENT" softkey is depressed before the completion of the automatic cycle (i.e., the autocycle LED is still flashing when the key is depressed) then the automatic cycle will be terminated and the machine will remain in the valve state at which the termination was initiated!***

4.2.8 LOADLOCK VENTING - MANUAL MODE

1. Ensure that the loadlock transfer arm is fully retracted and the "Sample Holder OUT" LED is illuminated.

2. Ensure that the loadlock isolation gate valve is fully closed.

3. Ensure that the system keyswitch is set in the Manual Mode position.

4. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is not flashing.

5. Close (if open) the loadlock rough valve.

6. Open the loadlock vent valve. When loadlock is fully vented and the loadlock lid can be opened, close the loadlock vent valve.

4.3 MANUAL PROCESSING

4.3.1 LOADLOCK TO CHAMBER SUBSTRATE TRANSFER

1. Ensure that the loadlock has been vented to atmospheric pressure.

2. Ensure that the loadlock transfer arm is fully retracted and the "Sample Holder OUT" LED is illuminated. Load appropriate substrate onto substrate transfer arm (transfer disk MUST be resting against fork back-stop!)

3. Ensure that loadlock and main chamber are in vacuum status.

4. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is not flashing.

5. Open the loadlock gate valve (insure that all in-situ processes have been completed!!).

6. Ensure that the substrate transfer arm is in the "UP" position.

7. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is flashing.

8. Depress the "Sample Holder In" keyswitch to initiate the automatic transfer insertion process. While the sample is driven into the chamber, the "Sample Holder In" LED will flash. Once the sample is fully driven into the chamber the "Sample Holder In" LED indicator will be continuously illuminated.

9. Lower the substrate transfer arm to the "DOWN" position.

10. Depress the "Sample Holder Out" keyswitch to initiate the automatic transfer insertion process. While the sample is driven into the loadlock, the "Sample Holder Out" LED will flash. Once the sample is fully driven into the loadlock the "Sample Holder Out" LED indicator will be continuously illuminated.

11. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is not flashing.

12. Close the loadlock gate valve.

4.3.2 CHAMBER TO LOADLOCK SUBSTRATE TRANSFER

1. Ensure that the loadlock has been vented to atmospheric pressure.

2. Ensure that the loadlock transfer arm is fully retracted and the "Sample Holder OUT" LED is illuminated.

3. Ensure that loadlock and main chamber are in vacuum status.

4. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is not flashing.

5. Open the loadlock gate valve (insure that all in-situ processes have been completed!!).

6. Ensure that the substrate transfer arm is in the "DOWN" position.

7. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is flashing.

8. Depress the "Sample Holder In" keyswitch to initiate the automatic transfer insertion process. While the sample is driven into the chamber, the "Sample Holder In" LED will flash. Once the sample is fully driven into the chamber the "Sample Holder In" LED indicator will be continuously illuminated.

9. Raise the substrate transfer arm to the "UP" position.

10. Depress the "Sample Holder Out" keyswitch to initiate the automatic transfer insertion process. While the sample is driven into the loadlock, the "Sample Holder Out" LED will flash. Once the sample is fully driven into the loadlock the "Sample Holder Out" LED indicator will be continuously illuminated.

11. Depress the "AUTO ENABLE" switch and ensure that the "AUTO ENABLE" LED indicator is not flashing.

12. Close the loadlock gate valve.

4.3.3 FIXED-FLOWRATE PROCESS GAS (SPUTTERING/PRESSURE CONTROL)

1. Ensure that process gas (5-10 psig) is supplied to the appropriate MKS 2259C mass flow controller(s).

2. Refer to the MKS 247 and MKS 2259C manuals for all adjustment procedures.

3. Ensure that the correct gas correction factor is set for each mass flow controller on the rear of the MKS 247C.

4. Ensure that power has been applied to the MKS 247C and PDR-C-1C for at least 8 hrs (necessary to establish thermal equilibrium for the mass flow controllers and capacitance manometer).

5. Zero the mass flow controller(s); this process can only be accomplished with the appropriate gas isolation valves closed.

6. Adjust the setpoint potentiometer for each channel to the desired flowrate. Don't forget to depress the setpoint display switch and set the display select switch for each channel.

7. Ensure that the chamber is under high vacuum status (pressure < 1.0E-5 torr).

8. Zero the capacitance manometer.

9. Toggle the "AUTO ENABLE" keyswitch so that the "AUTO ENABLE" LED indicator is not flashing.

10. Open the appropriate gas isolation valve (Gas #1 or Gas #2).

11. Adjust the setpoint potentiometer for each flow channel to achieve the desired pressured, indicated on the PDR-C-1C readout. Remember: the units of display on the PDR-C-1C readout are xx.xx mtorr!

4.3.4 SUBSTRATE HEAT

1. Prior to any attempt at processing, ensure that the quartz lamp housing is installed in the main chamber and that the electrical connections have been made to the power feedthrough (polarity is not important).

2. Ensure that main chamber has been pumped to a state of high vacuum and that substrate has been transferred from the loadlock onto the substrate table.

3. Toggle the "AUTO ENABLE" keyswitch so that the "AUTO ENABLE" LED indicator is not flashing.

4. Turn on substrate rotation. Verify that the substrate stage is rotating at the appropriate speed.

Note: Make sure the speed potentiometer has not been dialed down to zero!

5. Adjust the heater temperature setpoint (refer to heater controller manual for proper adjustment procedures).

6. Turn on heat power. Allow temperature to stabilize (if serious undershoot or overshoot occurs, re-tune heater control using procedure outlined in heater control manual).

4.4 PLASMA PROCESSING

4.4.1 DC SPUTTERING (CATHODES 1, 2, OR 3)

1. Ensure that main chamber has been pumped to a state of high vacuum and that substrate has been transferred from the loadlock onto the substrate table (refer to Section 4.3.1).

2. Toggle the "AUTO ENABLE" keyswitch so that the "AUTO ENABLE" LED indicator is not flashing.

3. Establish a suitable flow of gas into the chamber; achieving a process pressure of > 1 mtorr indicated by the MKS 127A capacitance manometer (refer to Section 4.3.3).

