SPI Supplies
Vacu Prep II™
Operation Manual

SPI Supplies # 12200-AB
12200-AX

Structure Probe, Inc. / SPI Supplies
569 East Gay Street
West Chester, PA 19380

Toll-free from USA/Canada: 1-(800)-2424-SPI
Phone: 1-(610)-436-5400
FAX: 1-(610)-436-5755
E-mail: spi3spi@2spi.com

Structure Probe, Inc. / SPI Supplies
Street address for UPS, FedEx, DHL, other couriers, trucks
569 East Gay Street
West Chester, PA 19380

Mailing address P.O. Box 656 West Chester,
PA 19381-0656 USA

Toll-free from USA/Canada: 1-(800)-2424-SPI
Phone: 1-(610)-436-5400
FAX: 1-(610)-436-5755
E-mail: spi3spi@2spi.com

For further information regarding any of the other products designed and manufactured by SPI Supplies, contact your local representative or directly to SPI Supplies at the address above, or visit **www.2spi.com**

- Carbon and Sputter Coaters
- Osmium Plasma Coaters
- Ion Mills
- Plasma Reactors for ashing and etching
- Plasma Cleaners
- Critical Point Dryers
- Electron Microscopy Supplies, Consumables and Accessories

WARRANTY

The SPI Supplies unit you have purchased is guaranteed to be free of defects in workmanship on the day of shipment. This warranty covers parts and labor for a period of one year, excluding shipping charges or consumables. Breakage of glassware is specifically excluded from this warranty.

Proper use of your unit, according to the operation manual, should result in trouble-free operation. Any improper use of the SPI Supplies unit through modifications or unreasonable operating procedures will void this warranty.

Disclaimer

SPI Supplies instruments are designed for simplicity of installation and operation. This manual provides full and complete information in both these areas. SPI Supplies therefore assumes no liability or responsibility of any kind for damage or injury resulting from incorrect installation or operation of the machine.

If any questions arise, contact SPI Supplies from the USA/Canada 1-800-2424-SPI or 1-610-436-5400 for assistance. For all other countries, contact our nearest agent or SPI Supplies directly. A listing of our agents may be found on our website at:

http://www.2spi.com/info/agents/

TABLE OF CONTENTS

Section **Page No.**

TABLE OF CONTENTS

Section **Page No.**

TABLE OF CONTENTS

Section **Page No.**

TABLE OF CONTENTS

Section **Page No.**

INTRODUCTION

GENERAL DESCRIPTION

The SPI Supplies Vacu Prep II™ is a fast, clean laboratory deposition system. By using state-of-the art electronic components and an advanced roughing/backing vacuum integration, the system can rapidly and repeatedly cycle from atmosphere to high vacuum.

This system is designed to simplify the geometry necessary for coordination of multiple source depositions.

Using the finest available subsystems and components, the system is highly reliable and durable. The system's inherent flexibility allows the operation of an evaporation sources, plasma sources, and gas control.

The Vacu Prep II system is semi-automatic and is equipped with programmable logic control (PLC) through a touch screen interface. The controls are contained in the main system cabinet. It can be access through the front or rear door.

The system offers you a myriad of thin film process options. However, it is important to note that with all of this system's potential there exist safety considerations.

Individuals who are to operate, service, or maintain this system should familiarize themselves with this manual.

If this equipment is used in a manner not specified by SPI Supplies, the protection provided by the equipment may be impaired.

SAFETY WARNINGS

 **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 subsystems 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.**

 **Only personnel with proper training and process experience should operate the system.**

PLEASE NOTE BEFORE SYSTEM STARTUP

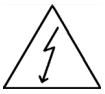
Do not attempt to operate this system until you have read this manual completely. Failure to operate the system properly may result in damage to the system.

This unit has been shipped with the high vacuum pump section under vacuum. Do not open any vacuum valves until the procedure outlined in the Pumping System Operation section of this manual has been followed. Failure to heed this warning may result in damage to the equipment.

If the opening of the High Vacuum Valve is attempted, the valve operating mechanism may be damaged.

Air used for the automatic valves MUST be clean and dry to ensure proper operation of the valves. Failure to comply may result in a voiding of the warranty.

SAFETY SYMBOLS

	CAUTION: Risk of Electrical Shock
	CAUTION: This symbol is intended to alert the user to the presence of important operation & maintenance instructions in this manual.
	Protective Conductor Terminal: this symbol indicates where the protective earth ground is connected.

PHYSICAL SPECIFICATIONS

- Dimensions: 43" high x 31" wide x 25 5/8" deep (with bell jar up)(109 x 79 x 65cm)
- Weight: 260 pounds (118Kg)
- Electrical: 120/230V, single-phase, 50/60 Hz, 20A (typically), 3wire
- Air: 80-100 lbs. Air (clean and dry)
- Nitrogen: 5-15 psi for venting (suggested, laboratory grade or better)
- Argon: 5-15 psi (sputtering or AC Glow, laboratory grade or better)
- Water Cooling: for sputterhead (1 gpm)

UTILITY REQUIREMENTS

Electrical:

The Vacu Prep II deposition system is available with a variety of options. Electrical requirements vary. Typical requirements are listed here for reference. Check the Power Schematics or contact SPI for final system specifications.

- 110 VAC (+/- 5 %), 50/60 Hz, Single phase, 3 wire, 20 – 40 Amps (SEE POWER SCHEMATIC). Contact SPI for final system specifications.
- 220 VAC (+/- 5 %), 50/60 Hz, Single phase, 3 wire, 20 - 40 Amps (SEE POWER SCHEMATIC). Contact SPI for final system specifications.

Water:

- (1.0) GPM, 60-80 °F, 40-60 psig differential between supply and return (80 psig maximum inlet pressure).
- Water distribution:
    - Turbo Pump. (OPTIONAL)
    - Quartz crystal monitor or controller. (OPTIONAL)

Compressed Air:

- Normal dry shop air, 80-100 psi (system valve operation).
- Stand-alone air manifold with solenoid valves incorporating removable plug-type electrical connections.

Argon (99.9995 % purity)(if equipped):

- 3-15 psi (process gas).

Nitrogen (optional):

- Preferentially evaporated from a liquid source, and
- 3-15 psi (chamber venting).

INSTALLATION

After ensuring that all utility connections have been made (See Utility Requirements), the installation can be completed.

The vacuum system requires minimal assembly upon installation because most subassemblies are mounted on the unit frame.

Note: Initial installation completed by SPI Supplies Technicians only as a paid option.

There are subsystems not on the unit frame that may require re-installation after the system is operational.

PLEASE NOTE BEFORE SYSTEM STARTUP

Do not attempt to operate this system until you have read this manual completely. Failure to operate the system properly may result in damage to the system.

This unit has been shipped with the high vacuum pump section under vacuum. Do not open any vacuum valves until the procedure outlined in the Pumping System Operation section of this manual has been followed. Failure to heed this warning may result in damage to the equipment.

If the opening of the High Vacuum Valve is attempted, the valve operating mechanism may be damaged.

GENERAL

- This system is for indoor use only. The system must be placed on a flat, sturdy bench. Otherwise, any vibration from the unit could be picked up and amplified by the table. Three feet clearance is required for the operating the system. At least six inches clearance on both sides to leave adequate room for the fan to ventilate the system interior.

- Consumables are generally bulk material, boats or filaments and require all power supplies to be shut down before venting and exchanging these items.

MECHANICAL PUMP

- A mechanical pump is not included with the Vacu Prep II System.
- SPI Supplies suggests the use of either:
  - Leybold SCROLLVAC SC 15D Scroll Pump
  - Leybold Triviac D8B Rotary Vane Pump

TURBO PUMP

- The Vacu Prep II is equipped with an Agilent Technologies Varian air-cooled turbo pump.

COMPRESSED AIR

- An external air supply of 80 to 100 psi is required to operate the air valves. The connections are located in the rear up right side of the unit.

HIGH PURITY GAS LINES – OXYGEN, ARGON, NITROGEN

- All pumps must be operational before connecting the high purity gas line.
- All gas supply lines must have an ON/OFF valve between the regulator and the vacuum system.
- Connect the gas supply line to the rear of the machine and close the valve near the pressure regulator.
- Pump the chamber out manually and open the Gas Isolation Valve. Use the gas adjust micrometer valve to increase the gas flow set point to 50%. Continue pumping out the system until the actual flow in the line decreases or the pressure returns to the original value.
- Increase the flow Set point to maximum. Continue pumping until the actual flow is approximately zero (0).
- Reduce the set point to zero or close the micrometer valve and close the Gas Isolation Valve. Open the toggle valve near the pressure regulator and adjust the regulator to 0.75 bar.

FILAMENT HOLDER

- The filament holders screw directly onto the threaded 3/8" low voltage feedthroughs, which are mounted in pairs at the left and right of the baseplate. Filaments can be positioned low for low angle rotary shadowing or well over the tilting OMNI for conductive coatings. Make all connections snug for good electrical contact.

SOFTWARE OVERVIEW

This chapter will describe the control screens. An understanding of these screens is required to proceed with operation of the vacuum system.

CONTROL SYSTEM

The Vacu Prep II system is semi-automatic and is controlled by a PLC from Automation Direct. The operator interface is a touch screen with a graphical interface to the PLC. Manual operation of the valves, pumps, low voltage sources, DC sputter sources, and the fixture rotation subsystems is through this graphical interface. Automatic processes are also initiated through this screen.

This software links the operator to the PLC. It provides control input and data display of the current status. This software is active whenever the power is applied to the system. Graphical display of the control system is organized onto nine main sections with each containing it's own sub-screens.

Graphic display of the control system is arranged on eight or nine "screens":

- Start (Screens)
- Overview
- Pumps & Valves
- Gauges
- Low Voltage Sources Control
- DC Sputter Sources (if equipped)
- Substrate Rotation
- Auto
- Service

Start is the first screen active when power is applied. It gives the operator access to the other screens through the "System Start" push button at the top of the screen. Access to the control software is through this screen.

Overview is the primary operating screen. A graphical representation of the vacuum system is displayed on this screen. Individual vacuum component graphics (valves, pumps) change color to indicate ON/OFF condition. All current system data is displayed on this screen. The current vacuum pressure, system Mode, and interlock status are displayed on this screen. The operator can access all subsystem control screens through a push button on this screen. This screen is described in detail later in this section of the manual.

Pumps & Valves: All pumps and valves can be controlled from this screen as long as the safety interlocks are satisfied. The color of the push buttons change color to indicate ON/OFF status. If a button does not change color when pressed, an interlock is not satisfied. Interlock and system status are displayed on the screen. Current vacuum pressure is also displayed on this screen.

Gauges: All vacuum gauge functions are displayed on this screen. Vacuum gauge Degas function is activated from the screen. Interlock and system status are displayed on the screen. Current vacuum pressure is also displayed on this screen.

Low Voltage Sources & Glow (If equipped): All low voltage source functions are displayed on this screen. Power On/Off, power setpoint input, source selection are available on this screen. Low Voltage Source current is displayed on this screen as well as the overview screen. The Glow power supply ON/OFF button is on this screen. The Source Shutter button is on this screen. Interlock and system status are displayed on the screen. Current vacuum pressure is also displayed on this screen.

DC Sputter Control (If equipped): All sputter source functions are displayed on this screen. Power On/Off, power setpoint input, source selection are available on this screen. DC Setpoint is displayed on this screen as well as the overview screen. The Gas power and Rotation ON/OFF buttons are on this screen. The Source Shutter button is on this screen. Interlock and system status are displayed on the screen. Current vacuum pressure is also displayed on this screen.

Substrate Rotation: Substrate Rotation ON/OFF and speed setpoint input are available on this screen. Interlock and system status are displayed on the screen. Current vacuum pressure is also displayed on this screen. Rotation MUST be ON when operating LV Power Supply.

Auto Buttons are available on this screen to initiate automatic sequences that are programmed into the PLC. Auto Pump and Auto Vent are available. An Abort button is available to stop an automatic sequence. Interlock and system status are displayed on the screen. Current vacuum pressure is also displayed on this screen.

Automatic Process Buttons are available on this screen to initiate automatic deposition sequences (low voltage or sputter) that are programmed into the PLC. An Abort button is available to stop an automatic sequence. Interlock and system status are displayed on the screen. Current vacuum pressure is also displayed on this screen.

Service Access to the Service Mode is through the hidden buttons on this screen.

MODES OF OPERATION

Auto:

Auto mode is used to run automatic sequences. All interlocks are active in this mode. The Abort button is active in this mode.

Note: Access to all other on-screen controls are denied in the Auto mode. This interlock is built in to avoid manual operation of a subsystem in the Auto Mode.

Interlocks:

Interlock messages are displayed on the control screens. Unsatisfied interlocks are listed. The word "Satisfied" is displayed when all interlocks are satisfied. A complete listing of the system interlocks is included in the Interlock section of this manual.

Manual:

The operator can safely run the system from the touch screen in the Manual mode. All interlocks are active in Manual mode.

All on-screen control systems are available. The state of the valves, pumps, low voltage source, DC sputter sources, and fixture rotation can be changed on the touch screen.

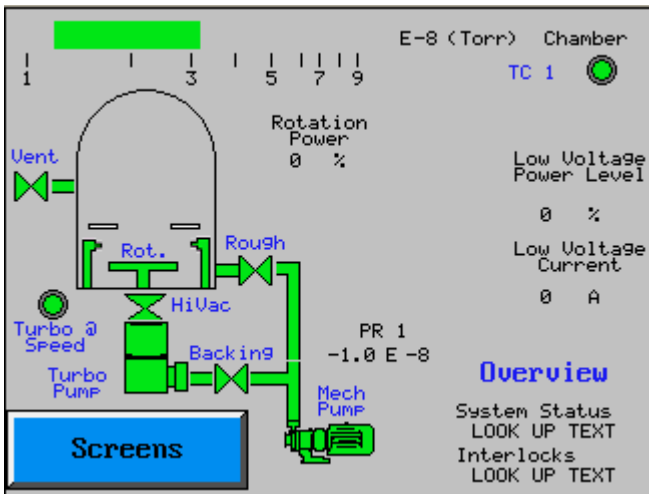
Service:

CAUTION: Interlocks are inactive in service mode. Caution must be taken to safely operate the vacuum system

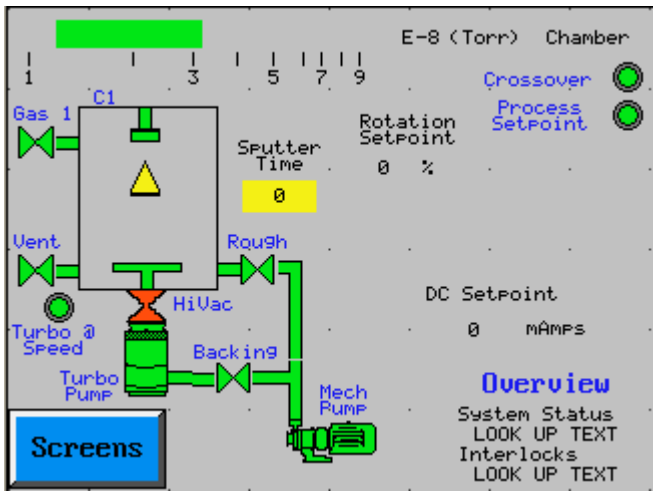
NOTE: Service Mode is not accessible to System Operators. Service Mode is only accessible by activating the hidden Service key buttons.

