PVD Products, Inc.

Sputter Deposition System
Project 121

Operation and Service

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02/2007	1	Initial Release

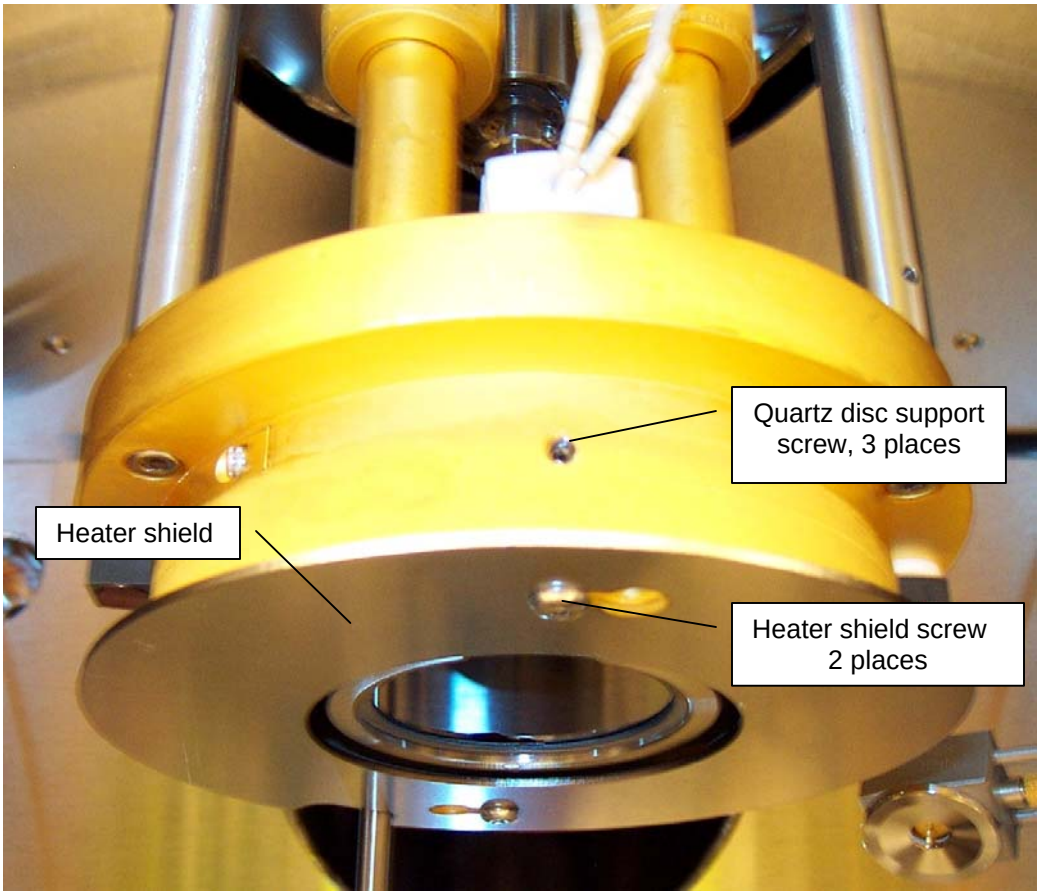
Contents

1 Installation

1.1. Heater

1.1.1. Element and Heater Shields

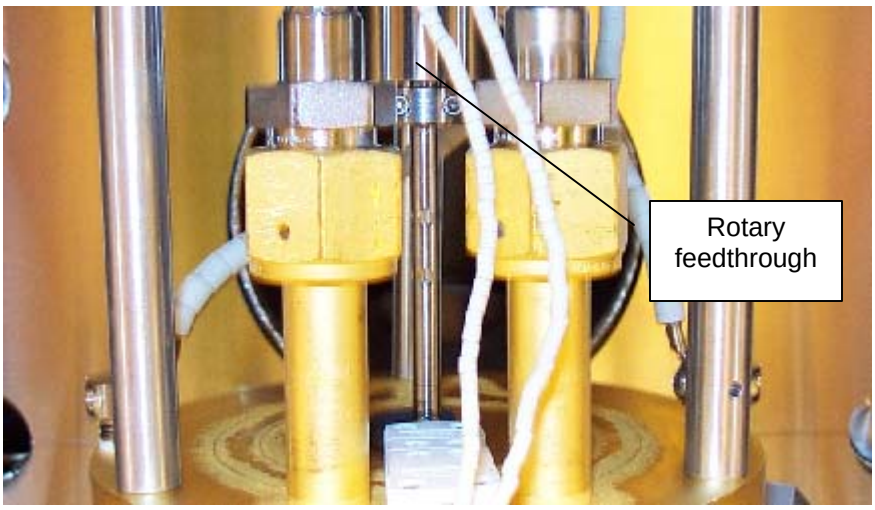
The quartz disc used to shield the heater element from deposition has been removed for shipping purposes. This needs to be reinstalled prior to operation. There are three screws that hold it in place in the water-cooled heater assembly. A stainless steel shield for the heater assembly itself has also been removed. This is held in place by two screws. Follow the steps below to reinstall the shields.