4. Verify and ensure that a the MDX1.5K DC power supply is set for "Power Regulation".

5. Program the Ramp Timer on the MDX1.5K DC power supply. The Ramp Timer is adjusted by first pressing the MDX's "SETPT" switch until the "SECONDS" LED lights on the unit's right hand display and then adjusting the "RAMP ADJUST" potentiometer. Five to ten seconds is generally a suitable period.

6. Program the Setpoint Level on the MDX1.5K DC power supply. The Setpoint Level is adjusted by first pressing the MDX's "SETPT" switch until the "WATTS" LED lights on the unit's right hand display and then adjusting the "LEVEL" potentiometer.

7. Ensure that the "INTLK" LED is illuminated. This LED is illuminated when the safety interlocks to the power supply are satisfied (Refer to Section 6 of this manual).

8. Close all cathode shutters.

9. Turn on substrate rotation. Verify that the substrate stage is rotating at the appropriate speed

Note: Make sure the speed potentiometer has not been dialed down to zero!

10. Select the desired sputter cathode by toggling the "Sputter Head Select" Keyswitch. The active sputter head will be indicated by a continuously illuminated LED above the "Sputter Head #1/#2/#3" display pads.

Note: ***Never change the active sputter head while the MDX power supply is operational. In addition, it is good practice to "park" the DC switching network in the "off" position (i.e., none of the "Sputter Head #1/#2/#3" display pads are illuminated) when the DC supply is not in use.***

11. Apply power to the cathode by depressing the "OUTPUT ON" key. At this point power will be ramped to the preset level over the preset period!

12. Soak (i.e., presputter) the target for approximately 15 to 30 seconds. Presputtering is necessary to insure the target's thermal equilibrium and a clean (on an atomistic scale) target.

13. Verify once again that the substrate is rotating.

14. Open the corresponding cathode shutter. Deposit for the prescribed time period.

15. Turn off power to the cathode by depressing the "OUTPUT OFF" key.

16. Close the cathode shutter.

17. Turn off substrate rotation.

18. Close process gas isolation valve(s).

19. Ensure that the loadlock is in vacuum status.

20. Transfer sample from main chamber to system loadlock (refer to Section 4.3.2).

21. Allow substrate to cool under vacuum before exposure to atmospheric pressure. This step is necessary to ensure that the freshly deposited film will not be oxidized.

4.4.2 RF SPUTTERING (CATHODES 1 AND 2)

1. "Park" the DC switching network in the "off" position (i.e., none of the "Sputter Head #1/#2/#3" display pads are illuminated). Even though RF blocking filters are installed in the DC inputs to the Cathode 1 and Cathode 2 matching networks, it always pays to take the safest system approach.

2. Ensure that main chamber has been pumped to a state of high vacuum and that substrate has been transferred from the loadlock onto the substrate table (refer to Section 4.3.1).

3. Toggle the "AUTO ENABLE" keyswitch so that the "AUTO ENABLE" LED indicator is not flashing.

4. Establish a suitable flow of gas into the chamber; achieving a process pressure of > 1 mtorr indicated by the MKS 127A capacitance manometer (refer to Section 4.3.3).

5. Verify the setpoint of the RF power supply you intend to use. Remember: you don't know what output level was programmed by the previous user of the system!!!

6. Momentarily place the corresponding ATX600 automatic matching network in manual mode. Ensure that the ATX 600 display is indicating capacitor position. Manually adjust BOTH capacitor positions to the center of the control span. This action will preset the networks capacitors in the center position; an ideal location to start a matching algorithm (Preset 1 and Preset 2 can also be used to achieve this goal. Please refer to the ATX600 manual for further instructions.)

7. Close cathode shutter (if open).

8. Turn on substrate rotation. Verify that the substrate stage is rotating at the appropriate speed.

Note: Make sure the speed potentiometer has not been dialed down to zero!

9. Verify that all interlocks are satisfied and reset the interlock string by depressing the "RF OFF" toggle switch. If all interlocks are satisfied the "RF OFF" and "INTLK" indicators will be steadily illuminated.

10. Turn on the RF power by depressing the "RF ON" key. In general, it will be difficult to light off the RF target if there are no other sources of electrons in the chamber. A convenient way to ensure ignition is to momentarily raise system pressure (by closing the hivac valve until ignition occurs) OR lighting off (with closed shutter) one of the other cathodes with the DC power supply. If an RF discharge is established which is not stable then it may be necessary to repeat step #6 to re-initialize the matching network. Once a stable plasma is established, the process pressure can be dropped to approximately 1 millitorr (if required).

11. Soak (i.e., presputter) the target for approximately 1 to 2 minutes. Presputtering is necessary to insure thermal equilibrium and a clean (on an atomistic scale) target.

12. Verify once again that the substrate is rotating.

13. Open the cathode shutter. Deposit for the prescribed time period.

14. Close the cathode shutter.

15. Turn off the RF power by depressing the "RF OFF" key.

16. Turn off substrate rotation.

17. Close process gas isolation valve(s).

18. Transfer sample from main chamber to system loadlock (refer to Section 4.3.2).

19. Allow substrate to cool under vacuum before exposure to atmospheric pressure. This step is necessary to ensure that the freshly deposited film will not be oxidized.

4.4.3 RF BIAS

This system has been delivered to the University of Utah with an RF bias stage. It is assumed that at some point in the future, an RFX600 power supply and ATX600 matching network will be installed on the system.

1. Ensure that main chamber has been pumped to a state of high vacuum and that substrate has been transferred from the loadlock onto the substrate table (refer to Section 4.3.1).

2. Toggle the "AUTO ENABLE" keyswitch so that the "AUTO ENABLE" LED indicator is not flashing.

3. Establish a suitable flow of gas into the chamber; achieving a process pressure of > 1 mtorr indicated by the MKS 127A capacitance manometer (refer to Section 4.3.3).

4. Verify the setpoint of the RF Bias power supply. Remember: you don't know what output level was programmed by the previous user of the system!!!