Use Service Mode only for maintenance. Software interlocks are inactive in this mode. Hardwired interlocks are active in service mode. All control systems are active as in Manual mode.

OVERVIEW SCREEN



Typical Overview Screen (Low Voltage)



Typical Overview Screen (Sputter)

This screen is used to display current system status and the state of vacuum chamber, pumping system and Sputter Sources. Access is provided to the screens display.

Graphics change color to indicate current state: **GREEN** = ON/OPEN, **RED** = OFF/CLOSED. Valves, pumps, rotation motor, and interlocks change color to indicate current state (**GREEN** = ON/OPEN; **RED** = OFF/CLOSED). Graphic indicators are displayed on the vacuum system graphic when evaporation sources are active.

The Chamber Pressure (from the full range gauge in Torr) and Rotation Setpoint (0-100%) are displayed on this screen.

Pressure setpoint indicators are visible:

- TCI Setpoint is a pressure setpoint interlock ($1.0e^{-1}$ Torr).

The current state of the Crossover and Process vacuum setpoints and the Turbo @ Speed indicator are displayed on this screen (**GREEN** = Satisfied; **RED** = Open).

Current System Mode and Interlock Status are also displayed on this screen. The System Status will be Manual, Auto, or Service.

The various interlocks that will appear will be Bellows (BL), Skins (SK), and the chamber Door (DR). If all interlocks are met, the system will display SATISFIED. If an interlock is not met, the system will read unsatisfied and the name of the interlock will appear on the interlock message. Clearing this interlock will allow continuation of process.

Push button at the bottom is used to switch back to "Screens"

Low Voltage

Low Voltage (LVA or LVB) graphics change color to indicate current state (ON/OFF; OPEN/CLOSED).

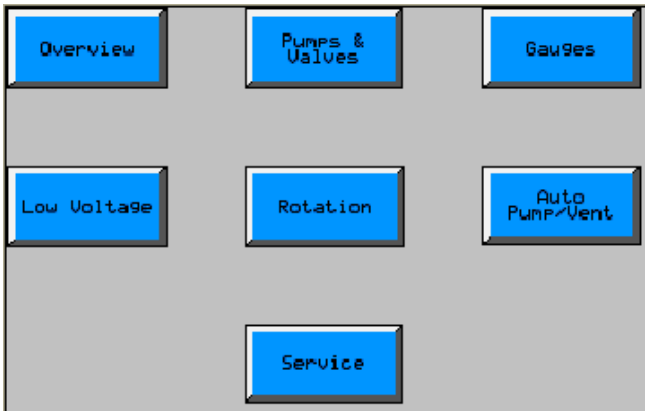
Low Voltage power setpoint & Low Voltage Current are displayed on the screen.

Sputter

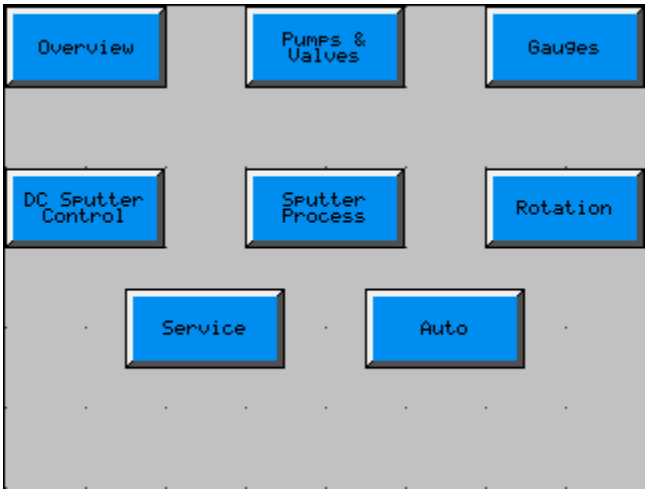
Cathode and Gas graphics change color to indicate current state (ON/OFF; OPEN/CLOSED).

The DC Setpoint and the Sputter countdown Timer are displayed.

SCREENS



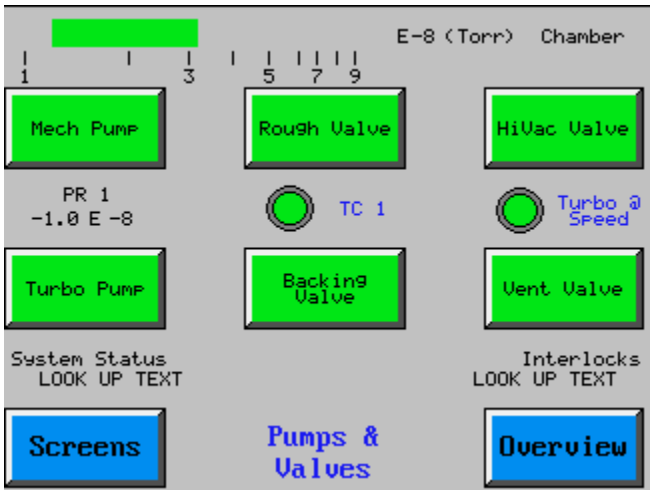
Screens (typical for Low Voltage)



Screens (typical for Sputter)

Access to all subsystem control screens is available through this menu screen

PUMPS & VALVES



Buttons change color to indicate current state: green = ON/OPEN, red = OFF/CLOSED.

Current System Status (Auto, Manual, Service) is displayed on this screen. Current Chamber vacuum pressure is displayed on the screen. Unsatisfied Interlock messages are displayed on the screen.

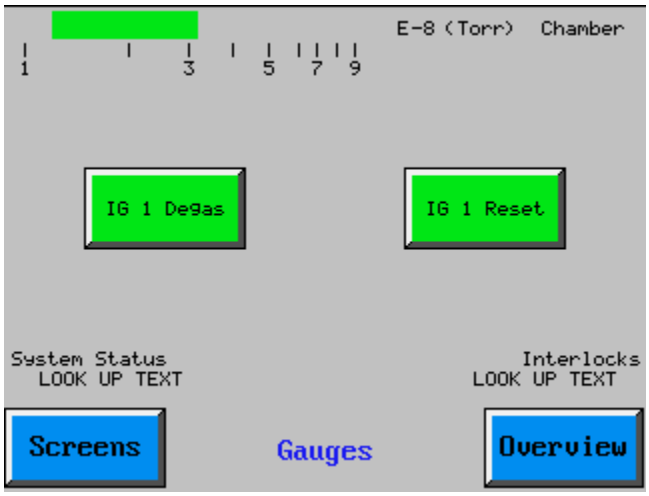
The mechanical (roughing/backing) pump and valves can be operated from this screen.

TC #1 and Turbo @ Speed interlock conditions are displayed on the screen (satisfied = green).

Screens Push button is used to switch to the Screen menu. Overview button is used to switch to the Overview screen.

Operation of the Pumps and Valves is described in detail in the Pumping System section of this manual.

GAUGES



Buttons change color to indicate current state: **GREEN** = ON, **RED** = OFF

The degassing of the Ion gauge can be controlled from this screen. When the Chamber Degas button is pressed, the gauge will be degassed for three (3) minutes. Degassing of the Ion gauges requires the system to be under vacuum with all vacuum interlocks met, such as the bellows and chamber door.

NOTE: Chamber pressure must be below 1e-4 Torr before activating the Degas feature. Read the gauge manual before attempting to degas the gauge tube.

The vacuum gauge can be Reset from this screen. The Reset function powers the gauge OFF momentarily. This will reset the gauge.

The Chamber Pressure (from full range gauge in Torr) is displayed continuously on this screen.

Current System Mode and Interlock Status are also displayed on this screen. The System Status will be Manual, Auto, or Service. The various interlocks that will appear will be Bellows (BL), Skins (SK), and the chamber Door (DR).

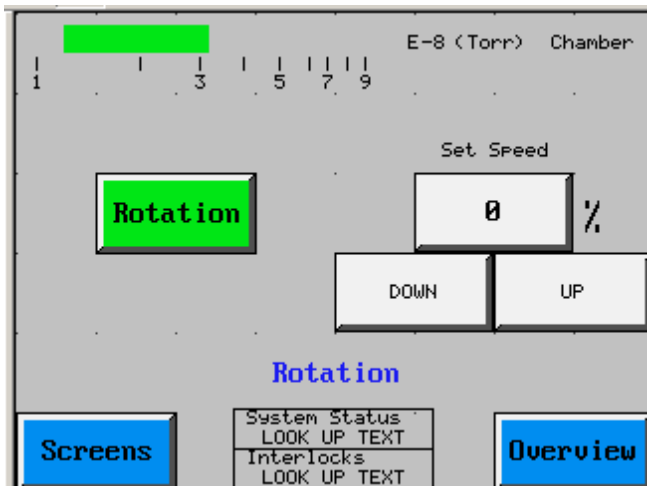
If all interlocks are met, the system will display SATISFIED. If an interlock is not met, the system will read unsatisfied and the name of the interlock will appear on the interlock message. Clearing this interlock will allow continuation of process.

Push buttons across the bottom are used to switch back to "Screens" or "Overview".

Screens Push button is used to switch to the Screen menu. Overview button is used to switch to the Overview screen.

ROTATION

(If Equipped)



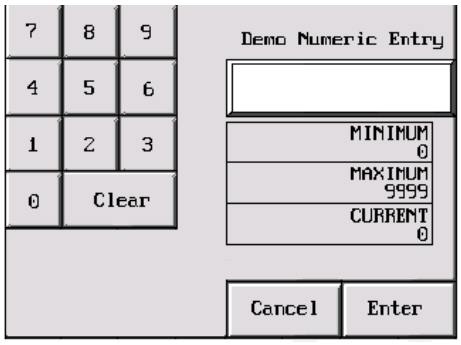
Buttons change color to indicate current state: green = ON/OPEN, red = OFF/CLOSED.

Current System Status (Auto, Manual, Service) is displayed on this screen. Current Chamber vacuum pressure is displayed on the screen. Unsatisfied Interlock messages are displayed on the screen.

The substrate Rotation drive motor can be turned ON/OFF on this screen.

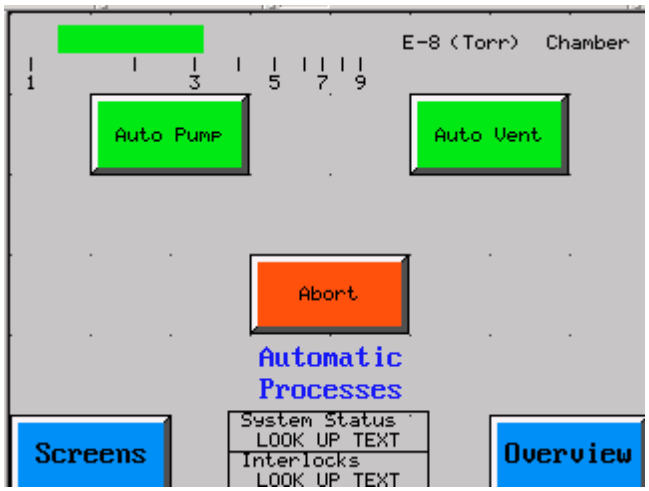
The rotation Set Speed (%) can be input on this screen. Press the Set Speed button and a digital keypad will pop-up for data entry or use the UP/DOWN button..

Screens Push button is used to switch to the Screen menu. Overview button is used to switch to the Overview screen.



Numeric Keypad

AUTO



Automatic operation of the vacuum system is initiated from this screen.

AUTO PUMP is an automatic sequence that safely pumps the vacuum system into high vacuum.

AUTO VENT is an automatic process that safely vents the vacuum chamber to atmospheric pressure.

The ABORT button stops an automatic sequence with all valves returning to a safe condition. The ABORT button will also change the System Status from Automatic to Manual Mode.

Current System Status and Interlock Status are also displayed on this screen. The System Status will be Manual, Auto, or Service. The various interlocks that will appear will be Bellows (BL), Skins (SK), and the chamber Door (DR).

If all interlocks are met, the system will display SATISFIED. If an interlock is not met, the system will read unsatisfied and the name of the interlock will appear on the interlock message. Clearing this interlock will allow continuation of process.

The Chamber Pressure (from the full range gauge in Torr) is displayed continuously on this screen.

Push buttons across the bottom are used to switch back to "Screens" or "Overview".

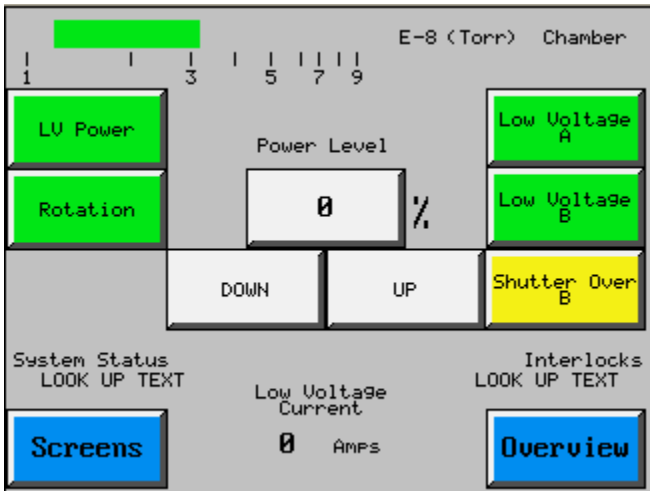
NOTE: AUTO PROCESSES WILL AUTOMATICALLY START ROTATION. SYSTEM VENTING WILL AUTOMATICALLY STOP ROTATION.

NOTE: Selection of either button will cause the system to switch from Manual to Auto Mode. Manual operation of subsystems is NOT available in Auto Mode. Manual operation of subsystems is available ONLY in Manual Mode.

Screens Push button is used to switch to the Screen menu. Overview button is used to switch to the Overview screen.

LOW VOLTAGE & GLOW

(If Equipped)



Buttons change color to indicate current state: green = ON/OPEN, red = OFF/CLOSED.

Current System Status (Auto, Manual, Service) is displayed on this screen. Current Chamber vacuum pressure is displayed on the screen. Unsatisfied Interlock messages are displayed on the screen.

The Low Voltage (LV) Power supply can be turned ON/OFF on this screen. The Rotation MUST be ON (green).

The Low Voltage (LV) Shutter supply can be switched between sources on this screen.

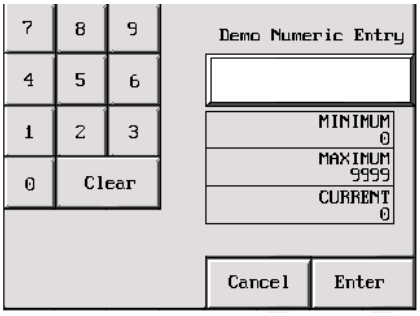
The Power Level (%) of the Low Voltage Source can be input on this screen. Press the Power level Button and a digital keypad will pop-up for data entry or use the UP/DOWN button. The Low Voltage Current (Amps) is displayed on this screen.