1. Remove the three set screws in the heater assembly
2. Insert the quartz disc into the heater and reinsert the set screws
3. Allow the disc to rest on all three support screws
4. Place the heater shield up against the bottom of the heater assembly and line up the screws holes
5. Use the supplied screws to reattach the heater shield

1.1.2. Substrate Spinner

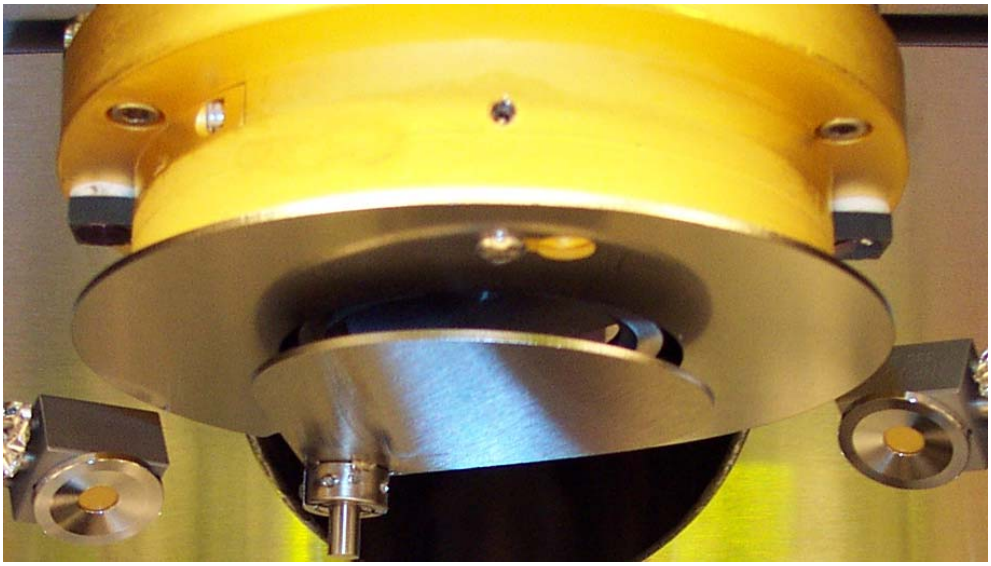
The substrate spinner assembly has been removed for shipping purposes. This spinner assembly needs to be reinserted through the holes in the quartz disc and heater assembly and secured to the rotary feedthrough at the top of the chamber with the supplied collar clamp.



As the shaft of the substrate spinner is inserted through the heater assembly, care should be taken to avoid any damage to the quartz disc or heater element. When the shaft clears the top of the heater assembly secure the spinner shaft to the rotary feedthrough shaft with the supplied collar clamp.

1.1.3. Substrate shutter

The substrate shutter has been removed for shipping purposes. This shutter has a collar clamp that is welded in place. Slide the shutter onto the rotary feedthrough shaft at the back of the heater assembly and secure it in place.



The picture above shows the fully assembled heater with the shields (quartz disc cannot be seen), spinner, and shutter in place.

1.2. Viewport Shield

The chamber door has viewport for inspecting inside the chamber during deposition. There is a stainless steel shutter protecting the viewport from deposition that can be rotated out of the way to see inside the chamber. There is also a holder for a quartz plate between the viewport and the shutter as additional protection from deposition. This plate has been removed for shipping purposes and needs to be reinstalled prior to operation.

1.3. Sputter Sources

The sputter sources have been wrapped in aluminum foil for shipping purposes. This foil needs to be removed prior to operation. The sources and shutters should be inspected at this point to see if any damage has occurred due to shipping.

1.4. Computer

The system computer must be unpacked and setup on the tabletop above the electronics rack. The power, USB, and Ethernet cables on the left side of electronics rack must be reattached to the computer.

1.5. Power

Please refer to the power requirements for the system in the Facilities section of this manual. A main system ground cable is supplied as well. This ground wire can be found at the back of the system coming through the electronic rack and MUST be connected to a proper earth ground before system operation.

CAUTION
The ground cable MUST be connected to a proper earth ground before the system is to be operated. Failure to do so could result in a safety hazard and will invalidate the warranty.

2 System Specifications

2.1. Technical Information

PVD Product's Sputter system is a completely integrated deposition tool capable of depositing films on 2-inch diameter substrates or multiple smaller samples per the customer requirement. The system includes an electro polished 304SS chamber with internal removable stainless steel shields. There are multiple Conflat® flange ports for user accessories including a residual gas analyzer (RGA), load lock, atomic absorption or emission spectroscopy, ion gun or sputter source, target and substrate view ports. The chamber is mounted to a stand-alone frame with casters and leveling pads. A separate 19-inch wide electronic rack houses all system electronics and the power distribution box. A water manifold with an interlocked flow switch and a nitrogen manifold with pressure regulator are included on the main chamber frame.