5. Momentarily place the Bias ATX600 automatic matching network in manual mode. Ensure that the ATX600 display is indicating capacitor position. Manually adjust BOTH capacitor positions to the center of the control span. This action will preset the networks capacitors in the center position; an ideal location to start a matching algorithm (Preset 1 and Preset 2 can also be used to achieve this goal. Please refer to the ATX600 manual for further instructions.)

6. Turn on substrate rotation. Verify that the substrate stage is rotating at the appropriate speed.

Note: ***Make sure the speed potentiometer has not been dialed down to zero!***

7. Verify that all interlocks are satisfied and reset the interlock string by depressing the "RF OFF" toggle switch. If all interlocks are satisfied the "RF OFF" and "INTLK" indicators will be steadily illuminated.

8. Turn on the Bias RF power by depressing the "RF ON" key. In general, it will be difficult to light off the RF target if there are no other sources of electrons in the chamber. A convenient way to ensure ignition is to momentarily raise system pressure (by closing the hivac valve until ignition occurs) OR lighting off (with closed shutter) one of the sputter cathodes with the DC power supply. If an RF discharge is established which is not stable then it may be necessary to repeat step #6 to re-initialize the matching network. Once a stable plasma is established, the process pressure can be dropped to approximately 1 millitorr (if required).

9. At this point additional RF/DC plasma processing (refer to Sections 4.4.1 and 4.4.2) may be initiated.

10. At the conclusion of all in-situ processing, turn off the Bias RF power by depressing the "RF OFF" key.

11. Turn off substrate rotation.

12. Close process gas isolation valve(s).

13. Transfer sample from main chamber to system loadlock (refer to Section 4.3.2).

14. Allow substrate to cool under vacuum before exposure to atmospheric pressure. This step is necessary to ensure that the freshly deposited film will not be oxidized.

4.5 CATHODE CONSTRUCTION

Removal/reinstallation of a cathode backing plate (necessary for bonded target changes) can be achieved by the following procedures. Please be sure to refer to the 3.0" cathode assembly drawing (C-0128-018-000) and the balloon descriptions which are listed in Section 4.5.3.

4.5.1 CATHODE DISASSEMBLY

1. Close the cathode water supply and return valves. These valves are located by the utility service plate on the system frame.

2. Make sure all power supplies are completely powered down.

3. Disconnect the power lead to cathode. Make sure the connector body is supported as the shell is loosened.

4. Remove the three, 4-40 socket head cap screws (#26) which secure the utility housing (#16) to the connector body (#15). Place the screws in a container which cannot be tipped over! Gently slide the utility housing back over the two 0.25" water lines. Ensure that all internals are exposed and accessible.

5. Locate a metal pan or dish. Mark both water lines as to where they are inserted on the water manifold (#5). Loosen both water fittings and place both water lines in the tray to drain.

6. Grasp the shaft of the cathode and at the same time remove the water manifold (#5) from the tube. The water manifold may require a wrench to loosen it from the body. Extract the manifold from the tube and ensure that the internal o-ring (#32) has not been dislodged.

7. Remove the thin nut (#22) from the tube. Loosen the two socket head set screws (#30) in the connector body and gently slide the connector body off the tube.

8. Ensure that the main chamber is vented to atmospheric pressure.

9. Loosen the split collar which secures the cathode's shutter blade to the shutter rotary motion. Remove the shutter blade.

10. Disengage the two gas struts which support the chamber's top plate. Tilt the plate back so that the cathode is completely exposed. NOTE: **This is a two person job!!**

11. Remove the split collar which secures the cathode shaft above the chamber lid's compression fitting. Loosen the shaft tube compression fitting and GENTLY slide the cathode down through the fitting. BE CAREFUL!!! The outside shaft of the cathode is a sealing surface. Slide the cathode out straight and try not to rock it from side to side. Any small scratches can be buffed out later with 320 grit emery paper.

12. Gently lower the chamber top plate so that it rest's on the seal surface.

13. Remove the three socket head cap screws (#20) which secure the dark space shield cover (#10) to the seal base assembly (#11). Remove the dark space shield cover.

14. Place the cathode body on a work bench and position the tube vertically. Grasp the shaft and at the same time loosen and then remove the compression nut (#21). Remove the metal washer (#23) and the alumina washer (#14). Slide the seal base assembly (#11) up and over the alumina insulator tube (#13). Inspect the seal base assembly's o-ring (#27) for and nicks or debris and place face down on a clean surface.

15. Slide the alumina insulator tube (#13) over the base assembly (#3) and then slide the alumina seal washer (#12) over the base assembly (#3).

16. Remove the vented, socket head cap screws (#28) which secure the backing plate assembly (#2) to the base assembly (#3). DO NOT LOSE THESE SCREWS!! After all the screws ore removed, gently twist/slide the backing plate straight down and off the base assembly. Inspect the o-ring (#31) for damage and .debris. Ensure that the backing plate seal surface is not scratched.

17. At this point the magnet assembly may be removed from the backing plate. Drain all water from the backing plate. Remove the stand-off bushing (#29) then grasp the pole piece (#7) between thumb and forefinger; pull straight out.

4.5.2 CATHODE RE-ASSEMBLY/SYSTEM INSTALLATION

1. Using a Magnaprobe, ensure that the polarity between the inner and outer magnet races (#38 and #39), as they are mounted on the pole piece (#7), is **OPPOSED**! If

these two magnets show the same polarity then the device will no longer function as a magnetron!!

2. Insert the magnet assembly (magnets face down) into the backing plate (#2) by grasping the pole piece between the thumb and forefinger and pushing straight down. Ensure that both magnets are seated into the recesses which have been machined in the bottom of the backing plate. Insert the stand-off bushing (#29).

3. Remove the o-ring (#31) from the base assembly (#3). Clean the sealing surface with a lint-free cloth. Ensure that the o-ring is damage free, debris free, and lightly greased with silicon hi-vacuum grease (Dow Corning DC976 or equivalent). Insert the o-ring (#31) on the base assembly. Be careful not to twist the o-ring (pay attention to the o-rings parting line!!) as it is inserted onto the step.