The Rotation can be switched ON/OFF from this screen.

The Glow Power Supply can be turned ON/OFF on this screen if equipped. Gas is introduced into the vacuum chamber manually through the Micrometer Bleed valve. Gas pressure should be set between 5 x 10^{-3} Torr and 9 x 10^{-3} Torr.

NOTE: CHECK THAT THE TWO ANTENNAE ARE NOT TOUCHING ANY OTHER PARTS.

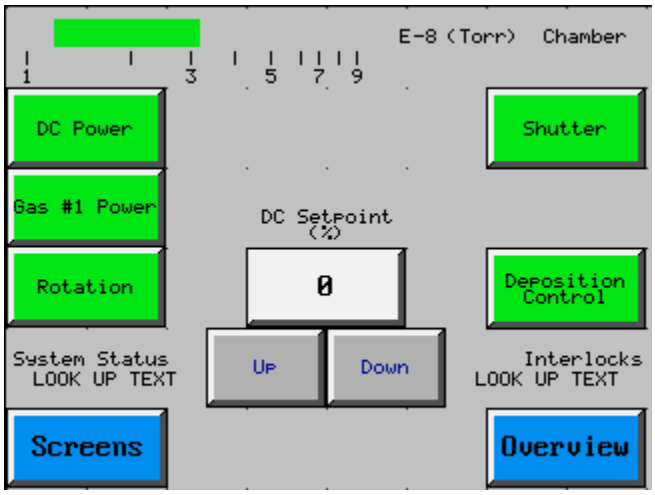
Screens Push button is used to switch to the Screen menu. Overview button is used to switch to the Overview screen



Numeric Keypad

SPUTTER CONTROL

(If Equipped)



Buttons change color to indicate current state: **GREEN** = ON, **RED** = OFF

The DC Power on/off can be controlled on this screen.

Gas 2 Power on/off can be controlled on this screen. GREEN = ON, RED = OFF

The DC Setpoint (mAmps) can be manually controlled form this screen using the Up/Down buttons. The current DC Setpoint is displayed. The RF Setpoint can also be changed by clicking on the white data entry box. Enter the desired setpoint on the pop-up screen and press Enter.

The DC Power is also displayed on the Overview screen.

The Cathode Shutter can be operated from this screen. GREEN = OPEN, RED = CLOSED.

The substrate Rotation can be controller on/off from this screen. GREEN = ON, RED = OFF

The Deposition Controller button will switch Sputter power control to the deposition controller. This will disable the Sputter Power input from this screen. The DC Power button must be ON before activating the Deposition Control button.

NOTE: Read the deposition controller operating manual before proceeding to operate the sputter source through the deposition controller!

All deposition parameters must be programmed into the deposition controller. The deposition controller will control the power supply.

Power ramp and soak settings are programmed into the deposition controller. The cathode shutter will open when the deposition controller enters the Deposit state and close when the Final Thickness is reached.

The Chamber Pressure (from the full range gauge in Torr and from the Capacitance manometer in mTorr) is displayed continuously on this screen.

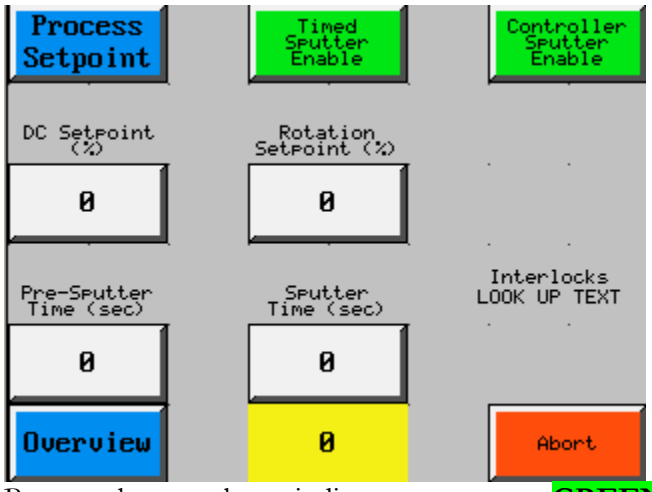
Current System Mode and Interlock Status are also displayed on this screen. The System Status will be Manual, Auto, or Service. The various interlocks that will appear will be Bellows (BL), Skins (SK), and the chamber Door (DR).

If all interlocks are met, the system will display SATISFIED. If an interlock is not met, the system will read unsatisfied and the name of the interlock will appear on the interlock message. Clearing this interlock will allow continuation of process.

Push buttons across the bottom are used to switch back to "Screens" or "Overview".

SPUTTER PROCESS

(If Equipped)



Buttons change color to indicate current state: **GREEN** = ON, **RED** = OFF

Click on the white data entry box to change the Rotation Setpoint. Enter the desired setpoint on the pop-up screen and press Enter.

NOTE: Rotation will be activated before operating sputter power.

Pre-Sputter Time and Sputter Time (in seconds) can be input on this screen. Tap the white input box and a digital input screen will pop-up for data entry. A countdown timer is visible on the screen in the GREEN box.

The current DC and Rotation Setpoints are set on this screen and displayed on the Overview screen.

NOTE: Gas flow will be activated before operating RF or DC power.

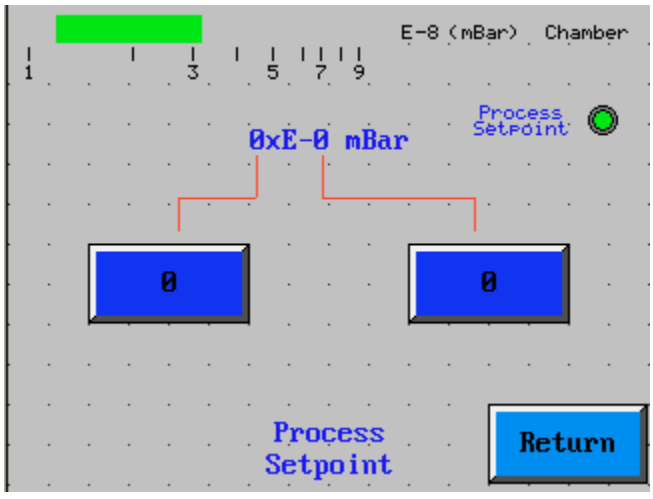
The Timed Sputter Enable button will activate an Auto Pump sequence followed by a Timed Sputter process. This process is described in detail in the System Operation section of this manual.

Power setpoints must be entered, gas flow setpoints must be set, and a Process setpoint should be programmed before starting a Timed Sputter process.

The Abort button will stop the Timed Sputter sequence and switch the System Status from Automatic to Manual.

Process Setpoint

(If Equipped)



The Process Setpoint button will activate a screen that provides access to program the Process Setpoint.

This setpoint is used as an interlock for the start of an automatic deposition process. Process Setpoint indicator will indicate current state of the pressure interlock. **GREEN** = Satisfied, **RED** = Not Satisfied.

The Process Setpoint indicator is also visible on the Overview screen.

A Timed Sputter process will not begin until this setpoint is satisfied.

TIMED SPUTTER EXAMPLE

NOTE: A DC Setpoint must be entered on the Sputter Process screen. A Process Setpoint must be entered on the Process Setpoint screen.

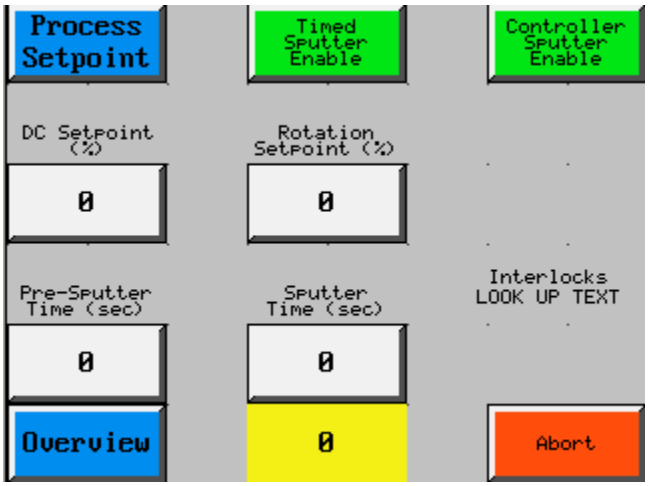

NOTE: The Gas flow setpoint must be manually adjusted before starting a Timed Sputter sequence.

The Timed Sputter process is Enabled from the Sputter Process screen. GREEN = ON, RED = OFF. The Timed Sputter procedure is as follows:

- System will pump down to reach the programmed Process Setpoint.
- Substrate Rotation will turn ON.
- When the Process Setpoints is satisfied:
    - The Gas Valve will open and gas will flow to manually programmed flow setpoint.
    - DC plasma will be initiated on the cathode using the DC Power Supply.
    - DC power will continue for the programmed Pre-Sputter Time.
    - The Shutter will open for the selected cathode;
    - DC power will continue for the programmed Sputter Time. A countdown timer is visible on the screen in the YELLOW box.
    - DC power will end at the end of the preprogrammed sputter Time. A countdown timer is visible on the screen in the YELLOW box.

The Timed Sputter Abort procedure is selected from this screen. GREEN = ACTIVE, RED = INACTIVE. Pressing the Abort button during a Timed Sputter procedure will end the Timed Sputter procedure and switch the System Status from Automatic to Manual.

Controller Sputter Enable



Buttons change color to indicate current state: **GREEN** = ON, **RED** = OFF

The Pre-Sputter and Sputter Timers are inactive when the Controller Sputter Enable button is active.

All deposition parameters must be programmed into the deposition controller. The deposition controller will control the power supply.

Power ramp and soak settings are programmed into the deposition controller. The cathode shutter will open when the deposition controller enters the Deposit state and close when the Final Thickness is reached.

Push buttons across the bottom are used to switch back to "Screens" or "Overview".

NOTE: AUTO PROCESSES WILL AUTOMATICALLY START ROTATION. SYSTEM VENTING WILL AUTOMATICALLY STOP ROTATION.

The ABORT button stops an automatic sequence with all valves returning to a safe condition. The ABORT button will also change the System Status from Automatic to Manual Mode.

DEPOSITION CONTROLLER EXAMPLE

(If Equipped)

NOTE: Read the deposition controller operating manual before proceeding to operate the sputter source through the deposition controller!

All deposition parameters must be programmed into the deposition controller. The deposition controller will control the power supply.

Power ramp and soak settings are programmed into the deposition controller. The cathode shutter will open when the deposition controller enters the Deposit state and close when the Final Thickness is reached.

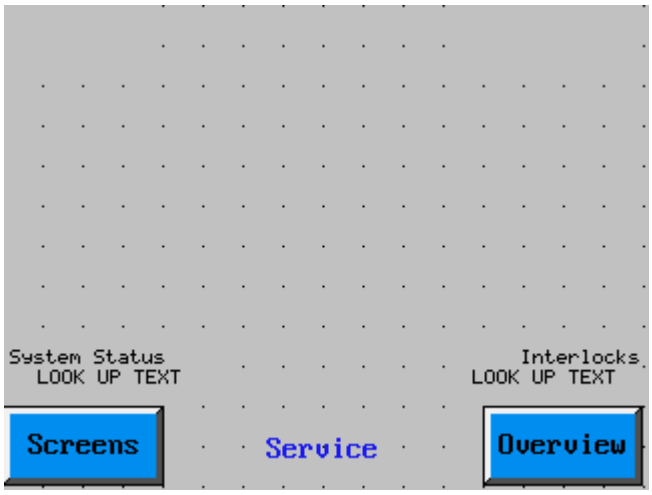
NOTE: The Gas flow setpoint must be manually adjusted before starting a Timed Sputter sequence.

The Controller Sputter process is Enabled from the Sputter Process screen. GREEN = ON, RED = OFF. The Timed Sputter procedure is as follows:

- System will pump down to reach the programmed Process Setpoint.
- Substrate Rotation will turn ON.
- When the Process Setpoints is satisfied:
    - The Gas Valve will open and gas will flow to manually programmed flow setpoint.
    - DC plasma will be initiated on the cathode using the DC Power Supply.
    - DC power will continue as programmed in the Material file of the deposition controller.
    - The Shutter will open when the Deposition state is active in the deposition controller
    - DC power will continue for the programmed Deposition Rate until the programmed Final Thickness setpoint is reached.
    - DC power will end at the programmed Final Thickness and the shutter will close.

The Abort procedure is selected from this screen.GREEN = ACTIVE, RED = INACTIVE. Pressing the Abort button during a Controller Sputter procedure will end the procedure and switch the System Status from Automatic to Manual.

SERVICE MODE



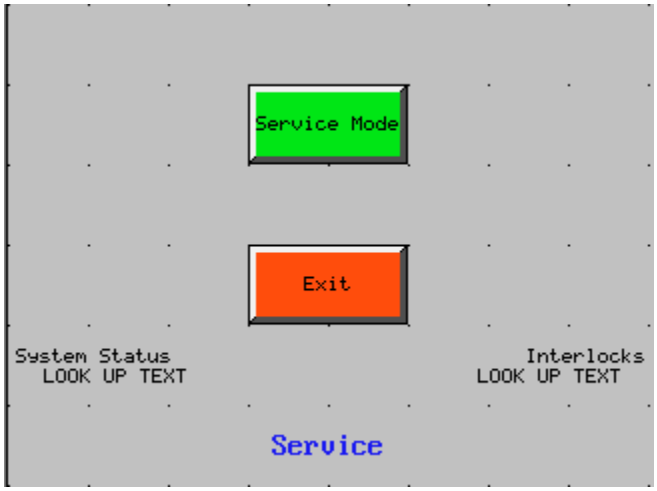
Access to the SERVICE MODE screen is available on this screen. Two hidden buttons must be pressed in sequence to activate the Service Mode. These hidden buttons are in the top corners of this screen.

Current System Mode and Interlock Status are also displayed on this screen. The System Status will be Manual, Auto, or Service. The various interlocks that will appear will be Bellows (BL), Skins (SK), and the chamber Door (DR).

Caution! ALL Interlocks are deactivated in Service Mode. Use caution when operating the system in Service Mode.

LETHAL VOLTAGES ARE AVAILABLE ON THIS VACUUM SYSTEM. EXTREME CAUTION MUST BE TAKEN TO OPERATE THE SYSTEM SAFELY IN SERVICE MODE.

SERVICE



Caution! ALL Interlocks are deactivated in Service Mode. Use caution when operating the system in Service Mode.

LETHAL VOLTAGES ARE AVAILABLE ON THIS VACUUM SYSTEM. EXTREME CAUTION MUST BE TAKEN TO OPERATE THE SYSTEM SAFELY IN SERVICE MODE.

Activate Service Mode on this screen by pressing the Service Mode button.

To switch from Service Mode to Auto Mode:

- Start an Auto Pump or Auto Vent process from the Auto screen.
- Start an Auto Process from the Auto Process screen.