The system comes with an all-manual valve package (or optional pneumatic control), and a Pfeiffer Vacuum 500 L/sec turbo pump. A BOC Edwards XDS-10 dry pump is used to evacuate the chamber, turbo pump and loadlock (optional). Vacuum gauging includes Convectron® gauges (measuring pressure from 1 mTorr to atmosphere), and Bayard Alpert ion gauges. Programmable mass flow controllers (MFC), calibrated for user specified gases, are also included for processing.

Four ultra high vacuum PVD Products Balanced Titan 2-inch magnetron sputter sources are incorporated into the deposition chamber. One magnetron is set up directly beneath the substrate for Gallium and the other three sources are set in a confocal sputter-up array. These sources have the magnets housed in the vacuum, no water to vacuum interface, and provide easy target changes. All the sources can run either RF or DC power. The three standard sources are mounted on their own 6-inch Conflat® flange with individual electro pneumatic shutter assemblies and are directed at a fixed angle with respect to the substrate normal. The sources can handle magnetic targets up to 1/8-inch thick and non-magnetic targets up to ¼-inch thick.

One Dressler (Advanced Energy) Cesar 13.54 MHz, 300-Watt, RF power supply with impedance matching network and auto tune capability is integrated into the system. The RF matching network is mounted to the side of the deposition system in close proximity to the RF sputter source. Three Advanced Energy MDX 500 Watt DC power supplies are provided for DC sputtering of conductive materials.

A substrate heater consisting of a SiC element housed in a water-cooled, gold -plated OFHC copper block is provided. A maximum substrate temperature of 800°C for sapphire and 900°C for silicon is achievable. The heater is controlled via a programmable Eurotherm closed-loop temperature control unit and power supply. A type K thermocouple is utilized as the input to the Eurotherm controller.

A substrate rotation stage is integrated into the heater assembly. This includes a magnetically coupled rotary feedthrough with servomotor control providing substrate rotation speeds up to 50 RPM. The unit is mounted to a servomotor controlled Z-stage with a 2-inch stroke to accommodate easy substrate transfers with the loadlock. An inconel substrate spinner assembly and shaft is included. Two sets of inconel substrate holders are provided and are fully compatible with the substrate spinner and loadlock assembly. These holders are also compatible with the use of properly designed masks.

A small loadlock is provided for substrate transfers. The chamber is pumped via a Pfeiffer 210 l/sec water-cooled turbo pump with splinter screen. This loadlock includes a small vacuum chamber with a manual isolation gate valve separating it from the main chamber. The loadlock includes electropneumatic gate, foreline, rough and vent valves as well as an overpressure relief valve. A Granville Phillips Micro ion gauge and an Instrutech Convectron® gauge are included to monitor the pressure. Pumping is conducted through the proper valves and the system dry pump (Edwards XDS-10). A manual linear transfer arm is used to insert the substrate holder into the chamber. The holder is then placed into the substrate heater through the use of a door mounted wobble stick.

A laptop computer with a software package based on National Instruments LabVIEW® is provided. The computer interface monitors and controls various system features such as vacuum valves, flow rates, shutters, power supplies, temperatures, and system pressure.

The system comes complete with a variety of safety features. All electro pneumatic valves and shutters will close on power failure, except the gate valve that isolates the main chamber from the load lock (if included). This includes the MFC isolation valves. At power-up the all valves and shutters will remain shut. The substrate heater will also become deactivated in case of a power failure. Furthermore, the sputter sources and the substrate heater assembly have a water flow switch interlocking the units to minimize risk of damage due to excessive heating. The chamber also comes with vacuum interlocks so that all lethal voltages are disabled if the chamber is vented to atmosphere or the chamber door is opened. An over-pressure relieve valve has been installed on the chamber. An Emergency Off Panel is supplied to disable all lethal voltages in case of emergency. The logic in the software is designed to override any command that may cause personnel or system damage.

2.2. Specifications

Maximum substrate size: Holds one 2-inch diameter substrate or multiple small samples per customer requirements
Maximum substrate temperature: 800°C for sapphire, 900°C for silicon
Operating Pressure Range: 2 to 100 mTorr in Ar gas or mix
Sputter Sources: Four 2-inch diameter sputter sources: one set up for gallium
Source Orientations: Sputter up configuration with three sources set in a confocal array and one source normal to the target
Power supplies: One 300 Watt RF supply with matching network, three 500 Watt DC supplies
Target to substrate distance: Nominal 4.75-inch throw distance per gun
Base Pressure: $P < 5 \times 10^{-8}$ Torr