Note: ***Lightly greased implies that a small amount of grease was first applied to thumb and forefinger and then transferred to the o-ring in a reciprocating manner so that it appears shiny under an inspection light. Do not apply excessive grease.***

4. Place the backing plate assembly face down (i.e. target side down) on a work surface. Grasp the base assembly (#3) and insert it straight into the backing plate's recess. Make sure the backing plate's threaded holes line up with the base assembly's counter-bored, thru-holes **before** the two assemblies are joined. Keep the parts straight and do not apply excessive pressure. Insert the vented, socket head cap screws (#28) which secure the backing plate assembly (#2) to the base assembly (#3) and tighten in a star pattern until snug.

CAUTION: Over-tightening these screws will damage the backing plate!

5. Ensure that the base's upper o-ring (#27) is damage free, debris free, and lightly greased with silicon hi-vacuum grease (Dow Corning DC976 or equivalent). Clean and inspect the alumina seal washer (#12) for chips/scratches; slide over the base assembly (#3). Clean and inspect the alumina insulator tube for chips/scratches; slide over the base assembly (#3).

6. Ensure that the seal base's lower o-ring (#27) is damage free, debris free, and lightly greased with silicon hi-vacuum grease (Dow Corning DC976 or equivalent). Slide the seal base assembly (#11) down over the alumina insulator tube (#13).

7. Slide the alumina washer (#14) and then the metal washer (#23) over the threaded portion of the base assembly (#3). Thread on the compression nut (#21) and finger tighten. Ensure that both washers are aligned with the outside of the seal base shaft (If they are not aligned then it will be impossible to reinsert the stalk through the chamber lid compression fitting). Grasp the backing plate and tighten the compression nut. Ensure that the two washers do not slip out of alignment during the tightening process. Make sure that there is a robust compression on the two o-rings (#27) in the base and seal base.

8. Attach the dark space shield cover (#10) to the seal base assembly (#11) with the three socket head cap screws (#20).

9. Tilt the top-plate back. NOTE: **This is a two person job!!**

10. Gently slide the cathode shaft through the chamber lid compression fitting. BE CAREFUL!!! The outside shaft of the cathode is a sealing surface. Slide the cathode in straight and try not to rock it from side to side. Once the cathode is inserted to the proper source to substrate distance, attach the split collar which secures the cathode shaft above the chamber lid's compression fitting. Tighten the shaft tube compression fitting.

11. Re-connect the two gas struts which support the chamber's top-plate.

12. Re-attach the cathode shutter blade by tightening the split collar which secures it to the shutter rotary motion. Align the blade so that it completely covers the target.

13. Gently slide the connector body (#15) onto the seal base tube until the power connector (#17) touches the lower compression nut (#21). Tighten the two socket head set screws (#30) in the connector body and insert/tighten the thin nut (#22) with a wrench.

14. Grasp the shaft of the cathode and insert/tighten the water manifold (#5). Prevent the cathode from spinning in the chamber lid compression fitting during this operation.

15. Attach both water lines to their original location on the water manifold (#5). Make sure both water lines are tight! Turn on the water and inspect for any water leaks!

16. Gently slide the utility housing (#16) over the water lines onto the connector body (#15). Secure the utility housing with three, 4-40 socket head cap screws (#26).

17. Re-attach the power lead(s). Insert the connector shell straight and ensure that the shells are tight!! (Use a pair of pliers to ensure that this connector(s) is tight.

4.5.3 3.0" CATHODE ASSEMBLY DRAWING LEGEND

Balloon #	DVI P/N	QTY	DESCRIPTION
	C-0128-018-000	1	Assembly Drawing
2	B-0128-018-002	1	Backing plate assembly
3	C-0128-018-003	1	Base assembly
4	B-0128-015-103	1	3.0" clamp ring
5	0128-009-015	1	Water manifold assembly
6		1	Sputter target
7	A-0128-018-103	1	Pole piece
8	4-40x.12LG	6	Socket head screw (SS)
9	8-32x.25LG	3	Set screw (SS)
10	B-0128-015-106	1	Dark Space Shield Cover
11	C-0128-015-105	1	Seal base assembly
12	A-0128-015-108	1	Alumina seal washer
13	1-998A-3108	1	Alumina tube
spare 14	A-0128-012-105	1	Alumina washer
15	B-0128-012-106	1	Connector Body
16	B-0128-021-106	1	Utility Housing
17	A-0128-021-101	1	Connector strip
18	1-68PL-4-2	2	Fitting (.25x1/8NPT)
19	A-0128-009-109	1	Fitting (modified 68PL-4-2)
20	4-40x.15LG	3	Socket head screw (SS)
21	A-0128-012-108-1	1	Nut

	Balloon #	**DVI P/N**	**QTY**	**DESCRIPTION**
	22	A-0128-012-108-2	1	Nut (.12 THK)
	23	A-0128-012-111	1	Washer
	24	A-0128-012-113-2	1	Tubing (SS)
	25	1-NN-4-035	6 ft	0.25″ tubing (plastic)
	26	4-40x.25LG	3	Socket head screw (SS)
spare	27	1-5015-224	2	O-ring (viton)
	28	4-40x.25LG	3	Socket head screw (SS)
	29	A-0128-018-102	1	Stand off bushing
	30	10-32x.50LG	2	Socket head screw (SS)
spare	31	1-5013-150	1	O-ring (buna)
spare	32	1-5015-013	1	O-ring (viton)
	33	1-2170	2	Rubber grommet
	34	1-UG-496	2	Connector (Type HN)
	35	B-0128-015-107	1	Collector screen mount not
	36	B-0128-008-121-1	1	Collector screen
	37	1-0128-018-004	1	Magnet Assembly
spare		5015 010		Rotary shaft "O" ring