To switch from Service Mode to Manual Mode:

- Start an Auto Pump or Auto Vent process from the Auto screen and then abort.
- Start an Auto Process from the Auto Process screen and then Abort.
- Deactivate Service Mode from the Service Mode screen.

Exit this screen by pressing the Exit button.

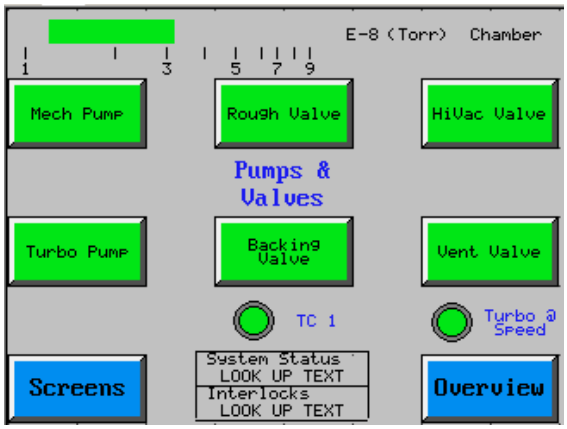
Current System Mode and Interlock Status are also displayed on this screen. The System Status will be Manual, Auto, or Service. The various interlocks that will appear will be Bellows (BL), Skins (SK), and the chamber Door (DR).

PUMPING SYSTEM OPERATION

Warning! Do not remove the vacuum system skins or defeat the door or skin switches. Do not attempt to bypass them. This is for your safety.

The SPI Supplies II vacuum system provides fully automated pumping processes. Auto Pump and Auto Vent are automatic sequences that provide safe operation of the pumps and valves to pump the system into high vacuum and vent the chamber to atmosphere.

System startup can be either a manual or auto operation. System shutdown is a manual operation. These sequences are fully outlined in this section of the manual.



START UP

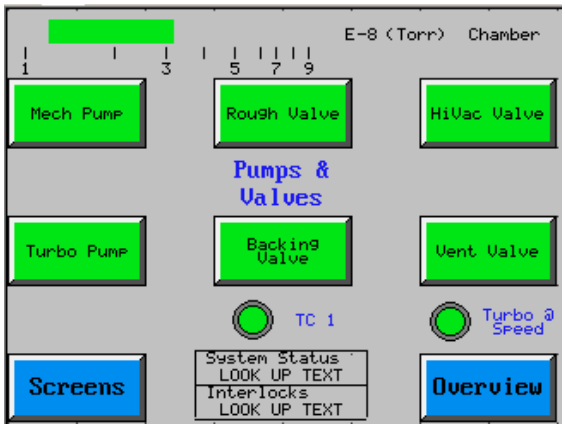
- Turn ON main electrical power and verify proper air pressure (80 –100 psi), and cooling water, if required.

NOTE: Verify that the Emergency Stop button is in the OUT position. Twist it to pull it out.

- Press the Green power button on the front door of the cabinet to apply power to the control system. Verify that all interlocks are satisfied. See the Interlock section of this manual for further details.
- Begin with all valves closed and all pumps OFF.
- Turn ON the Mechanical Pump [Mech Pump]. Run the mechanical Pump for two minutes.

- Open the Backing Valve. Run the Mechanical Pump with the Backing Valve open for two minutes.
- Turn ON the Turbo Pump [Hi-Vac Pump]. Wait until the turbo speed reached normal speed. The Turbo Pump will be ready for operation at this time.
- The vacuum system is now ready for operation.

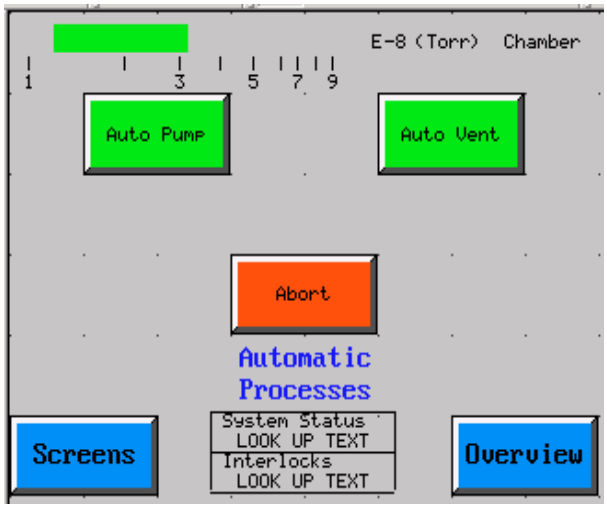
MANUAL MODE SHUTDOWN



NOTE: This Shutdown sequence must be performed whenever the vacuum system will not be used or for cleaning or maintenance. The chamber can be left at atmosphere if cleaning or maintenance will be performed, but it is recommended to pump the vacuum system into high vacuum before proceeding with a prolonged shut down of the system.

- Close the Hi Vac valve. Turn OFF the Turbo [Hi Vac] pump.
- Close the Backing Valve.
- Turn the Mechanical [Mech] Pump OFF.
- Turn OFF Main Electrical Power, Compressed Air, and cooling water.

AUTO PUMP SEQUENCE



Note: The Auto Pump sequence is used to safely and automatically evacuate the chamber. All interlocks are active to safely operate the pumping system. The glass bell-jar must be in place. The Auto Pump sequence will end when the Hi Vac valve opens.

The pumping system on the Vacu Prep II system is designed to deliver quick, easy evacuation of the vacuum chamber. The pumping system is versatile and is delivered with many interlocks to provide for safe operation under most production conditions. The pumping system can be operated in the Automatic Mode.

All graphics on the Overview screen will change from red to green as they are cycled ON and OFF. Chamber pressure is displayed on all screens. Auto Pump will proceed as follows if the pumping system is ready:

- The Backing Valve will close.
- The Roughing Valve will open. The mechanical pump will pump the chamber down to roughly 150mTorr.
- The Roughing Valve will close and the Backing Valve will open.
- After a brief delay, the High Vac Valve will open.

AUTO VENT SEQUENCE

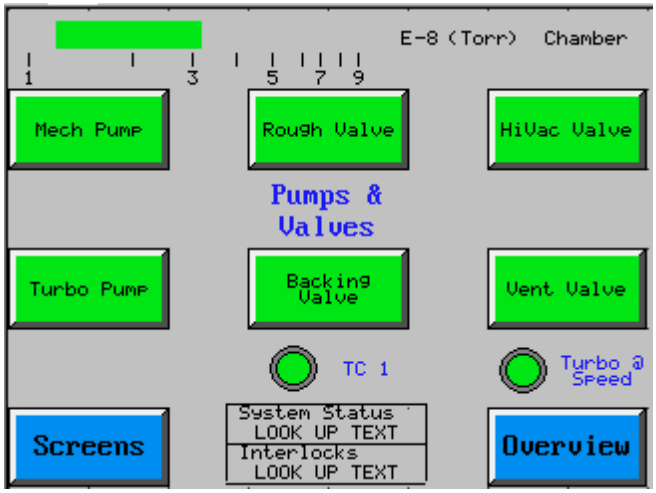
Note: The Auto Vent sequence is used to safely and automatically vent the chamber to atmosphere. All interlocks are active to safely operate the pumping system.

The pumping system is versatile and is delivered with several interlocks to provide for safe operation under most production conditions. The pumping system can be operated in the Automatic Mode.

All graphics on the Overview screen will change from red to green as they are cycled ON and OFF. Chamber pressure is displayed on all screens. Auto Vent will proceed as follows:

- The High Vac Valve will close.
- The Vent Valve will open and remain open until the chamber is at atmospheric pressure.

MAIN CHAMBER PUMPING – MANUAL MODE



- Ensure that the Mechanical Pump is on, backing is open, and the turbo pump is on and up-to-speed.

NOTE: All manual operations are carried out from the Pumps & Valves Screen on the touch screen.

- Place the glass bell-jar or chamber lid into place. Then close Backing Valve. Open the Roughing Valve.
- Wait until the Chamber pressure is less than 1.5×10^{-1} Torr (crossover pressure) or TC 1 indicator turn to green.

- Close the Roughing Valve wait 15 seconds and open the Backing Valve.

Caution: Monitor Chamber pressure while the Roughing Valve is closed. If Chamber pressure rises above 5.0e000 Torr with the Roughing Valve closed, DO NOT PROCEED. A leak is suspected and must be diagnosed before proceeding. Continued operation of the diffusion pump with the High Vac Valve open and Chamber pressure above 5.0e000 Torr will result in damage to the diffusion pump.

- If the Chamber pressure holds, open the High Vacuum Valve.
- The Vacuum Chamber is now in High Vacuum.

MAIN CHAMBER VENTING – MANUAL MODE

- Close the Hi-Vac Valve if it is open.
- Open the Vent Valve.

PROCESS GAS START-UP (IF EQUIPPED)

- All pumps must be operational before connecting the high purity gas lines. Connect the lines to the rear of the system. Close the toggle valves near the regulators.
- Pump the chamber out manually and open the Gas Bleed Valve. Observe the increased pressure from the gas flow. Continue pumping out the system until the Chamber pressure returns to it's lowest level.
- Close the Gas Bleed valve. Open the toggle valves near the regulators and adjust the regulators to 15 psi.

NOTE: This procedure MUST be followed whenever a gas tank is replaced or a gas line is opened to atmosphere.

SYSTEM INTERLOCK

Interlocks are provided to insure operator safety. Operation of the vacuum system with bypassed interlocks is unsafe and may cause damage to the system.

Please verify interlock status before assuming that a repair is necessary. This list is provided for reference. Please check this list before proceeding with troubleshooting or repair.

HARDWARE INTERLOCKS

Hardware interlocks are standard in all Vacu Prep II systems. These interlocks protect the operator from unsafe operating conditions (high voltages, high temperatures, dangerous pressure differentials, etc.). Subsystems will not operate when hardware interlocks are not satisfied.

The status of all hardware interlocks is displayed on the touch screen at all times. These messages are described in the following list:

ON-SCREEN INTERLOCK MESSAGES	DESCRIPTION
Skins (Sk)	Electrical Cabinet Door Open
Bellows (Bl)	Minimum Vacuum Sensor Open (in Chamber)
Water (Wt)	Cooling Water Sensor Open
All Satisfied	All Hardware Interlocks Satisfied
COMBINATIONS WILL BE DISPLAYED AS FOLLOWS:	
Sk	Skin
Bl	Bellows
Bl-Sk	Bellows-Skin
Bl-Sk-Wt	Bellows-Skin-Water

	To Turn ON	To turn OFF
Mechanical Pump	None	None
Turbo Pump	None	None
Turbo Backing Valve	None	None
Vent Valve	None	None
High Vac Valve	None	None
Chamber Rough Valve	None	None
Gas Valves	None	None
DC Power Supply	Bellows Switch Satisfied	None
	Skin Switches Satisfied (Cabinet)	
	Water Satisfied (when applicable)	
Low Voltage Power	Bellows Switch Satisfied	None
	Skin Switches Satisfied	
Low Voltage Select	None	None
Glow Discharge	Bellows Switch Satisfied	None
	Skin Switches Satisfied	
Rotation	None	None
Shutters	None	None
Degas 1	None	None
Auto Pump	None	None

SOFTWARE INTERLOCKS

Software interlocks are standard in all Vacu Prep II systems. These interlocks protect the operator from unsafe operating conditions (high voltages, high temperatures, dangerous pressure differentials, etc.). Subsystems will not operate when software interlocks are not satisfied.

Verify that all software interlocks are satisfied before troubleshooting a subsystem. Software interlocks are listed below for each subsystem.

	To Turn ON	To turn OFF
Mechanical Pump	None	Chamber Rough Valve Closed
		Turbo Backing Valve Closed
Turbo Pump	None	None
Turbo Backing Valve	Chamber Rough Valve Closed	None
	Mech Pump ON	
Chamber Vent Valve	High Vac Valve Closed	None
	Chamber Rough Valve Closed	
	Gas Valves Closed	
High Vac Valve	Turbo Pump ON	None
	Turbo Pump @ Speed	
	Chamber Rough Valve Closed	
	Chamber Vent Valve Closed	
	Chamber Pressure Below Crossover Setpoint 150mTorr	
Chamber Rough Valve	Mechanical Pump ON	None
	Chamber Vent Valve Closed	
	Turbo Backing Valve Closed	
	Gas Valves Closed	
	High Vac Valve Closed	

	To Turn ON	To turn OFF
Gas Valves	Chamber Vent Valve Closed	None
	Chamber Pressure Below Crossover Setpoint 150mTorr	
	Chamber Rough Valve Closed	
DC Power Supply	Rotation On	None
	Bellows Switch Satisfied	
	Skin Switches Satisfied (Cabinet)	
	Water Satisfied (When applicable)	
Low Voltage Power	Rotation On	None
	Bellows Switch Satisfied	
	Skin Switches Satisfied (Cabinet)	
	High Vac Valve Open	
Low Voltage Select	Low Voltage Power Off	None
Glow Discharge	Bellows Switch Satisfied	None
	Skin Switches Satisfied	
Rotation	None	None
Shutters	None	None
Degas 1	Bellows Switch Satisfied	None
	High Vac Valve Open	
Auto Pump	Auto Vent Off	None
Auto Vent	Auto Pump Off	None

SYSTEM SETPOINTS

PRESSURE SETPOINTS

All system pressure setpoints are programmed into the PLC. They are factory set. They are not displayed in the software.

The setpoints should not be changed. They are an integral part of the software and PLC program.

The pressure setpoints are provided here for verification and as a backup record in the event a setpoint must be changed.

SETPOINT #	ASSIGNMENT	PRESSURE	PURPOSE
#1	IG-1	Not used	Process Setpoint; customer adjustable (functional only if system is equipped with Auto Process).
#3	TC-1	1.5e-001 torr	Crossover

SYSTEM ALARMS

No alarms are programmed into the PLC or control software.

OPERATING PROCEDURE

NOTE: IF THE UNIT HAS JUST BEEN DELIVERED, OR IF THE CHAMBER HAS BEEN OPEN TO ATMOSPHERE FOR SEVERAL DAYS AND HAS PICKED UP WATER VAPOR ON THE SURFACES, IT WILL BE NECESSARY TO PUMP THE SYSTEM FOR MANY HOURS (even overnight) TO FULLY CLEAN IT OUT.

BELL JAR LOADING

- Open the CHAMBER vent valve and bring the bell jar to atmosphere. (Necessary only if bell jar was left under vacuum previously.)
- Lift off bell jar.

NOTE See the Lift section of this manual for specific instruction for operating the chamber Lift.

- Load filament and/or carbon sources. Adjust sources to desired position.
- Position samples in bell jar.
- Replace bell jar being careful not to hit baseplate fittings.