2.3. Facilities

System Gas Requirements				
Process Gas	**Pressure**	**Flow**	**Purity**	**Connection Type**
N2	100 psi	1 slm	99.999%	1/4" Swage
AR	100 psi	50 sccm	99.999%	1/4" Swage
N2	100 psi	20 sccm	99.999%	1/4" Swage
Compressed Air	100 psi	100 slm	clean dry	1/4" Swage
Exhaust	N/A	12 cfm	N/A	kf-25
N2 (Vent)	30-60 psi	1 slm	98.50%	1/4" Swage

System Water Requirements	
(closed loop Heat exchanger re-circulating supply & return)	
Flow	11 l/Min. (2.9 Gal/Min.)
Pressure	414 kpa (60 psi Max)
Temp	18C (64 F)-24C (75F)
Resistivity	1-3 Mohms
Particle Size	30 Microns Max

System Electrical Requirements	
A/C	208 V, 3 Phase, 50/60 Hz, (5 Wire)
Power Consumption	Max: 8.6 kVA, Full Load: 40A
Main Breaker	40A, 3 pole
Building Ground	AWG #4
Main Connector	So Wire Mesh Cord Grip

2.4. System Safety / Interlocks

2.4.1. Emergency Off (EMO)

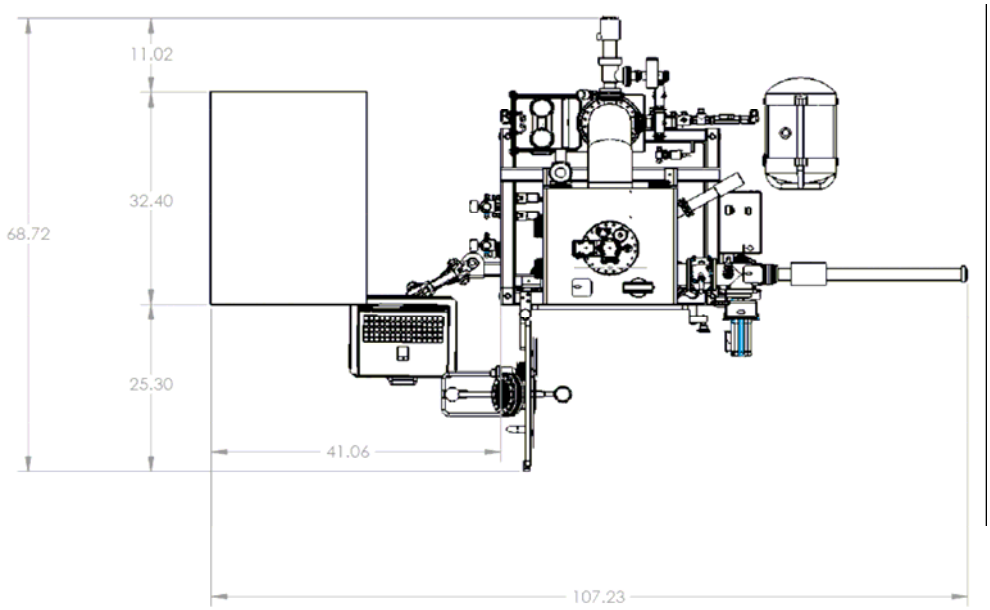
The system is equipped with an Emergency Off (EMO) button that disables all lethal voltages in the case of an emergency. The button is located in the electronics rack and when pushed, needs to be reset for normal system operation. This button should be checked at least once a month for proper operation. Contact PVD Products immediately if the EMO button fails to safely power down the system.