5. I/O LIST

OUTPUT

Module	Address	Pin	Description
IC693MDL940	**Slot #1**		**Rely Output (24vdc)**
A1	%Q0001	2	CRYO PUMP
A2	%Q0002	3	TURBO BACKING VALVE
A3	%Q0003	4	CHAMBER POUGH VALVE
A4	%Q0004	5	CHAMBER VENT VALVE
A5	%Q0005	7	LOADLOCK ROUGH VALVE
A6	%Q0006	8	LOADLOCK VENT VALVE
A7	%Q0007	9	GAS #1 VALVE
A8	%Q0008	10	GAS #2 VALVE
B1	%Q0009	12	SHUTTER #1
B2	%Q0010	13	SHUTTER #2
B3	%Q0011	14	SHUTTER #3
B4	%Q0012	15	MECH PUMP
B5	%Q0013	17	TURBO PUMP
B6	%Q0014	18	HEAT POWER
B7	%Q0015	19	ROTATION POWER
B8	%Q0016	20	LL HOLDER MOTOR FOR/REV
IC693MDR390	**Slot #3**		**Rely Output (24vdc)**
B1	%Q0017	12	SPUTTERHEAD #1
B2	%Q0018	13	SPUTTERHEAD #2
B3	%Q0019	14	SPUTTERHEAD #3
B4	%Q0020	15	LL HOLDER MOTOR ON/OFF
B5	%Q0021	16	GATE OPEN
B6	%Q0022	17	GATE CLOSE
B7	%Q0023	18	NOT USED
B8	%Q0024	19	NOT USED

INPUT

Module	Address	Pin	Description
IC693MDL645	**Slot #1**		**24vdc Input**
A1	%I0001	2	CATHODE #1 WATER SENSOR
A2	%I0002	3	CATHODE #2 WATER SENSOR
A3	%I0003	4	CATHODE #3 WATER SENSOR
A4	%I0004	5	SKIN SENSOR
A5	%I0005	6	DOOR SENSOR
A6	%I0006	7	BELLOWS
A7	%I0007	8	SERVICE MODE (Key)
A8	%I0008	9	TCI SETPOINT
B1	%I0009	10	TC2 SETPOINT
B2	%I0010	11	IG SETPOINT
B3	%I0011	12	LOADLOCK SETPOINT
B4	%I0012	13	TURBO PUMP SPEED (NORMAL)
B5	%I0013	14	NOT USED
B6	%I0014	15	NOT USED
B7	%I0015	16	NOT USED
B8	%I0016	17	SUBSTRATE WATER SENSOR
IC693MDR390	**Slot #3**		**24vdc Input**
A1	%I0017	2	LL HOLDER IN SENSOR
A2	%I0018	3	LL HOLDER OUT SENSOR
A3	%I0019	4	LL GATE OPEN
A4	%I0020	5	LL GATE CLOSED
A5	%I0021	6	NOT USED
A6	%I0022	7	NOT USED
A7	%I0023	8	NOT USED
A8	%I0024	9	NOT USED

DISCOVERY 18 "SOFTWARE" INTERLOCK STRATEGY

6.1 VARIAN CC2 SENTORR SETPOINTS:

TC1 (Chamber):	1.5E-1 torr
TC2 (Turbo Foreline):	5.0E-1 torr

6.2 MECHANICAL PUMP:

To turn on: No Interlocks

To turn off:

Turbo Backing Valve	CLOSED
LL Rough Valve	CLOSED

6.3 TURBO PUMP:

To turn on:

Mechanical Pump	ON

To turn off:

6.4 CHAMBER ROUGH VALVE:

To open:

Chamber Door	CLOSED
Chamber Vent Valve	CLOSED
LL Rough Valve	CLOSED
Turbo Backing Valve	CLOSED
Mech Pump	ON

To close: No Interlocks

6.5 CHAMBER VENT VALVE:

To open:

Chamber Door	CLOSED
Chamber Rough Valve	CLOSED
Chamber Hivac Valve	CLOSED
Loadlock Rough Valve	CLOSED
Turbo Backing Valve	OPEN
Gas 1 Valve	CLOSED
Gas 2 Valve	CLOSED
Heat Power	OFF

To close: No Interlocks

6.6 CHAMBER HIVAC VALVE:

To open:

Chamber Door	CLOSED
Chamber Rough Valve	CLOSED
Loadlock Rough Valve	CLOSED
Chamber Vent Valve	CLOSED
Mechanical Pump	ON
Turbo Pump	ON
Turbo Backing Valve	OPEN
TC1 Setpoint	SATISFIED

To close: No Interlocks

6.7 TURBO BACKING VALVE:

To open:

Chamber Rough Valve	CLOSED
LL Rough Valve	CLOSED
Mechanical Pump	ON

To close: No Interlocks

6.8 LOADLOCK ROUGH VALVE:

To open:

Loadlock Vent Valve	CLOSED
Turbo Backing Valve	CLOSED
Mech Pump	ON

To close:	No Interlocks

6.9 LOADLOCK VENT VALVE:

To open:

LL Rough Valve	CLOSED

To close:	No Interlocks

6.10 GAS#1 and GAS#2 ISOLATION VALVES:

To open:	No Interlocks
To close:	No Interlocks

6.11 SOURCE/STAGE SHUTTERS:

To open:	No Interlocks
To close:	No Interlocks

6.12 ROTATION:

To turn on:	No Interlocks
To turn off:	No Interlocks

6.13 HEAT POWER:

To turn on:

Skin switches	SATISFIED
Vacuum safety(*)	SATISFIED
Chamber door(*)	CLOSED
Cathode 1 Water Flowswitch (*)	SATISFIED
Cathode 2 Water Flowswitch (*)	SATISFIED
Cathode 3 Water Flowswitch (*)	SATISFIED
Bias Stage Water Flowswitch (*)	SATISFIED

To turn off: No Interlocks

6.14 RFX#1 RF POWER SUPPLY

To turn on:

Skin switches	SATISFIED
Vacuum safety(*)	SATISFIED
Chamber door(*)	CLOSED
Cathode 1 Water Flowswitch (*)	SATISFIED

To turn off: No Interlocks

6.15 RFX#2 RF POWER SUPPLY

To turn on:

Skin switches	SATISFIED
Vacuum safety(*)	SATISFIED
Chamber door(*)	CLOSED
Cathode 2 Water Flowswitch (*)	SATISFIED

To turn off: No Interlocks

6.16 MDX DC POWER SUPPLY:

To turn on:

Skin switches	SATISFIED
Vacuum safety(*)	SATISFIED
Chamber door(*)	CLOSED
Cathode 1 Water Flowswitch (*)	SATISFIED
Cathode 2 Water Flowswitch (*)	SATISFIED
Cathode 3 Water Flowswitch (*)	SATISFIED

7. GE 90-30 LADDER LOGIC PROGRAM

LOCATED IN BINDER

8. TROUBLESHOOTING

8.1 INTRODUCTION

WARNING!