EVAPORATING

(If Equipped)

When the bell jar reaches the necessary vacuum:

- Open the LV/Glow control screen
- Select the appropriate filament holder electrode (Low Voltage A/B Select).
- Check that the Power Level is set at 0%.
- Turn ON Rotation (OPTION).
- Turn the LV POWER button ON.
- Increase the Power Level to bring the filament to red color. Hold at this power level. Check HIGH-VACUUM gauge to see if vacuum is holding. Check ammeter to obtain ampere reading. This is process serves to outgas the filament and source material. Do this for about 20 seconds or until the pressure begins to drop. Raise power to the appropriate level to complete the evaporation. The Power Level is adjustable from 0 – 100%.
- Depending on the resistance of the carbon rod or filament wire used, different power levels will be drawn. If you are unable to draw 40 amps with the SCR on full scale, you must use a wire of larger diameter. If you can draw 55 amps, but nothing is evaporating, then:
    - FOR FILAMENT WIRE:
        - Use smaller diameter wire.
        - Check melting point of material.
        - You may require an evaporation power supply with lower voltage and higher amp output.

- FOR CARBON RODS:
  - Check purity of carbon rods. Use only highest purity rods that have the highest resistance.
  - Check diameter of reduced section. It MUST be .040" or less to have appropriate resistance.

AC GLOW DISCHARGE

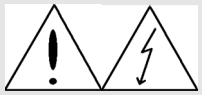
(If Equipped)

When a bell jar high-vacuum evaporator is equipped with a glow discharge cleaning circuit, carbon support films and grids may be cleaned in vacuum to remove the molecular layers of oil and water. All materials exposed to our atmosphere tend to accumulate molecular layers of oil and water on the surface. These few molecular layers cause the surface to repel water. Carbon films so contaminated will cause aqueous solutions to bead rather than to spread over the surface. Contaminated grids will not pick up replicas readily. The AC Glow Discharge will clean the carbon support films and grids in vacuum of the molecular layers of oil and water.

The AC Glow Discharge apparatus consists of a 4000V, 30MA high-voltage transformer, two high-voltage baseplate feedthroughs, and a bellows activated safety switch.

This apparatus should be installed in the evaporator when being built, but it can be added in the field by using three spare baseplate holes for the safety switch and the two antennae.

To set up for glow cleaning, two pure aluminum wires, connected to two high-voltage feedthroughs, are brought about above and below the sample area.



WARNING! MAKE SURE GLOW WIRES ARE COMPLETELY ISOLATED FROM FIXTURING (FOIL SHUTTERS, ETC.) TO PREVENT IT FROM SHORTING.

Rough out the bell jar to high vacuum and back fill with a gas inlet valve to 5 – 9 x 10^{-3} Torr. Open the Low Voltage & Glow screen. Turn the Glow Power button ON. A glow or plasma should be visible between the aluminum wires. The material to be cleaned should be just below the visible glow. Little or no glow should be evident below the port cover. (To see the glow it may be necessary to shadow the bell jar from bright room lighting.) Hold for 2 to 15 minutes. All surfaces are being bombarded with ions formed in the high-voltage field.

Reducing the pressure results in less gas to be ionized. Visible glow is hardly visible below

3 x 10^{-3} Torr. At this pressure the rate of cleaning is very slow. At pressures between 5 – 9 x 10^{-3} Torr, the glow fills the bell jar and the cleaning rate is best.

After cleaning, turn the Glow Power button OFF, vent the chamber and remove cleaned material. It should stay visibly clean for a day or so.

CARBON ROD EVAPORATION SOURCE

(If Equipped)

The carbon evaporation unit is designed to use high-purity nominal 1/8" (.120") diameter carbon rods. It will fire the .040" reduced diameter, as supplied. The fixed carbon must have the contact end flat, smooth, and square to the moving carbon. The height is adjustable by loosening a screw holding the unit to the mounting post.

NOTE: DO NOT permit the mounting post to touch the pumpout cover, which is at baseplate ground. This would short the filament current directly to ground.

Loading Carbon Rods:

Two carbon rods are positioned in the center of the "yoke" to do the coating. One rod will have a reduced section; the other will have a full diameter section that has been carefully flattened on the end touching the point (or reduced section) of the other rod. A metal or emery board nail file is useful for this task.

Both carbon rods should be inserted, one after another, through the outside end of the fixed rod holder. First, the flattened rod should be inserted and pushed through with another rod or a 1/16" wooden stick into the moving rod holder. Tighten the rod when the flat end is exposed approximately 1/4" from the holder. Push the holder against the spring and deflect approximately 3/8" by hand. Insert the second rod (point first) and push it up against the fattened rod. Tighten the thumb screw holding the pointed carbon in the fixed holder. When using a reduced section carbon rod, the spring should be moved out a little more than the length of the reduced section.

When properly loaded, the reduced section goes from a solid to a gas (sublimes) with no liquid phase. When unloading, allow time for mandrels to cool as they get quite hot, especially when firing carbon for 30 seconds or longer. The screws holding the guide sleeve and the carbon rod need only be finger tight. The screw for the power lead should be tightened snugly. NOTE: EXCESSIVE TIGHTENING OF CARBON LOCKING SCREW WILL BREAK THE ROD.

Evaporation:

The chamber should first be pumped to 2×10^{-5} Torr or less. SPI Supplies offers a hard carbon rod of excellent quality. With the reduced diameter (.040") section, we suggest using a filament power setting of about 15 amps to degas the carbon; about 40 to 45 amps to evaporate. Degas

the carbon (bright red) for 5 to 10 seconds. (Watch the chamber pressure rise and then start to fall back.) Carbon should be evaporated slowly. Normally, after degassing, the filament power is increased to where the carbon starts lightly sparking, then backing off 5 percent on the power setting. Length of evaporation time will depend on desired thickness of carbon film. It should take from 30 seconds to two minutes to totally evaporate the carbon rod.

A carbon rod with a .040" reduced section heats up and stabilizes more quickly. The rate of evaporation remains fairly constant. Thickness of the deposited film may be controlled by the length of the reduced section.

To check the carbon evaporation technique before coating samples, do the following: Coat a glass cover slip with gold. The gold color will change to copper when the cover slip is over-coated with 100 angstroms of carbon, to orange with 150 angstroms of carbon, and to purple with 200 angstroms.

WARNING! USE DARK GLASS TO OBSERVE CARBON EVAPORATION. INTENSE BRIGHTNESS IS HARMFUL TO EYES WHEN VIEWED DIRECTLY.

Evaporation Tips:

If you cannot evaporate your carbon at 40 amps in 10 seconds, then you need to:

- Check your carbon's purity. Use only the highest purity carbon with high internal resistance.
- Check the diameter of the reduced section. It should be .040" x .125" long. Current required to evaporate is dependent on the square of the diameter. A small difference in diameter can make a big difference in power required.

CARBON FIBER EVAPORATION SOURCE

(If Equipped)

The Carbon Fiber Evaporation Source is adjustable and is designed to provide carbon films for support, replication or conduction. The mounting posts are drilled and tapped to screw onto one of a pair of low-voltage feedthroughs. The rectangular extension block connects the upper post to the lower post. Two blocks clamp the carbon evaporation unit to the upper post. This arrangement gives flexibility to locate the source as desired.

NOTE: DO NOT PERMIT THE MOUNTING POST TO TOUCH THE PUMPOUT COVER, WHICH IS AT BASEPLATE GROUND. THIS WOULD SHORT THE FILAMENT CURRENT DIRECTLY TO GROUND.

The carbon fiber evaporation unit is designed to use high-purity carbon fiber. The height is adjustable by loosening the screw holding the unit to the mounting post.

Loading the Carbon Fiber:

The carbon fiber is placed across two spring-loaded electrode posts. Carbon sublimes, i.e., it goes from solid to a gas with no liquid phase. When reloading, allow time for mandrels to cool as they get quite hot, especially when firing carbon for 30 seconds or longer.

Evaporation:

The chamber should first be pumped to 2×10^{-5} torr or less.

SPI Supplies offers a carbon fiber of excellent quality. It is suggested that a low power setting, to degas the carbon, be used; slowly raise to evaporate. Degas the carbon (bright red) for 5 to 10 seconds. (Watch the chamber pressure rise, and then start to fall back.)

Carbon may be evaporated slowly or rapidly. Normally, after degassing, the power is increased to where the carbon starts depositing. Length of evaporation time will depend on the desired thickness of carbon film. It should take from 30 seconds to totally evaporate the carbon. DO NOT take power too high for more than one minute. NEVER EXCEED 50 AMPS.

A rapid evaporation (flashing) may be utilized by presetting the control to 75 percent and then turning on the power. The flash will last from 1 to 2 seconds and help reduce heat damage.

Carbon vaporizes due to localized heat caused by resistance to flow of electric current. Carbon resistance lowers as carbon heats up, but will stabilize.

To check the carbon evaporation technique before coating samples, do the following: Coat a glass cover slip with gold. The gold color will change to copper when the cover slip is over-coated with 100 angstroms of carbon; to orange with 150 angstroms of carbon; and to purple with 200 angstroms.

WARNING! USE DARK GLASS TO OBSERVE CARBON EVAPORATION. INTENSE BRIGHTNESS IS HARMFUL TO EYES WHEN VIEWED DIRECTLY.

SHADOW CASTING, REPLICATION, CONDUCTIVE FILMS

The High Vacuum Evaporators are designed to deposit thin films on specimens for transmission and scanning electron microscopes, and for electron microprobe analyzers.

A thin film of carbon, in the order of 50 to 150 angstroms, is used to support specimens. A thicker film of carbon, in the order of 200 angstroms, will form a replica of a specimen surface. Metal evaporated in a high vacuum, i.e. 10^{-5} Torr, will deposit a thin coating on specimen surfaces that can see the source of metal vapor. Surfaces that do not see the source receive little or no vapor. Shadow casting with heavy metal increases specimen contrast. Shadowing at a known angle also provides a means to estimate heights from the length of the shadow.

To shadow with platinum, wrap about 2.5 cm of .005" diameter platinum wire at the point of a "V" shaped in a single .020" diameter tungsten filament. Set the angle between source and specimen. Degas the filament at 10-12 amps for 10 seconds, then increase the filament power to melt the platinum. Hold until the platinum evaporates completely. At a source to specimen distance of 10 cm, 2.5 cm of .005"diameter platinum wire will deposit a coating of about 30 angstrom units. Vary the thickness of the platinum coating by using more or less wire. The bell jar should be pumped to at least 2 x 10^{-5} Torr for sharp shadows. At higher pressures, molecular collisions may blur the shadows.

Carbon replication is done with the specimen facing the carbon source. To form a continuous coating, it is preferred that the specimen change angles as the carbon film forms. Rocking the specimen will expose irregular surfaces. In extreme cases, we have a rotating, tilting table that exposes all irregular surfaces to the carbon source.

Carbon is evaporated from a special fixture using a fixed 1/8" diameter carbon rod with a flat end and a moving pointed carbon. The moving arm is spring loaded to maintain point contact. Our carbon fixture will work with either a carbon sharpened to a long point or a carbon with a section reduced to .040" diameter. The point is sturdier and easier to use. The reduced section is more precise as to reproducibility.

To evaporate carbon rod with the 1 mm reduced section, degas the carbon at red heat with a power setting of 20 amps for a few seconds; evaporate at 28 to 34 amps. As power is increased to evaporate carbon, it will tend to spark. Careful power adjustment will hold this to an occasional visible spark. With a source to specimen distance of about 10 cm, a 3mm length of the 1mm diameter carbon section will deposit about 140 angstroms of carbon on a specimen.

Carbon support films mounted on grids may cause water suspensions to bead. The support film may be cleaned so that it will set, by exposure to a high voltage glow discharge. Glow cleaning is done at about 100-150 microns bell jar pressure with about 2000 V applied for several minutes. If equipped, two aluminum glow rings provide a means of adjusting the glow area.

All connections in the filament circuit must be making good contact. For proper firing, the filament must be the highest resistance in the circuit.

For scanning electron microscopy, non-conducting specimens should be coated to prevent electron accumulation. For irregular surfaces, the conductive coating should get down into the

pockets and crevices. We use a tilting rotating table with a vapor source about 15° from directly over the specimen. This rotating, tilting motion bathes the specimen at all angles in the conductive metal vapor. Gold or gold-palladium is generally used. About 4" (10cm) of .008"(0.2mm) diameter gold wire will deposit about 200 angstroms of gold at a source to specimen distance of about 12cm. For very difficult surfaces, a combination of carbon plus gold is used.

Highly polished specimens, as used for an electron probe, may need a very uniform conductive coating of carbon. The tilting, rotating table will hold the thickness of the carbon deposition within +/-5%. The film deposition of all evaporated materials varies in thickness inversely as the square of the source to specimen distance. Film thickness at 4 inches distance is more than double what it would be at 6 inches distance. Consequently, specimen rotation tends to even out the variations in coating thickness that a stationary specimen might receive.

Tungsten filaments tend to become brittle with use. They oxidize readily if exposed to atmosphere while hot. It is good practice to allow 2 to 3 minutes cooling time before venting the system. The high vacuum evaporators have filament cooling time programmed into its automatic cycle.

To clean apertures, use a .001" thick tantalum or molybdenum boat about 6 mm wide with a dimple. Mount boat in place of tungsten filament. Place aperture in boat dimple. Pump bell jar to 10^{-5} Torr. Bring filament power up sufficient to turn the boat bright red. Hold at high vacuum until the aperture is the same color as the boat. Contamination will vaporize and be pumped away. Cut off filament power and allow to cool for 5 minutes or so before venting the system.

Tungsten filaments and carbon rods reach a white heat at the evaporating temperature. The brilliant white light should not be stared at without eye protection, such as a piece of dark glass or plastic.

DSM-5A COLD SPUTTER MODULE

(If Equipped)

Assembly:

The sputtering module stands on the baseplate or the raised cover plate of the bell jar evaporator. Three ½" diameter holes are required in the baseplate. One is for the positive high-voltage feedthrough, one for the gas bleed, and one for the bellows safety switch. The high-voltage feedthrough and leads in the bell jar are shielded to prevent sputtering except from the cathode target.

Connect the cable from the target head to the H.V. feedthrough in the baseplate. Connect the cable from the grid on the stand to the banana plug on the specimen holder.

The sputtering module removes from the bell jar by unplugging leads at the high-voltage feedthroughs and lifting out.

Although sputtering is possible using room air as the bleed gas, it is not recommended. The composition of room air varies with water and oil vapor as contaminants. Argon, recommended as the ionized gas, is an efficient, repeatable sputter medium. Connect a cylinder of argon equipped with pressure reducing valves to the micrometer bleed valve using plastic tubing. The cylinder should be chained upright.

Operation:

When the sputtering module is in position and all the connections are made, it is ready to operate. Use the following procedure:

- Before pumping the bell jar, open the argon cylinder shutoff valve, open the toggle valve behind the micrometer valve, and open the micrometer valve. Adjust the gas cylinder pressure regulator valve to approximately one psi reading on the low pressure gauge and purge the gas line. Shut off the gas flow by closing the toggle valve.

- Be sure the cathode is centered over the specimen holder with 3 3/4" between cathode and specimens. Lower bell jar and pump to 10^{-5} torr to outgas specimens and remove moisture.