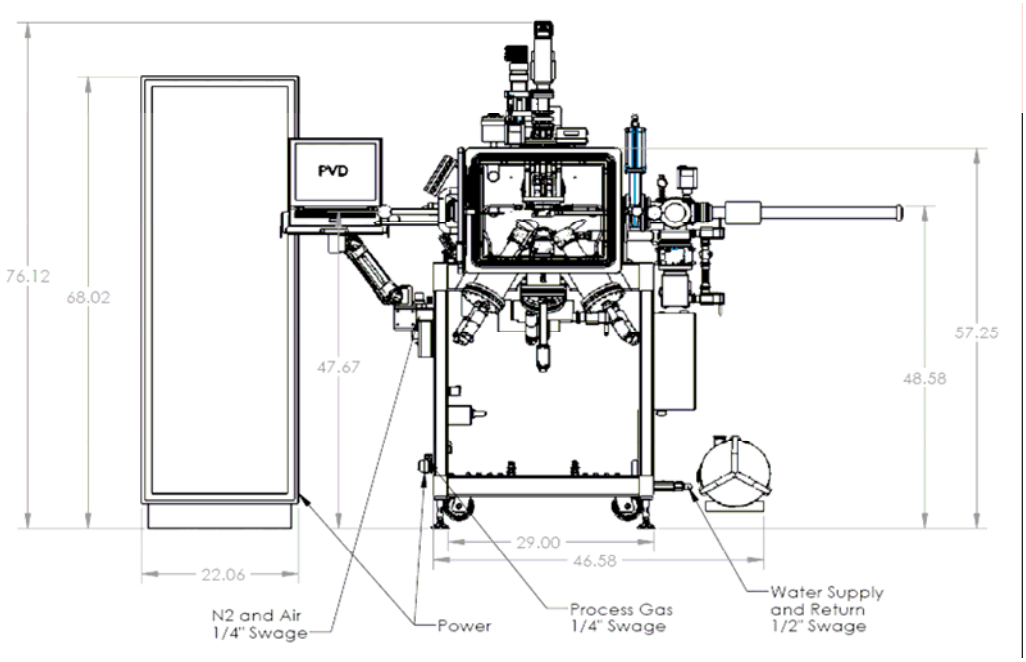
2.4.2. Interlocks

A system wide safety interlock governs all system power supplies. All panel doors, including the main chamber door, must be closed/secured and there must be water flow present in the system for the power supplies to operate. If the door interlock is not satisfied, the contactor that supplies line voltage to the power supply outlets will open and not allow voltage to any of the units. Indicator lights are present in the software to inform the user of the interlock status. These interlocks should be checked at least once a month for proper operation. Removing any panel of the system or opening the main chamber door should always trigger the Door/Panel interlock. Contact PVD Products immediately if this fails to trigger the interlock. Closing either valve on the water manifold should always trigger the water flow interlock. Filtered, recirculating cooling water should be used at all times for the system. If unfiltered water is used, it is possible that the water flow switch could become clogged and stay in the open position. This could give a false reading for water flow. If the flow indicator reads positive when it is know that there is no water flow, the flow switch should be removed and cleaned to insure proper operation. If cleaning the flow switch does not solve the problem, the switch will need to be replaced. Contact PVD Products for a compatible flow switch replacement.

CAUTION
All system interlocks should be tested at least once a month to insure proper operation.

2.5. Layout





Electronics Rack: 400 lbs.
System: 800 lbs.

Please refer to documents: J00S2021 for more detailed information.

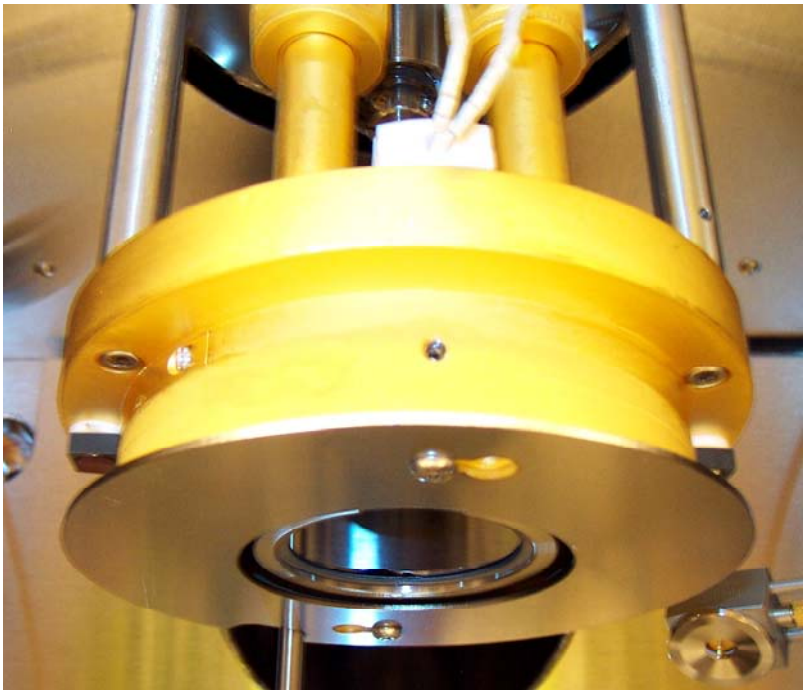
2.6. Transportation

In the event that the system needs to be moved from its current location, please contact PVD Products for detailed instructions for safe transportation.

3 System Components

3.1. Heater

The heater assembly consists of a water-cooled gold-plated copper shroud with a silicon carbide (SiC) heating element. Electrical and water-cooling lines are connected at the top of the heater. A shutter assembly allows for masking of the substrate.



CAUTION
Cooling water must be supplied to the heater assembly and the water flow and pressure interlock cables must be connected for safe operation. Failure to do so can result in heater failure and will invalidate the warranty.

A type K thermocouple is installed to provide feedback to the Eurotherm controller. This thermocouple is inserted through an opening in the top of the heater. This temperature reading is not a direct indication of the substrate temperature, since the thermocouple itself is floating. It simply provides closed loop temperature feedback to the PID control loop of the Eurotherm controller. To get an accurate substrate temperature, a viewport is provided on the bottom or side of the chamber for pyrometer measurements.

CAUTION
During heater operation, it is very important to monitor the current/voltage characteristics for each setpoint.

The reason for keeping a data record of current versus voltage for a known temperature setpoint is to verify the status of the SiC element. If an issue arises with the SiC, there should be a change in the amount of voltage/current required to maintain a given setpoint. Once a change is noted, the heater should be shut down immediately to verify the status of the SiC element.