DUE TO THE NATURE OF HOW A VACUUM SYSTEM OPERATES, THERE ARE MANY TYPES OF VOLTAGES ON A VACUUM CHAMBER.

BEFORE ATTEMPTING ANY TYPE OF TROUBLE-SHOOTING ON THE VACUUM SYSTEM OR ANY SUBSYSTEM, REFER TO PROPER SECTION OF THE OPERATING MANUAL FIRST TO CHECK IF THE SYSTEM IS BEING OPERATED IN THE PROPER MANNER. THERE MIGHT BE AN INTERLOCK PARAMETER BEING OVERLOOKED, RATHER THAN A SYSTEM FAILURE.

8.2 BASIC TOOL REQUIREMENTS

NOTE ON JEWELRY

When working around a vacuum system,
there is one good practice,

DO NOT WEAR ANY JEWELRY!

AN ARC MAY BE DRAWN FROM A HIGH VOLTAGE SOURCE!

REQUIRED TOOLS	
DESCRIPTION	**USE**
Multimeter (Analog or Digital)	A - To Read A.C. or D.C. Voltage B - To Read low A.C. or D.C. current C - To Read OHMs of resistance
Hand-held Current Meter (Amp probe)	Clamps around an A.C. line to read current
H.V. Probe	Attaches to a multimeter so that very high voltages can be measured
Screw Drivers (Both +/- types)	For disassembly and assembly
Wrenches (Box type)	For disassembly and assembly 3/8" to 1" for most items
Allen Wrenches	For disassembly and assembly 1/16" to 3/8" for most items

8.3 VACUUM SYSTEM CONTROL RACK

Problem: No panel lights displayed, or no activation of subsystems when switch is toggled.

Cause: No +24V DC power from DC power supply.

Solutions:

1. Check to see if there is 208V AC, 3 phase power at main breaker of vacuum system.
2. Turn on main breaker.
3. Turn on aux breaker.
4. Press green "START" button.
5. Check the fuse F2 for the 24 volt DC supply located in the Nema enclosure. Replace if blown.
6. Check the fuse F1 for the AC power to the DC power supply located in the Nema enclosure. Replace if blown.
7. Pull out 24 volt fuse from panel. Then, with voltmeter, check output terminals of +24 volts at power supply. These terminals can be found on the 24 volt supply P.C. board.
8. Check AC input on transformer of DC power supply to see if 120V AC power is present.
9. If there is 120V AC input power, but no 24V DC output, replace power supply.
10. If there is no AC power at this point, call Denton Vacuum (609-439-9100).

Problem: Panel light on, but no control of switches to pumps, valves and subsystems.

Causes: 24V DC Relay.

Solutions: Pumps, valves and subsystem are controlled by relay through PLC controller. Each relay is numbered. Check the relay according to the schematic so it is in position.

8.4 PLC CONTROLLER INPUT/OUTPUT

The program (software) installed into the PLC controller is set up so that when a key is toggled, it will send a signal to the PLC controller. And, if all interlock parameters are satisfied, the PLC controller will prompt a particular output. When the output is turned on it will activate the valve or subsystem which it is intended to turn on.

Problem: When a switch is toggled but the output assigned does not activate.

Causes:

1. Unsatisfied interlocks are stopping the outputs from activating.
2. No +24 volts DC to the relay.

Solutions for Cause 1:

1. If the key being pressed is to a subsystem, such as heat, make sure the interlocks are all satisfied and rotation is on.
2. If it is a valve key being pressed, make sure that the proper items are on and the proper items are off. For example, to activate the ROUGH valve, the MECH PUMP should be on and the HI-VAC and VENT valves should be off.

Solutions for Cause 2:

1. Using a multimeter, check to see if there is +24V DC present on the coil of 24V relay.

NOTE

KEEP IN MIND THAT THIS PART OF THE TROUBLESHOOTING MANUAL ASSUMES THAT THE POWER SUPPLIES ARE GOOD, BECAUSE THE FRONT PANEL LEDs ARE LIT AND THE INPUTS ARE RECEIVING A SIGNAL TO ACTIVATE THEM.

IF THIS IS NOT TRUE, THEN REFER TO THE FIRST PART OF THE TROUBLESHOOTING MANUAL FIRST TO DETERMINE IF THE POWER SUPPLIES ARE GOOD.

2. Check relay.

8.5 VALVES AND SHUTTERS

All the pumping valves and the source shutter on the vacuum system are pneumatically controlled.

The valve operation procedure is as follows:

There is a 24V DC signal from an output relay that feeds into a DC solenoid (electromagnetic) coil. The electromagnetic field created by the coil pulls up a "plunger valve" mounted to the air flow manifold. When this "plunger" is pulled up it permits air pressure (80 to 100 psi) to pass through the manifold into an air operated cylinder. The air pressure going into the air cylinder becomes greater on one side of the cylinder than on the other side. The side of the cylinder with the greater air pressure will move a "diaphragm" the opposite way. Depending on which way the "diaphragm" is travelling the valve is being opened or closed.

Problem: When the assigned output is activated the valve or shutter associated with it does not respond. But the panel indicator light turns green.

Causes:
1. No air pressure to the air manifold.
2. No power at valve or shutter solenoid.
3. Valve or shutter solenoid burnt out.

Quick Test: Before going on to the solutions for the above causes there is a quick way of diagnosing if an inappropriate valve has +24V DC and the solenoid is active:

Place a common size screw driver on top of the solenoid with the valve output on. If the screw driver is slightly magnetized to the top of the solenoid, the coil is good and there is most likely a mechanical problem such as no air or a stuck plunger. Remember this is only a quick test, **it is not 100% foolproof.**

Solutions for Cause 1:

A.
1. Check to see if there is 80 to 100 psi of air pressure to the vacuum system.
2. Check to see if the air lines are free of any water.