- Open gas toggle valve. Adjust micrometer valve to obtain 10 to 15 microns in bell jar as read on Process Pressure Reading.

- Turn on power supply. Input a Power Level setpoint on the touch screen to obtain glow. At 45% about 500 volts is applied to the cathode; at 90% the cathode receives approximately 1000 volts. Do not exceed 50 milliamps current. The rate of deposition relates to the distance from the cathode to the substrate, gas pressure, target material, and voltage.

NOTE: A STABLE GAS FLOW IS ESSENTIAL TO PRODUCE REPEATABLE COATINGS.

Approximate rates for gold with the sputterhead 3 3/4" above the substrate table are:

RATE A/sec.	CURRENT Ma.
6.2	50
4.4	40
3.1	30
1.7	20
0.7	10

Deposition Timers are available for semi-automatic operation of the sputter power supplies. Manual (ON/OFF) operation is also available.

- With desired coating deposited, input Power Level of zero. Turn off power supply. Close toggle valve. Close main valve of vacuum system. Vent the bell jar and remove specimens.

A casual check of the thickness of the gold coating can be made by placing a glass cover slip at the same level as the specimen. With about 50A of gold, glass will transmit a light blue-gray coloring agent against a piece of white paper. A 100A gold coating is blue-green against white and has a faint gold reflection. At 200A the green is deeper and the gold reflection is obvious.

NOTE: THE DSM-5A AND THE DSM-300A SPUTTER UNITS ARE SAFETY INTERLOCKED. THEY WILL NOT OPERATE IF THE BELL JAR IS AT ATMOSPHERE.

DSM-300A AND ADJUSTABLE SPUTTER MODULE OPERATION

(If Equipped)

Setup:

NOTE: THE SPUTTER UNITS ARE SAFETY INTER-LOCKED. THEY WILL NOT OPERATE IF THE BELL JAR IS AT ATMOSPHERE.

To be able to sputter aluminum, chromium or other metals that form oxides, it is necessary to eliminate virtually all oxygen from the system. Therefore, the vacuum chamber as well as the gas inlet line must be fully leak checked. This can be done in the following manner:

- The sputtering gas (typically argon) must be supplied from a tank, not a house line. The tank should be connected to a two-stage regulator, with the final pressure into the system being 3-10 psig.

- There must be a positive cutoff valve (customer supplied) after the regulator. This is normally a ball valve or a toggle valve.

- With the toggle valve closed, open the tank valve to pressurize the line to full tank pressure and then close it. Observe the pressure reading. Allow the system to sit for several hours and observe the pressure again. If it has not dropped, then the system is leak tight from the tank to the cutoff valve.

- Leaving the toggle valve closed, open the gas inlet valve and needle valve completely. Pump your vacuum system to high-vacuum and observe how low the ultimate pressure goes. The system should reach the same ultimate pressure that it would with the gas inlet valves closed (although slower). Sputtering aluminum requires a pressure lower than 1 x 10^{-5} torr.

Having ensured that your gas inlet line is leak tight, you can proceed to operation of the DSM-300A.

Operation:

- Pump system down to less than 1 x 10^{-5} torr. If this is the first time you have run system (or sputterhead), allow at least a two-hour period to pump out contaminants from the sputterhead.

- Use bypass option if available.

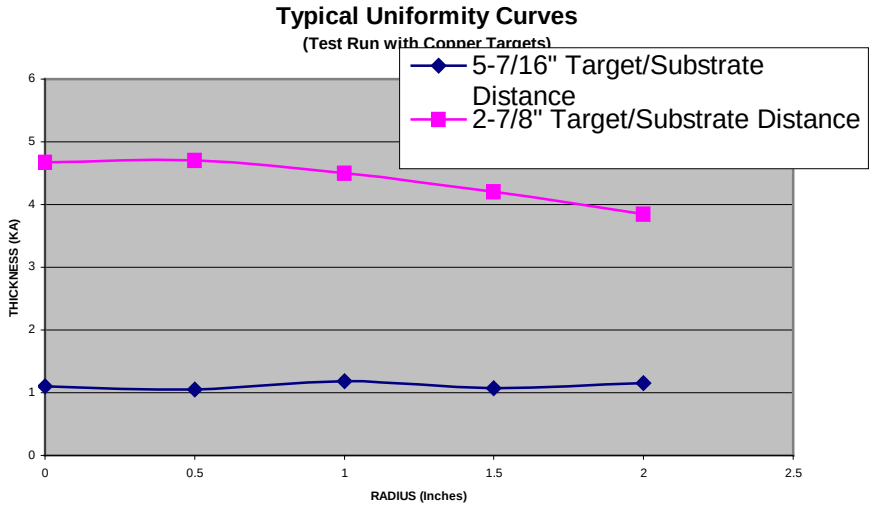
- Open gas valve. Allow thirty seconds for a pulse of gas to work its way through system, and for pressure to stabilize.

- Adjust needle valve to bring pressure to desired setting (generally 5 m. torr). The sputterhead is capable of sputtering between 6 x 10^{-4} torr and 1 x 10^{-2} torr (10mTorr) pressure in the chamber. (The lower the pressure, the less scattering losses there will be. The higher the pressure, the easier it is to develop a plasma.) A recommended starting pressure is 10 x 10^{-3} torr (or 10mTorr). A turbo pumped system can achieve this pressure reading within the chamber if the backing line is only pumped down to between 100 - 150mTorr. If in doubt as to exact operating pressure, go to a higher pressure before trying to power on the sputterhead.

- After ensuring that water flow to the sputterhead is on, turn on sputter power and bring up to desired setting. 300milliamps is sufficient to sputter Al, Cr, Ta, W. Ni and any other DC Magnetron sputterable material.

- When you have reached the desired thickness on your substrate, the power should be turned off, the argon turned off and the chamber vented.

Typical Uniformity Curves:



NOTE:

TARGET CONDITIONING

WHEN STARTING TO SPUTTER A NEW TARGET, OR IF THE VACUUM SYSTEM HAS NOT BEEN OPERATED FOR A LONG TIME, POWER TO THE SPUTTERHEAD MUST BE BROUGHT ON AT A LOW POWER LEVEL, AND THEN GRADUALLY RAISED TO HIGHER POWER LEVELS AS THE TARGET ARCING DECREASES OVER THE COURSE OF SEVERAL MINUTES. THIS WILL ALLOW CONTAMINANTS TO OUTGAS AND FOR THE TARGET TO PROPERLY PREPARE ITSELF FOR SPUTTERING GOOD QUALITY FILMS.

NOTE

ORIENTATION OF MAGNETS

POSITION OF THE MAGNETS INSIDE OF THE SPUTTERHEAD IS CRITICAL TO ACHIEVE THE SPUTTERING PLASMA RING. THE CENTER MAGNET SHOULD BE POSITIONED WITH THE "NORTH" POLE FACING OUTWARD AND THE OUTSIDE MAGNETS WITH THE "SOUTH" POLES FACING OUTWARD. IF YOU HAVE ANY QUESTIONS/CONCERNS ABOUT THE ORIENTATION OF THE MAGNETS WHEN REMOVING/INSTALLING THEM, CONTACT SPI SUPPLIES.

Maximum Power Settings:

- For DSM-300A systems/w 300 W high amp supply:
    - **Do not** exceed 300 milliamps.
    - Supply water for sputtering.
- For DSM-300A systems with 1.0 amp supply:
    - **Do not** exceed 1.0 amps.
    - Supply water for sputtering.

DSM-300A EXTERNAL SPUTTERHEAD:

TARGET CHANGEOUT:

The DSM-300A sputterhead is externally mounted on top of the cylindrical chamber and is protected by a cylindrical aluminum guard.

To remove the sputterhead:

- Three screws which hold the top aluminum outer shield are removed. Then by raising the aluminum shield, the target assembly is visible.
- The target assembly is released by loosening the six socket head screws in the Teflon ring.
- The target assembly may now be lifted (without disconnecting the water lines) and positioned to gain access to the target supporting ring. The ring is held by three horizontally positioned flat head screws.
- The ring is loosened or clamped to the target by rotating the slotted sections. To change targets the screws must be removed and then replaced. If using a foil target, a 1/8" thick backing plate of copper or aluminum must be used to give a good thermal and electrical connection.

ROTATING / TILTING STAGE

These rotary fixtures provide variable speed rotation for specimens under high-vacuum. The tilting stage causes the angle between the source and the specimen to vary continuously during rotation. The tilting stage can also rotate at a fixed angle for cone shadowing simply by substituting a sleeve and screw, provided with the fixture, in place of the PTFE pin. The stage remains in a fixed horizontal position.

A 0-60 rpm gear motor mounts in a "C" bracket below the baseplate. Power is driven through a flexible coupling to a 1/4" rotary motion feedthrough, which is also the vacuum seal at the baseplate. The gear motor is shipped mounted to the bracket. The 1/4" rotary motion device installs through the baseplate from the vacuum side. The long threaded end under the large hex nut clamps the bracket firmly to the baseplate; the open side of the bracket faces out.

The 1/4" rod should move freely in the rotary motion feedthrough. Install the PTFE washer, the thrust clamp, and the upper part of the flexible coupling on the 1/4" rod. Lower the rod assembly so the bar on the motor shaft and the bar on the rod fit snugly into the nylon insert. Tighten the rod thrust clamp and the upper and lower part of the flexible connector.

Plug in the gear motor and test the rotation. The vacuum end of the rotary motion device should rotate smoothly and the nylon insert should turn evenly with no play where it meshes with the drive and driven bars.

The rotating table assembly mounts through a 25/32" hole in the port cover with two 6/32" x 3/8" long flat head screws, which thread into holes with centers 19/32" from mounting hole center. The cover port must be firmly positioned. The table is drilled to accept 12 specimen mounts with .128" pins or 8 mounts 13/32" in diameter. The standard table is 2 1/2" in diameter, but larger tables may be used. The Omni Rotary Fixture is also available with a microscope slide.

The pulley ratio for rotation is 1:1. Mount the driving pulley on the 1/4" rod in the same plane as the driven pulley. The small gear drives the tilting cam. The chain drive for the tilt cam is fitted after the table assembly and the rotary motion feedthrough are installed.

Wrap the chain around the driving and driven gear. Mark the length carefully. Use long-nosed pliers to open the chain. Make certain that the link ends are bent evenly. Properly assembled, the joined links will look exactly like the rest of the chain. The Omni Rotary Fixture uses a rubber belt in lieu of a chain. Wrap the belt around the pulley on the drive shaft and the pulley on the rotary motion shaft. All bearings in the vacuum space run dry. The rotary motion feedthrough uses a lubricated sleeve plus two spring-loaded o-rings for a vacuum seal. Use a high quality lubricating vacuum grease. Do not use silicon-based grease.

To lubricate the rotary motion feedthrough, loosen the upper end of the flexible connector, loosen the thrust clamp, and remove the hex nut. All these parts are within the "C" bracket below the baseplate. The motion feedthrough will now lift from the baseplate. Loosen the hex nut on the vacuum side of the motion feedthrough. Inspect lower end of 1/4" rod for burns. Rod should lift out easily bringing the o-ring, spring, and o-ring assembly with it. Wipe spacers, o-

rings, and spring clean. Lubricate o-rings lightly. Lubricate 1/4" rod lightly. As you reassemble, pack grease into the spring area. This will act as a lubricant reservoir.

The Omni and Tilting Omni may be adapted to any evaporator with a 10" diameter or larger bell jar. At additional cost we can supply a mounting plate or a motion feedthrough flanged for baseplate holes larger than 33/64" diameter.

EVAPORATION PROCESSES

Metal Evaporation:

For shadowing, increase the filament power sufficient to melt the source material. Platinum melts at 1769° C and evaporates readily at 1800° C. Watch the source material through dark glasses to avoid eye damage. Increase power to evaporate quickly without causing source material to fly off in chunks. Molten platinum dissolves tungsten. A slow platinum evaporation usually will stop due to the filament breaking. The diameter of filament wire is limited to a size that will heat above 1800° C with not more than 50 amperes current. Do not operate above 40 amps for more than one minute as this will exceed 1kva.

For low angle rotary shadowing, use a straight length of multi-strand .015" filament with a 1" length of .005" diameter platinum wrapped along the filament. Position the source out from the sample 10 cm and up 1 cm above the plane of the sample for the shadow angle of 9 degrees. Rotate sample 100 rpm while evaporating platinum vapor evenly for a period of 10 to 15 seconds. Shadowing is usually done at 1 or 2 x 10^{-5} Torr.

To shadow without rotation the V-shaped filament is often used with the platinum wire wrapped at the point of the "V." It melts to form a drop. Evaporate rapidly just below the temperature causing spitting. It is a race between evaporation and dissolution. Seldom can a "V" filament be used a second time, as it will show thinning from the first use. Shadowing is done at a 45° angle to provide a height to shadow length of one to one. Smoother samples require a more shallow angle for the shadow to be discernable. As low as 6° has been used with careful setup.

Conductive coating uses the same techniques with differences. A conductive coating provides an electrical path to dissipate electrons from the beam. A gold coating of 100Å will increase secondary emission, provide a measure of heat dissipation, and, to a degree, provide radiation protection for the sample. To aid in making the coating continuous, the samples are rotated and tilted during deposition. This gets a conductive coating into the hills and valleys avoiding shadows.

If sufficient gold is evaporated to deposit 100Å on a smooth surface, the exposure determines how much deposits on any given spot. If the bottom of a depression is exposed 10 percent of the time, it will receive only 10Å of gold. The sample may need extra coating to become conductive. Use only the coating needed to prevent charging. If gold wire .008"(0.2mm) diameter of a measured length is used and the wire is completely evaporated, the conductive coating is repeatable; however, for each sample, the thickness of the coating for an area is determined by its exposure to the metal vapor.

When evaporating metals that do not dissolve the tungsten filament, at the completion of the evaporation allow the filament to cool for several minutes before venting. With care, a filament will last for 15 to 20 evaporations. Venting immediately will cause the tungsten to oxidize.

Carbon Evaporation:

Carbon is used in a thin film to support samples as they stretch over the grid openings. This supporting film can be as thin as 30Å to 35Å. A drop of diffusion pump oil placed on a piece of white porcelain and carbon coated will show a discernable gray at about 30Å carbon. The porcelain stays white under the oil and is carbon coated elsewhere. Thicker carbon films are used for replicas. Replicas usually are 100Å to 150Å. Carbon is used for conductive coatings ranging in thickness from 50Å to several hundred angstroms.

A useful carbon thickness monitor can be made by gold coating cover slips. Place the gold cover slip with the samples to be carbon coated. The gold will change to a copper color when 100Å of carbon is deposited, to orange with 150Å carbon, to purple with 200Å carbon.

The Carbon Evaporation Source uses a nominal ⅛" carbon rod that is .120" in diameter. A fixed rod holder and a spring loaded moving rod holder combine to maintain contact during evaporation. The current is adjusted to approximately 40 amps to achieve the sublimation temperature of the carbon.