CAUTION
A cool down period must be allowed before opening the main chamber when heater temperatures above 100ºC have been attained.

When the heater is operational, if the temperature attained is above 100ºC, a cool down period is recommended before the user should vent and open the main chamber to atmosphere. This is to protect the user from any possibility of burns when working inside the main chamber. Although the main body of the heater is water-cooled, other components of the system inside the main chamber may be hot.

3.2. Sputter Sources

Four UHV PVD Products Balanced 2-inch magnetron sputter source are incorporated into the system. All sources can run either RF or DC power and are mounted on individual 6-inch Conflat® flanges with electro pneumatic shutters. The sources can handle 1/8-inch magnetic targets and ¼-inch non-magnetic targets. Optionally, the sources may have tilt capability (±15°).

3.2.1. Target changes

- Remove the 4 screws holding the anode to the magnetron, and slide the anode off of the magnetron.
- Remove the 3 screws holding the target clamp to the magnetron. This will loosen both the target clamp and the target itself, so be careful not to drop them.
- Be careful not to lose the piece of copper mesh that is between the target and the magnetron. This aids conductivity.
- Replace the target clamp and the 3 target clamp screws, with the new target under the clamp. Try to avoid blocking the screw holes with the copper mesh.
- Only tighten the target clamp very lightly, making sure to evenly distribute clamping force…over tightening may cause the cracking of delicate targets (i.e. oxides) when heat cycled.
- The screw holes in the target clamp and the tapped holes on the magnetron are not radially symmetric. This means that some orientations work while others do not. Also there are two sets of holes (6 total) in case some of the holes become damaged. The clamp can then be oriented so as to use the other set of holes.
- With the copper mesh, target, and target clamp attached the anode can be reinstalled using the 4 anode screws.
- The anode should sit between 1 mm and 2mm above the target.
- Over tightening the anode screws may deform the anode enough to cause a short.

3.2.2. Cleaning

- To avoid contamination when changing targets or because of excessive build-up of sputter material (i.e. material flaking off of the anode) the anode, target clamp, and the shutter may need to be cleaned (according to user discretion).
- Cleaning can be done with either a media blaster (sandblaster), or with a wire brush wheel. PVD Products recommends using a media blaster if available, but either is acceptable. No matter which method you use, be careful not to be too aggressive to avoid damaging the anode or target clamp.
- Further cleaning with solvents will then be necessary to remove any dust/grease left behind from the physical cleaning process.

3.2.3. Removing / Installing Shutters

- Remove or install the magnetron shutters by loosening or tightening the screws on the two-piece collar clamp that is attached to the shutter.
- To re-align the shutter so that it operates correctly with the rotary feedthrough, tighten the two-piece shutter clamp with the rotary feedthrough in the closed position and the shutter aligned over the magnetron.

3.3. Temperature Control Chassis

The Temperature Control Chassis houses the Eurotherm temperature controller for the substrate heater. On the front of the chassis are the following controls/indicators:

- Eurotherm segment skip
- Fuse

The Eurotherm skip button will skip from one segment of the program stored in the Eurotherm controller to the next segment. The Eurotherm can be programmed with one eight-segment program. Please refer to the included Eurotherm manual for detailed information of how to operate the unit.

3.4. Heater Power Supply

The heater power supply is tied to two interlock connections (water and chamber pressure below 400 Torr). Both interlocks must be satisfied for the power supply to output current and voltage. If either interlock is not satisfied, this will be indicated on the front panel of the supply by the red light labeled “S/D.” The power supply can only be enabled when both interlocks are satisfied.

CAUTION
Never try to operate the heater with any of the interlocks disabled. This could result in heater failure and/or personal injury.

The heater power supply is a Sorensen 3 kWatt power supply (0-150V 0-20A). The supply has been configured by PVD Products to operate in remote mode in conjunction with the Eurotherm controller. The voltage and current will display on the front panel during operation. The control mode of the supply is configured for voltage control. In this mode, the voltage knob on the front panel is disabled and the Eurotherm controller sets the output voltage. The current knob is not disabled, however, and can be used to set the maximum current allowed. This knob should be set to its maximum value (fully clockwise) unless the user wishes to limit the current to a specific value.