B.
1. Prove that there is air to the valve in question:
   a. Each valve has two (white vinyl) air lines attached to it, one for air in and one for return. These air lines are attached by a special fitting that makes it easy to detach or reattach an air line. These special fittings are called "LEGRIS" fittings.
   b. While holding one of the air lines firmly in your hand, push in the red collar on the Legris fitting, pull out air line while pushing the red collar of the Legris fitting inward.

      NOTE: There might be 80 to 100 psi of air pressure on the air line. Make sure that you have a firm grip on it so it does not "whip" out of your hand.

c. While holding air line, activate and deactivate power to solenoid.

d. Air should flow out of the Legris fitting mounted in the air manifold when power is at one state, and air should stop flowing when the power to the solenoid is in the other state. " State" being ON or OFF.

e. Repeat steps 3, 4 and 5 for the second air line to see if it operates the same way.

f. If both Legris fittings operate with alternating air on and off, the problem is in the valve assembly itself.

2. Disassemble valve in question to see if there is any foreign matter lodged in it or if a seal is broken.

3. If the air flow coming out of the Legris fittings did not change from one port to the other, when the valve switch was activated or deactivated, then disassemble the Humphry solenoid attached to the top of the air manifold to see if that assembly is intact.

Solutions for Cause 2:

1. Locate the Humphry valve, attached to the air manifold, that is in question.

2. Open the black plastic enclosure that holds the wires connecting to the solenoid.

3. When the wires have been located, expose the connectors that join the power wires to the solenoid.

4. Place a volt meter across the wires at the crimp connectors.

5. Also disconnect the solenoid from the output leads and try to read +24V DC power at the ends of the two wires.

6. If there is NO power at the solenoid when the output is high, using the subsystem schematic and volt meter, trace the lines to see if there is a break in the signal path.

7. If there is power now that the solenoid is not attached, then the solenoid is shorted out.

8. Using an ohm meter, read the resistance of the solenoid. If the resistance is 00.0, then the solenoid is shorted out.

9. Replace solenoid, then try valve.

Solutions for Cause 3:

1. Disconnect solenoid from power leads.

2. Using an ohm meter, read the resistance of the coil.

3. If the coil is good, it should have a resistance of about 65 to 85 ohms ±10 percent.

4. If the coil reads infinity, then it is burnt out.

5. Replace the coil and try valve.

8.6 ROTATION

Problem: When rotation is powered on it does not rotate, or it stops rotating in the middle of a run.

Causes:

1. Fuse blown.

2. Power to and/or from the motor controller is not active.

3. Mechanical jam-up.

Solutions for Cause 1:

1. Located in the power distribution enclosure, on the frame of the vacuum system, is an SCR Controller.

2. Shut power before step 3 is executed.

3. There is a fuse holder with a 1 amp fuse (FU-6).

4. Remove the fuse, check it. If blown, replace.

Solutions A for Cause 2:

1. Using a volt meter, measure the 120V AC power going into the controller.

2. If no power is present, trace the circuit using the rotation schematic and a volt meter.

Solutions A for Cause 3:

1. Check to see if the chain is too loose or too tight. If too loose, the motor will turn but the chain will not hold onto the gear so as to turn the planetary.

2. If the timing belt is too tight, the motor will not have enough torque to overcome the tension of the chain.

8.7 SUBSTRATE HEAT

8.7.1 SCR Controller

The silicon control rectifier (SCR) controller is a solid state device designed to control a large AC power level with a small DC control signal.

The input of the SCR has a 208 VAC input protected by circuit breakers to limit the current that will be seen by the SCR controller. As the DC signal to the gate of the SCR increases so does the output of the SCR controller. The SCR controller is about 95% efficient. This means for a given input the output voltage will achieve 95% of the actual input voltage. An SCR has a preset gain and span set on it. If these parameters are readjusted, it will limit the control range of the SCR either at the low end or the high end.

Beside being able to control the SCR with an external 0 to 10 Volt DC source, it can be controlled by an internal signal from its own source of power. This is done by removing the 0 to 10 DC signal from the "W" and "CCW" terminals, then attaching a (1 K ohm) pot to the "CW, W, CCW" terminals of the SCR. An SCR controller has one unusual property. If there is no "LOAD" attached to the output, the SCR will pass full voltage no matter where the DC control voltage is set.

Problem: No output from SCR.

Causes:

1. No control signal.
2. SCR device defective.
3. 24 VAC control transformer does not output 24 VAC.

Solution for Cause 1:

1. Measure control signal and check if it is 0 to 10 VDC.

Solutions for Cause 2:

1. With all wiring attached to the SCR, read the 0-10 VDC control signal to the SCR.
2. Prove that input control voltage is present.
3. Prove that the AC power voltage is present.
4. With heater coils connected to the output, place a voltmeter across the output terminals of the SCR.

> **NOTE**
>
> Insure that chamber is under vacuum to prevent coil embrittlement.

5. a. If there is a constant high voltage present, of 190 VAC, with very little or no change when the setpoint is changed, then the SCR is shorted out.
   b. Replace SCR module mounted to the heat sink.

6. a. If there is no voltage present at all, the SCR is burnt out and "open."
   b. Replace SCR module.

Solutions for Cause No. 3

1. Check input voltage to 24 VAC transformer. It. shoud be 208 VAC.

2. If input voltage is present, check output voltage. It should be 24 VAC.

3. If output voltage is not present, substitute transformer.

8.8 SUMMARY

Troubleshooting procedures are the same whether it is a vacuum system, your home audio/visual system or an automobile.

Steps for troubleshooting are to be done in a logical order.

This manual reviews the most vulnerable parts of a vacuum system's operation. If a vacuum system is maintained properly, it will give many years of uninterrupted service.

When a vacuum system is constructed, there are many different vendor parts used in the vacuum system, everything from the pumps to the gas flow controllers. Each sub system is supplied with a manual of operation. Refer to these manuals for troubleshooting procedures on the individual equipment in question.