Three millimeters of reduced section can be evaporated when a rod is reduced in cross section to .040" diameter. The carbon rods are supplied with reduced sections. A reduced section will continue to evaporate at a given power level. Reduced sections are used when carbon deposits of 150Å to 200Å are desirable. Automatic carbon evaporation is easier to control using reduced sections instead of points. Incidentally, evaporation is not the proper description for carbon going from solid to vapor. Carbon sublimes when heated.

The Carbon Evaporation Source also uses carbon fiber for quick loading and easy evaporation.

Evaporation of gold, gold palladium, or carbon at pressures between 1 to 10mTorr can improve conductivity of coatings on SEM specimens having very irregular or porous surfaces difficult to penetrate with straight line (2×10^{-5} Torr) evaporation pressures. High-pressure evaporation will produce somewhat larger grain size, but only rarely will this increase be objectionable.

This high-pressure technique may also be adapted to protect heat sensitive specimens from filament or carbon-source thermal radiation. Because thermal radiation travels in a straight line at regardless of pressure, inserting a shield (25 mm to 30 mm diameter) between the filament and specimen (2.5 cm from the filament) will block the radiant heat while permitting the vaporous material to diffuse around the shield and coat the specimen.

At 10mTorr, some coating thickness is lost, but the diffuse nature of the coating permits conductivity and penetration to remain excellent. If evaporating carbon by this method, expect some loss to oxygen when bleeding air. Bleeding an inert gas would eliminate this loss.

SPUTTERING OPERATION

 **NOTE: THE SPUTTER UNITS ARE SAFETY INTER- LOCKED. THEY WILL NOT OPERATE IF THE CHAMBER IS AT ATMOSPHERE.**

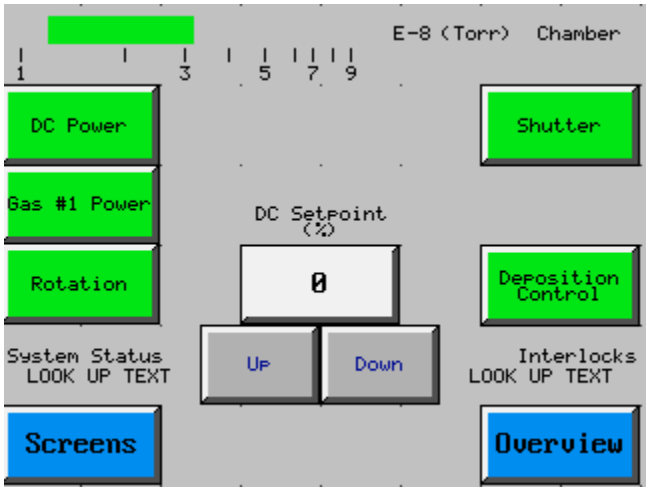
To be able to sputter aluminum, chromium or other metals that form oxides, it is necessary to eliminate virtually all oxygen from the system. Therefore, the vacuum chamber as well as the gas inlet line must be fully leak checked. This can be done in the following manner:

- The sputtering gas (typically argon) must be supplied from a tank, not a house line. The tank should be connected to a two-stage regulator, with the final pressure into the system being 10-15 psi.
- There must be a positive cutoff valve (customer supplied) after the regulator. This is normally a ball valve or a toggle valve.
- With the toggle valve closed, open the tank valve to pressurize the line to full tank pressure and then close it. Observe the pressure reading. Allow the system to sit for several hours and observe the pressure again. If it has not dropped, then the system is leak tight from the tank to the cutoff valve.
- Leaving the toggle valve closed, open the gas inlet valve and needle valve completely. Pump your vacuum system to high vacuum and observe how low the ultimate pressure goes. The system should reach the same ultimate pressure that it would with the gas inlet valves closed (although slower). Sputtering aluminum requires a pressure lower than $1x10^{-5}$ torr.
- Having ensured that your gas inlet line is leak tight, you can proceed to operation of the sputterhead.

Sputter Processing

 **NOTE: TARGET CONDITIONING! When starting to sputter a new target, or if the vacuum system has not been operated for a long time, power to the sputterhead must be brought on at a low power level, and then gradually raised to higher power levels as the target arcing decreases over the course of several minutes. This will allow contaminants to outgas and for the target to properly prepare itself for sputtering good quality films.**

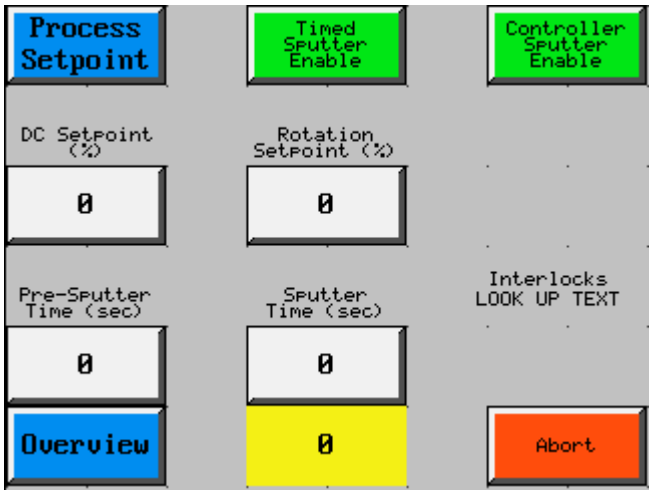
Manual DC Sputtering



NOTE: All manual operations are carried out from the DC Sputter Control Screen.

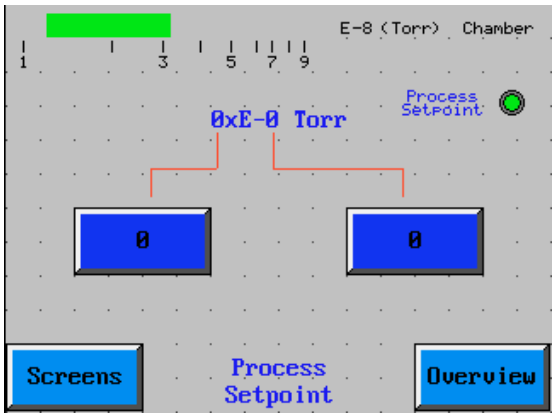
- Abort any Automatic process to switch to Manual mode.
- Pump system down to less than 1 x 10^{-5} Torr. If this is the first time you have run system, allow at least a two-hour period to pump out contaminants from the sputterhead.
- Open gas valve. Allow thirty seconds for pressure to stabilize.
- Adjust gas flow to bring pressure to desired setting (generally 5mTorr). The sputterhead is capable of sputtering between 6x10^{-4} Torr and 1x10^{-2} Torr (10mTorr) pressure in the chamber. (The lower the pressure, the less scattering losses there will be. The higher the pressure, the easier it is to develop a plasma.) A recommended starting pressure is 10x10^{-3} Torr (or 10mTorr).
- Select the desired Cathode.
- After ensuring that water flow to the sputterhead is on, turn on sputter power and bring up to desired power setting. 300 milliamps is sufficient to sputter Al, Cr, Ta, W, Ni and any other DC Magnetron sputterable material.
- After a suitable pre-sputter, open the shutter to deposit the coatings.
- Power Supply must be in power or current regulation.
- Final deposition rate will be dependent on material being sputtered, power setting, pressure, distance and time.
- When you have reached the desired thickness on your substrate, the power should be turned off, the shutter should be closed, the argon turned off and the chamber vented.

Semi-Automatic Sputtering



NOTE: All Timed Sputter operations are carried out from this screen.

- Program a Process Pressure setpoint



NOTE: The Gas flow setpoint(s) must be manually adjusted before starting a Timed Sputter sequence.

- Set power level by depressing the DC Set point Display. Use numeric keypad, as normal. Enter a power value. Press Enter. Set Pre-sputter time (sputter time) by depressing the Pre-sputter Time display (Sputter Time display). Use numeric keypad, as normal. Enter the desired time. Press Enter.

- Depress the "Timed sputter Enable" button.

- System will pump down to reach the programmed Process Setpoint.

- Substrate Rotation will turn ON.
- When the Process Setpoint is satisfied the rotation will turn on, the selected power supplies will turn on, the targets will pre-clean to the set time, and the shutter will open. The deposition will continue until the sputter time is complete and the shutter will close.

 **Note: If you need to abort the process at any time, press the "Abort" button.**

Deposition Controller

(OPTIONAL)

NOTE: All deposition parameters are programmed into the deposition controller. Read the operating manual for the deposition controller before proceeding.

- Pump system down to less than 1 x 10^{-5} Torr. If this is the first time you have run system (or sputterhead), allow at least a two-hour period to pump out contaminants from the sputterhead.
- Program the gas flow and intermediate position of the high vacuum gate valve for the desired chamber pressure for the deposition.
- Adjust needle valve (or mass flow controller) to bring pressure to desired setting (generally 5mTorr). The sputterhead is capable of sputtering between 6 x 10^{-4} Torr and 1 x 10^{-2} Torr (10mTorr) pressure in the chamber. (The lower the pressure, the less scattering losses there will be. The higher the pressure, the easier it is to develop a plasma.) A recommended starting pressure is 10 x 10^{-3} Torr (or 10mTorr).
- Program a Process Pressure Setpoint.
- Program the deposition monitor for the desired material and thickness.
- Select the Controller Sputter Enable on the Semi-Auto Sputter screen.
- Activate the Timed Sputter Enable button on the Semi-Auto Sputter screen.
- System will automatically pump down to reach the programmed Process Pressure setpoint before starting the rotation, gas flow and deposition controller.
- The deposition controller will begin to control the sputter power supply as programmed for the layer.

- The cathode shutter will open when the deposition controller enters the Deposit state and close when the final thickness is reached.
- Final deposition rate will be dependent on material being sputtered, power setting, pressure, distance and time.
- When you have reached the desired thickness on your substrate, the power, gas and rotation will be turned off.
- Vent the chamber using the Auto Vent process.

Deposition Monitor

(OPTIONAL)

NOTE: All manual operations are carried out from the Cathode 1 Sputter Control Screen.

- Abort any Automatic process to switch to Manual mode.
- Pump system down to less than 1 x 10^{-5} Torr. If this is the first time you have run system (or sputterhead), allow at least a two-hour period to pump out contaminants from the sputterhead.
- Open gas valve. Allow thirty seconds for a pulse of gas to work its way through system, and for pressure to stabilize.
- Adjust needle valve (or mass flow controller) to bring pressure to desired setting (generally 5mTorr). The sputterhead is capable of sputtering between 6 x 10^{-4} Torr and 1 x 10^{-2} Torr (10mTorr) pressure in the chamber. (The lower the pressure, the less scattering losses there will be. The higher the pressure, the easier it is to develop a plasma.) A recommended starting pressure is 10 x 10^{-3} Torr (or 10mTorr).
- After ensuring that water flow to the sputterhead is on, turn on sputter power and bring up to desired power setting. 300milliamps is sufficient to sputter Al, Cr, Ta, W, Ni and any other DC Magnetron sputterable material.
- Program the deposition monitor for the desired material and thickness.
- Select the XTM Control for the shutter.
- After a suitable pre-sputter, open the shutter to deposit the coating.
- Power Supply must be in power or current regulation.
- Final deposition rate will be dependent on material being sputtered, power setting, pressure, distance and time.

- The shutter will be closed by the deposition monitor.

- When you have reached the desired thickness on your substrate, the power should be turned off, the argon turned off and the chamber vented.

SYSTEM MAINTENANCE

A clean vacuum evaporator will more likely be a good operating evaporator. It is essential to keep the unit clean. A total system cleanup is recommended every six months. Scale build-up on the baseplate should be scraped off weekly and the surface cleaned with acetone or alcohol using a lint free cloth or paper and solvent. Be sure all debris is vacuumed away.

BELL JAR

- Clean coating build-up from the bell jar with a metal polish. "Wenol" or "Pol" is recommended. These polishes clean off the coating deposit and polish the glass. Follow-up with acetone and isopropyl alcohol.

- To ensure a proper vacuum seal, inspect the bell jar gasket for nicks, cracks, and other foreign material. Apply a thin coat of vacuum grease to the gasket. Immediately wipe off the grease to prevent excessive grease build-up. Inspect the sealing surface for nicks or scratches. These must be smoothed out with emery and polished with fine emery or non-scratch scour pad. Any deposit build-up must be similarly removed and the entire surface wiped clean with acetone and isopropyl alcohol. Vacuum the baseplate to remove all debris and powder deposits.

VACUUM GAUGE TUBES

- Degas gauge tubes for 3 minutes periodically.

- Replace gauge tubes when filaments fail. Do not remove gauge tube when under vacuum. Vent chamber before changing gauge tube.

- Loosen vacuum flange clamp around gauge tube and remove failed tube. Remove electrical connector.

- Install new gauge tube, clean o-ring and sealing surfaces. Re-install flange clamp. Reconnect electrical connector.

- Degas tube according to the guidelines in the subsystem operating manual.

CHECK AND RECORD THE OPERATING PRESSURES MONTHLY.

TURBO PUMP

- The turbo pump is equipped with ceramic bearings and requires greasing every 16,000 hours. See the enclosed vender manual for details.

HIGH VACUUM VALVE

- Check main o-ring seal every six months. This requires disassembly of the valve. Replace o-ring seal if it is scored or brittle.

- Clean o-ring and sealing surface every six months.

ROTARY FEEDTHROUGHS

- Fixture Drive, Shutter Drive, Electron Beam pocket select drive should be disassembled and inspected every 6 - 12 months.

- Replace all damaged, brittle, or worn seals. Clean and lubricate all seals before reassembly.

LOW VOLTAGE SOURCES

- Clean low voltage sources periodically. Do not allow excess coating material to build up on the copper blocks and feedthroughs.

- Vacuum up loose particulate and scrub copper blocks with a non-scratch scour pad and isopropyl alcohol.

- Remove blocks periodically and beadblast to remove all coating material.

DC SPUTTER SOURCES

- DSM 5A or DSM 300A sputter heads:

- Clean screen grids, dark space shields and target surfaces of loose debris using beadblaster or a non-scratch scour pad.

- Check targets for usage. If the center has fallen, change to a new target.

OVERALL SYSTEM MAINTENANCE

Refer to instrument manuals.

VACU PREP II MAINTENANCE SCHEDULE

Daily to once a week

- Clean inside of Bell Jar using lint free wipes and IPA. If needed use fine non-scratch scour pad with IPA to remove excessive build up.
- Once a week compare overnight pump value, pump down value and Rate of Rise value to that of system when originally started. This is a good way to tell if there may be a vacuum leaks or that the system needs to be cleaned.

Monthly

- All of the above.
- Inspect Bell Jar Gasket for wear and dirt as well as the bottom edge of the jar for chips or cracks. Keep the gasket lubricated with Vacuum Grease only making the gasket shinny with no excessive grease on the surfaces.
- Check mechanical pump for proper operation.
- While system is at high vacuum status operate any and all rotary motions for shutters and rotations (if equipped) and observe the vacuum reading for the chamber. If you notice the vacuum level fluctuating (rising and dropping) this is an indication that the rotary motion is leaking and needs servicing.