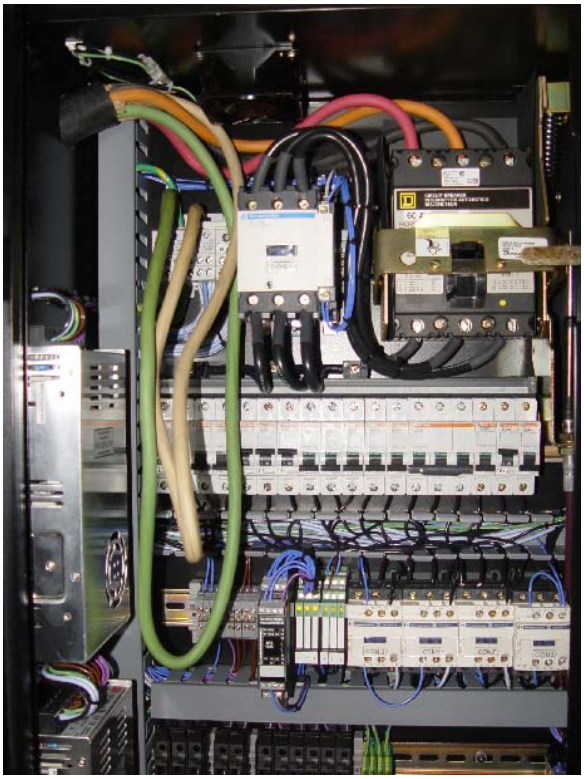
Please refer to the included Sorensen manual for detailed information on the operation of the unit.

3.5. Emergency Off Panel

The system Emergency Off (EMO) panel contains the main power controls for the system. Pressing the EMO button will turn off all lethal voltages for the system. To turn power back on, rotate the EMO button until it springs into the on position (out) and then press the green “ON” button next to the EMO button. After any power loss, the user must always press the green “ON” button to power up the system.

Depending on system configuration, various pump controls and indicators are also included on this panel. A main water flow indicator and pressure indicators are located at the opposite end of the panel. Water flow and the 400 Torr indicators must be active for heater operation. The 250-mTorr indicator must be active for ion gauge operation. The power switch for the mechanical pump as well the ion gauge filament switch is also located on this panel. If the optional pneumatic control is installed in the system, some of these controls and/or indicators may not be present. In this case, 5VDC and 24VDC power supply indicators for the digital/analog I/O system may be present.

3.6. Power Distribution



All power is distributed to the system through the Power Distribution (PD) cabinet. Whenever the door is opened, the main circuit breaker is turned off. When power is connected to the system, and the main circuit breaker is turned on, the red OFF button on the EMO panel will light. When the green ON button is pushed, the system is reset and power is applied to all instruments (assuming all interlock conditions are satisfied).

3.7. Pumping Stack

The sputter system comes with a water-cooled Pfeiffer Vacuum turbo drag pump and splinter screen. The turbo pump provides a pumping speed of 500 l/sec. A BOC Edwards XDS-10 dry pump is provided to evacuate the chamber, turbo pump, and loadlock.

The dry pump is used to evacuate the chamber and loadlock during the roughing cycle of pump down and also backs the turbo pumps during operation.

The foreline valves and the rough valves isolate the mechanical pump. The foreline valves connect the mechanical pump to the turbo pumps, and once the foreline valves are open the turbo pumps will evacuate. The rough valves connect the mechanical pump to the chambers, and once the rough valves are open the chambers will evacuate.

3.8. Sputter Source RF Power Supply

One Dressler Cesar 13.54 MHz RF Power Generator is included with the system to power a magnetron sources. The supply can output up to 300 Watts of RF power. The output from the supply is connected to an auto-matching network mounted on the side of the system frame. The supply can be operated from the front panel, or remotely through the system computer. Please refer to the included Cesar manual for more details.

3.9. Sputter Source DC Supply

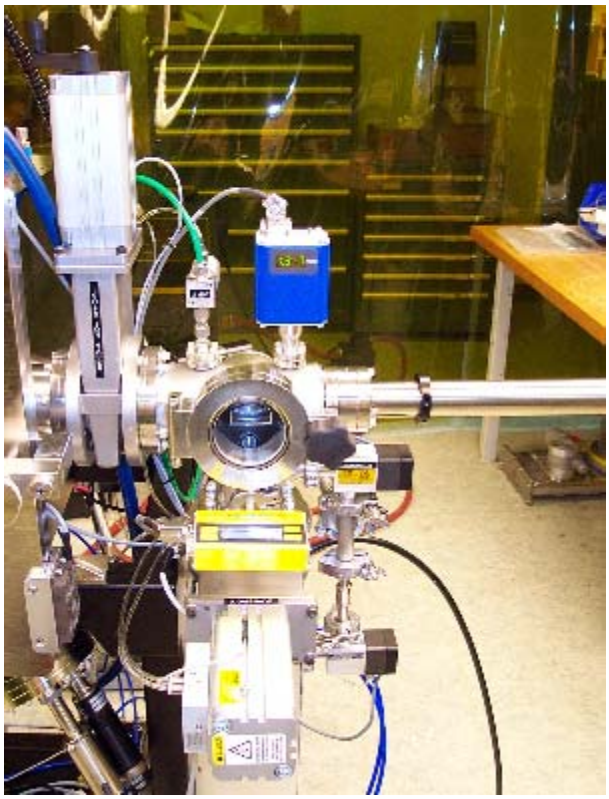
Three Advanced Energy MDX 500 Watt DC power supplies are provided for DC sputtering of conductive materials. The supplies can regulate in voltage, current, or power mode and have the ability to ramp the DC output. The supplies also have Arc-Out® suppression circuitry providing multi-level suppression and quenching of different types of arcs in the magnetron environment. Please refer to the included MDX manual for more details.