If after a reasonable time the problem cannot be found, call Denton Vacuum (609-439-9100) to help with the problem and help reduce down time.

SECTION 9

SPARE PARTS LIST

8033-368

DENTON VACUUM INC.

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SPARE PARTS LIST

Chamber

JOB # 18003

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
5015-347	O-RING	4" VIEWPORT	1	8.65
5015-465	O-RING	CHAMBER FLANGE	1	83.75
5015-365	O-RING	LOAD-LOCK LID	1	14.85
5015-122	O-RING	1.12 COMPRESSION SEAL	3	1.00
191000	COPPER GASKET	1.33 CONFLAT FLANGE	5	3.15
G-275	COPPER GASKET	2.75 CONFLAT FLANGE	5	3.75
5106-004	SIGHT-GLASS	4" VIEWPORT	1	78.00

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SPARE PARTS LIST

Pumping System JOB # 18003

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
5013-116	O-RING	POPPET VALVE - BELLOWS	1	1.00
5013-227	O-RING	POPPET VALVE - BELLOWS	1	1.00
5013-257	O-RING	POPPET VALVE	1	1.00
5015-240	O-RING	POPPET VALVE	1	3.65
5015-238	O-RING	TRAP BOTTOM FLANGE	1	3.00
5015-346	O-RING	NW 100 (TURBO PUMP)	1	18.55
5015-314	O-RING	NW 16 PORTS	2	2.50
5015-320	O-RING	NW 25 PORTS	2	2.85
5015-326	O-RING	NW 40 PORTS	2	3.25
5015-120	O-RING	1" COMPRESSION FITTING	1	1.00
191019	COPPER GASKET	LOADLOCK VALVE	2	12.85
191007	COPPER GASKET	3 3/8" CONFLAT FLANGE	2	4.50
5100-37	RETAINING RING	POPPET VALVE	4	1.00
5100-31	RETAINING RING	POPPET VALVE	2	1.00
A-1-1/2X1	AIR CYLINDER	POPPET VALVE	1	165.00
N14VCR2	GASKET	VCR CONNECTIONS	6	2.75

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SPARE PARTS LIST

Heater

JOB # 18003

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
2608	CERAMIC STANDOFF	HEAT FIXTURE	10	2.40
5103-007	QUARTZ LAMP	HEAT FIXTURE	2	115.00
9924006	IN-LINE CONNECTOR	HEAT FIXTURE	2	9.85
9424009	HI VOLTAGE FEEDTHRU	HEAT FIXTURE	1	495.00

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DENTON VACUUM INC.

SPARE PARTS LIST

Transport Mechanism

JOB # 18003

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
5015-244	O-RING	TRANSPORT HOUSING FLANGE	1	3.85
LBB-625	LINEAR BEARING	TRANSPORT MECHANISM	2	47.00
BIO-3	BALL BEARING	TRANSPORT MECHANISM	1	104.00
BI-9	BALL BEARING	TRANSPORT MECHANISM	4	33.50
LBB-1500	LINEAR BEARING	TRANSPORT MECHANISM	1	207.20
BI-26	BALL BEARING	TRANSPORT MECHANISM	2	28.00
5100-112	RETAINING RING	TRANSPORT MECHANISM	6	7.20
5000-87	RETAINING RING	TRANSPORT MECHANISM	2	1.00
5000-62	RETAINING RING	TRANSPORT MECHANISM	3	1.00
5100-25	RETAINING RING	TRANSPORT MECHANISM	1	1.00
005-0070DOA	U-CUP SEAL	TRANSPORT 1/4" SHAFT	2	10.00
005-166000A	U-CUP SEAL	TRANSPORT 1 1/2" SHAFT	2	20.00

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SPARE PARTS LIST

3" Sputter Cathode & Shutter

JOB # 18003

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
5015-013	O-RING	WATER CONNECTION	3	1.00
5015-224	O-RING	SPUTTER CATHODE	3	1.65
5013-150	O-RING	SPUTTER CATHODE	3	1.95
5015-010	O-RING	1/4" ROTARY SHUTTER SHAFT	3	1.00
998A-3108X16	ALUMINA TUBE	SPUTTER CATHODE	1	109.00
8-DP-2	AIR CYLINDER	CATHODE SHUTTER	1	33.00

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SPARE PARTS LIST

Biasable Substrate Rotation

JOB # 18003

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
191007	COPPER GASKET	3⅜" CONFLAT FLANGE	2	4.25
5015-218	O-RING	BIASABLE FEEDTHROUGH	2	1.45
005-186	SEAL U-CUP	BIASABLE FEEDTHROUGH	2	24.00
5261	EXTENSION SPRING	BIASABLE FEEDTHROUGH	2	12.55
60072RSI	BEARING	BIASABLE FEEDTHROUGH	2	65.00
5000-244	RETAINING RING	BIASABLE FEEDTHROUGH	1	7.20

10. ELECTRICAL SCHEMATICS

LOCATED IN BINDER

11. MECHANICAL DRAWINGS

LOCATED IN BINDER

12. PREVENTIVE MAINTENANCE

12.1 MECHANICAL PUMP

Inspect the oil level daily in the mechanical pump supplied with the system. Add oil to the fill line as required. Replace oil every three months or immediately if oil appears brown or black in color. If oil appears "frothy" open gas ballast to remove emulsified non-condensables (eg., water).

12.2 DEPOSITION CHAMBER

Ensure that no build-up of deposition material(s) occurs on the chamber walls and baseplate. Line chamber with disposable foil (degreased, heavy-gauge aluminum foil works well) and replace on a periodic (dependent on system use) basis.

12.3 TURBOMOLECULAR PUMP

The turbo supplied with the system is virtually maintenance free (lifetime grease lubrication). Please refer to the pumps operating manual for the procedure to clean the pump if it becomes contaminated with deposition materials.

12.4 SLIDING SEALS (SUBSTRATE STAGE/LOADLOCK TRANSFER ARM)

Replace the U-cup seal on the substrate stage and both U-cup seals on the loadlock transfer arm annually. Lubricate with perfluorinated-polyether grease (Kurt J. Lesker Co. RT-15 or equivalent) every 3 months.