Every 6 Months

- All of the above.
- Thoroughly clean all interior surfaces of vacuum chamber, cleaning base plate and all parts that are exposed to vacuum.
- Clean all bearings that are within vacuum chamber using an ultra sonic cleaner or alcohol and lint free wipes. After cleaning, re-apply vacuum compatible lubricant (ie; Dow Corning Vacuum Grease) to the bearing before re-installing.

Once a Year

- All of the above.
- Disassemble all vacuum valves (Rough, Backing and Vent). Inspect bellows and o-rings for wear or damage. Clean bellows and o-rings, replace if necessary. (DO NOT USE VACUUM GREASE ON THESE O-RINGS AS THIS WILL ATTRACT PARTICULANT TO ADHERE TO THE O-RINGS AND CAUSE VACUUM LEAKS).
- Remove High Vacuum valve plate and inspect o-rings for damage and wear and replace if necessary. (DO NOT USE VACUUM GREASE ON THESE O-RINGS). Remove High vacuum valve assy. and clean and lubricate seal cup.
- Disassemble all rotary motions (if equipped). Clean shaft, bearings, o-rings and inside of feedthrough. Inspect all surfaces for wear and damage. Lubricate bearings and o-rings with vacuum grease (Dow Corning). Re-assemble feedthrough parts on shafts and install in feedthrough. After high vacuum status is achieved activate rotaries and verify vacuum stability.
- Remove power feedthroughs for resistive sources and inspect o-rings and insulators. Clean buildup of evaporated materials from feedthrough using fine 3M Scotch Bright pad being careful not to remove the nickel plating from the feedthrough. Replace o-rings and/or insulators if necessary.
- Inspect and clean all remaining O-rings replacing if necessary.
- Change oil in vacuum pump using pump manufacturer recommended oil.
- Lubricate Turbo Pump to manufacturer recommendations.

FUSE RATINGS

Fuse	Rating:Amps (all are Slow-Blow CC Class) For 120VAC/230VAC	Circuit
1	25/15	Main Power
2	3/2	Primary 24 VDC PS
3	5/5	Secondary 24 VDC PS
4	0.5/0.5	Primary T1 Signal Trans.
5	1/1	Secondary T1 Signal Trans.
6	10/5	Low Voltage 1
7	2/2	Rotation Control
8	10/5	Mechanical Pump
9	1/0.5	PLC Power
10	2/2	PLC Touch Screen
11	2/1	Primary Turbo 24V PS
12	5/5	Secondary Turbo 24V PS

TROUBLESHOOTING

SAFETY WARNINGS

Warning! Due to the nature of the subsystems, there are many types of voltages on a vacuum system.

WARNING! Lethal high voltages are present!

Caution! Read the operating manuals supplied with the system before attempting any type of troubleshooting on the vacuum system. refer to the proper sections of the operating manuals to verify that the system is being operated in the proper manner.

Interlocks are built in to the control system. Rather than assuming a system failure, verify the problem is not an interlock intended to prevent unsafe operation.

Note on jewelry! When working around a vacuum system, there is one good practice:

Do not wear jewelry!

An arc may be drawn from a high voltage source!

REQUIRED TOOLS

TOOL	USE
Multi-meter (Analog or Digital)	To read AC or DC Voltages To read low AC or DC Current To read resistance (Ohms)
Hand-held Current Meter (Amp Probe)	Clamps around an AC line read current.
Screwdrivers (Flat & Phillips)	For disassembly and assembly.
Wrenches (Box Type)	For disassembly and assembly: 3/8" to 1"
Allen Wrenches	For disassembly and assembly: 1/16" to 3/8"

ELECTRICAL PROBLEMS

Vacuum System Control Rack:

Problem: No activation of subsystems when main switch is toggled.

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

Solution:

- Check to see if there is 110/220VAC, 1-phase power at main breaker of vacuum system.
- Turn ON main disconnect.
- Press green "START" button.
- Check the fuse for the 24-volt DC supply located on the control panel. Replace if blown.
- Check the fuse for the AC power to the DC power supply located on the control panel. Replace if blown.
- Pull out 24-volt fuse from panel. Then with voltmeter, check output terminals of the +24 volts at power supply. These terminals can be found on the 24-volt supply P.C. board.
- Check AC input on transformer of DC power supply to see if 208/220VAC is present.
- If there is 208/220VAC input power, but no 24V DC output, replace the power supply.
- If there is no AC power at this point, contact SPI Supplies

Problem: Subsystems activated, but no control of pumps, valves and subsystems.

Cause: 24V Relays.

Solutions:

- Be sure all relevant interlocks are satisfied before proceeding.
- Pumps, valves and subsystems are controlled through the PLC by relays. Each relay is numbered. Identify the correct relay according to the schematic and check correct position (OPEN/CLOSED) of the relay. Visually verify the proper operation of the relay against the schematic.
- If the relay fails to operate, remove it and use an Ohmmeter to read the resistance of the coil. Verify that the coil is not shorted .
- Verify that the contacts are not fused and preventing movement.
- If there is a problem with a relay, replace it.

- Use a voltmeter to determine if a signal is going to the relay.
- If the relay is not receiving a signal to open or close, contact SPI Supplies

Valves and Shutters

The source shutter and all vacuum valves on the vacuum system are pneumatically controlled. The valve opening and closing is controlled by a 24V DC signal from the PLC to a manifold. When the manifold is activated, the air pressure going into the air cylinder becomes greater on one side than the other. The side of the cylinder with the greater air pressure will move a "diaphragm" the opposite way. Depending on which way the diaphragm is traveling, the valve is opened or closed.

Problem: When the assigned output is activated, the valve or shutter associated with it does not respond. The on-screen indicator changes state.

Causes:

A. No air pressure to the air manifold.

B. No power at the valve or shutter solenoid.

C. Valve or shutter solenoid defective.

Quick Test: Before going on to the solutions for the above causes, there is a quick way to verify that a solenoid valve has +24V DC and the solenoid is active:

Place a common metal screwdriver on top of the solenoid with the valve output ON. If the screwdriver 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 (Cause A):

- Verify that there is 80 - 110 psi of air pressure to the vacuum system. Inspect airlines and filter for water.
- Prove that there is air to the valve in question.
    - Each valve has two airlines attached to it: one for air in and one for return. These airlines are attached by special fittings that make it easy to detach or reattach an airline. These fittings are called "LEGRIS" fittings.

- 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 - 110 psi of air pressure in the line. Make sure that you have a firm grip on it so it does not "whip out of your hand.

- While holding airline, activate and deactivate power to the solenoid.
- Air should flow out of the Legris fitting mounted in the air manifold when power is at one state (ON/OFF), and air should stop flowing when the power to the solenoid is in the other state (ON/OFF).
- Repeat steps 2 through 5 for the second airline to see if it operates the same way.
- If both Legris fittings operate with alternating air ON/OFF, the problem is internal to the valve assembly.
- Disassemble valve in question and inspect for foreign matter or broken seals.

- If the airflow from the Legris fitting did not change from one port to the other or when switched ON/OFF, then follow Solutions (Cause #2) below.

Solutions (Cause B):

- Locate the solenoid valve attached to the air manifold.
- Open the black plastic enclosure that holds the wires connecting to the solenoid.
- When the wires have been located, expose the connectors that join the signal wires to the solenoid.
- Place a voltmeter across the wires at the crimp connectors.
- Disconnect the solenoid from the output leads and try to read +24V DC power at the ends of the two wires.
- If there is NO power at the solenoid when the output is high, use the system schematic and a voltmeter, trace the signal lines and inspect for breaks.
- If there IS power on the signal lines when disconnected from the solenoid and the solenoid is not operating, see Solutions (Cause C)

Solutions (Cause C):

- Disconnect solenoid from signal leads.
- Use an Ohmmeter to read the resistance of the solenoid.
- A reading of approximately 65 - 85 Ohms (+/- 10%) indicates a good solenoid.
- A reading of 00.0 Ohms indicates a shorted solenoid.
- Replace the solenoid, then try the valve.
- A reading of infinity indicates the solenoid is burnt out (open coil).
- Replace the solenoid, then try the valve.

Rotation:

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

The rotation is interlocked to prevent processing in the event of a malfunction.

This interlock must be cleared from the Automatic Process screen after diagnosing the problem.

Causes:

A. Fuse blown.

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

C. Rotation is mechanically jammed.

D. Rotation interlock active.

Solutions (Cause A):

- Shut power to the Motor OFF before proceeding.
- Remove the fuse and check it with an ohmmeter. If blown, replace.

Solutions (Cause B):

- Use a voltmeter to measure the 240V DC power going into the circuit.

- If NO power is present, use the use the system schematic and a voltmeter, trace the signal lines and inspect for breaks.
- If there IS power coming in to the relay (CR), then the DC control output from the PLC may not be activating the relay.
- Check for 24V DC at the relay coil when the rotation power is on.
- If the relay is not receiving a signal to turn on or off, contact SPI Supplies.
- If either or both DC outputs are disabled for the field or armature, replace the motor controller.

Solutions (Cause C):

- Inspect main bearings in the planetary drive for damage.
- Disconnect the motor from the rotation so that the substrate drive can turn freely.
- Push the planetary with your hand. It should rotate freely for 3 to 5 revolutions after one firm push. Rotation motion should be smooth.
- If the rack does not rotate, or it is very hard to move, disassemble the planetary and replace the bearings.
- Reassemble the system and try again.

VACUUM PROBLEMS

Occasionally, a problem may arise in the vacuum system. Leaks may occur through bad seals, loose welds, or through the malfunction of a component. The following is presented as a guideline for servicing vacuum problems when they occur.

Mechanical Pump:

When starting up, leave the roughing valve open and check the pumpdown times. Check vacuum on the gauge.

- Refer to mechanical pump manual for specific troubleshooting procedures.
- Air leaks may occur at threaded connections. A drop of acetone or alcohol on a leaky connection will cause a change in pressure reading. A small leak may be sealed temporarily resulting in an improved vacuum. A larger leak will allow liquid acetone to enter and vaporize resulting in pressure rise. Even a small leak may degrade the vacuum considerably. Use PTFE tape on the threads when installing. If small leaks are detected, SPI Supplies offers other methods of temporary and permanent fixes.

- The roughing valves are bellows sealed with the bellows being on the mechanical pump side when the valves are closed. Bellows eventually will develop hairline cracks due to work hardening the copper alloy at the inner or outer convolution. Usually a hairline crack in the bellows will leak more with the valve completely open (bellows is compressed) than with the valve nearly closed (bellows in normal condition). Variations in pressure readings as the valve is moved from nearly full open to nearly closed indicate trouble in this area. Squirt acetone in the bellows vent hole in the stem flange to check. The bellows is replaceable with static o-rings forming the vacuum seal. To replace, remove stem assembly from valve body. Four Allen head screws hold the stem assembly. Spin the flange from the threaded stem. Slide a 6" length of ¾ " i.d. copper tubing with opposing ears 3/16" wide by ½ " long at the forward end down over the threaded stem to fit slots in the nylon valve stem nut. Remove stem nut. Bellows is free to be inspected. You should replace both the bellows and the nylon stem nut. When reassembling, a drop of thread seal on the stem nut will prevent the nut subsequently loosening. Normally the o-rings are reusable; however, all seals should be inspected and cleansed if necessary. Wipe the o-ring grooves. If vacuum grease is used, apply a thin coating and wipe it off with a clean rag. Sufficient grease will remain to lubricate the o-ring.

- Many evaporators are equipped with a mechanical pump line vent. Check to see if it is closed.

Mechanical Pump Troubleshooting:

Problem: Rough out times are increasing.

Solutions:

- Close all valves and turn ON Mechanical pump. Check vacuum when roughing chamber.

- Observe pressure on the gauge controller. This controller is used as a pressure sensor. It is used to evaluate mechanical pump performance.

- The pressure should go to less than 100mTorr (in 2 - 3 minutes) - this is a pressure that the mechanical pump can readily attain in the vacuum system.

- If the ultimate pressure is above this reading, refer to the operating manual. Maintain pump as advised.

- If the pump appears correct and is not damaged noticeably, but the ultimate pressure is still above 1mTorr contact SPI Supplies.

CHAMBER

The chamber area may be the source of a vacuum problem. Assume we have good vacuum with all valves closed and with the backing valve open, but the chamber area will not pump down:

- First check the door seal and the sealing surfaces. Wipe door seal and baseplate seal clean. Check door seal for cracks, slits, etc. Check window glass for chips and cracks.

- Is the vent valve open?

- The bellows for the main valve is located in the area above the valve. A bellows leak affects the bell jar vacuum. Check with acetone. The o-rings tend to maintain their static seal. Usually a leak is in a convolution of the bellows. Acetone can be squirted in the open end of the bellows through a hole in the flange. Start at the bottom and work up. The bellows is replaceable.

- All power feedthroughs have o-ring seals. These static seals seldom leak once they are properly installed. Any "just installed seals" should be immediately suspected when the vacuum failure occurs on the first subsequent pumpdown. Try to wiggle these feedthroughs from beneath the baseplate. Rotary motion seals for simple shutters and for power driven work tables use twin o-rings. Vacuum grease is packed between the o-rings to lubricate and seal. These feedthroughs should be removed, cleaned, and re-greased depending on the frequency of use. Some gas evolution is expected when the shaft moves in. Little or no leak should be expected when the shaft is rotated.

Small Leaks:

The preceding section covers leaks of appreciable magnitude. Leaks of a size to prevent attaining less then 1 x 10-4 torr will normally be found using acetone. At high vacuum actual leaks are likely to be small as to require a helium mass spectrometer to locate them. It is more common to have a problem with the cryo pump not pumping very well than it is to have a 10-5 torr leak suddenly appear.

Suppose your system will pump down to 2 x 10-4 torr but no further. To diagnose the problem, do the following:

- Close the main valve and watch the vacuum display. If the vacuum degrades (pressure increases) quickly, then time the rise for 5 microns at two points; say from 10 to 15 microns and from 50 to 55 microns. If the time interval is the same, we are likely dealing with an air leak from outside. If the time interval is somewhat longer at the higher pressure, we may have a contaminated system, and the system is outgassing slowly. Open the main valve and pump down again. Repeat the pressure rise check. If the rise time is longer, contamination is a likely cause. A thorough cleaning of all surfaces in the vacuum space will correct the trouble.

SUMMARY

Steps for troubleshooting should follow a logical order.

Vacuum systems are constructed from many different vendor parts and subassemblies: everything from electrical valves to electron beam guns. Each subsystem is supplied with a manual of operation. Familiarize yourself with all the operating manuals supplied with the vacuum system. Refer to these manuals for trouble shooting procedures on the individual equipment in question.

This manual reviews the most common problems experienced with similar vacuum systems. Possible causes are described and solutions are presented in a step-by-step procedure. Most problems can be identified and corrected with a similar approach.

If after a reasonable time the problem cannot be identified, contact SPI Supplies to assist with troubleshooting and repair. We can also provide system training to facilitate system maintenance and reduce down time.

For additional support and information, contact SPI Supplies directly.

1-800-2424-SPI (800-242-4774)

1-610-436-5400

spi3spi@2spi.com