3.10. Optional Components

3.10.1. VAT Pressure Control

An optional stepper motor pressure controller in conjunction with a VAT electronic valve can be installed to maintain system pressure from 1 mTorr to approximately 1000 mTorr. It adds pneumatic valves for the roughing line, foreline, and vent valve, as well as to all MFC valves.

3.10.2. Loadlock



An optional loadlock with transfer arm can be mounted to the system. The loadlock has a quick access door for sample loading. The sample is transferred into the main chamber with a magnetically coupled linear actuator. The loadlock includes a mechanical pump, roughing valve, foreline valve, vent valve, pressure relief valve, Convectron® gauge, and ion gauge.

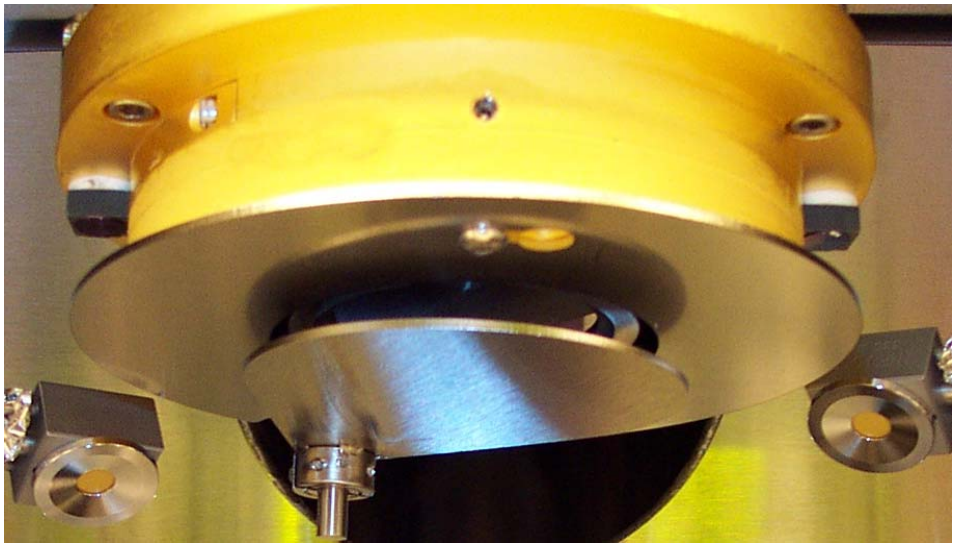
3.10.3. Substrate

An optional substrate rotation assembly sits on top of a 2.75 inch Z-stage. The Z-stage movement is controlled by a servomotor and has mechanical hard stops to limit the range of motion. The Z-stage can be lowered for substrate loading/unloading and then raised for deposition. The rotary motion feedthrough is magnetically coupled and the entire assembly moves in unison with the motion of the Z-stage. The magnetic feedthrough should never be turned by hand unless the power to the servomotor is turned off (through software or circuit breaker).

CAUTION
Turning the magnetic rotary feedthrough by hand with the servomotor powered on can damage the servomotor and will invalidate the warranty.

The load/unload position for the substrate holder is a user-defined position and typically is aligned with the front of the chamber. This position corresponds to the index pulse of the servomotor encoder. Loosening the coupling between the servomotor shaft and the magnetic feedthrough can change the position of the substrate holder in relation to this index pulse. With the motor in its “home” position, loosen the coupling connection to the magnetic feedthrough and rotate the substrate holder to the load/unload position using the magnetic collar. Be careful not to rotate the motor shaft in the process. Then re-tighten the coupling connection between the magnetic feedthrough and the servomotor shaft.

3.10.4. Substrate Shutter

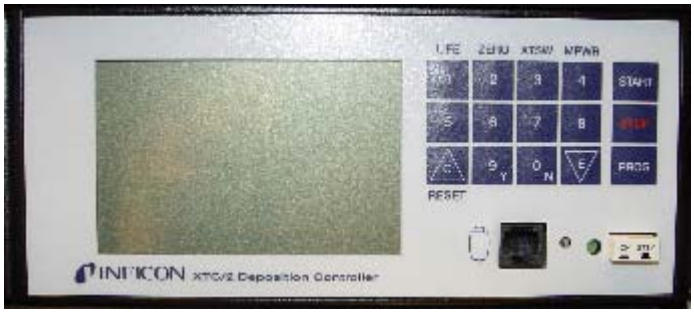


Optional shutters may be installed to allow thickness gradients to be deposited on the substrate. Motorized linear actuators are mounted to the chamber and the shutters are allowed to move in front of the substrate in a well-defined pattern. The actuator includes a servomotor and encoder.

3.10.5. Sputter Source Pulse generator

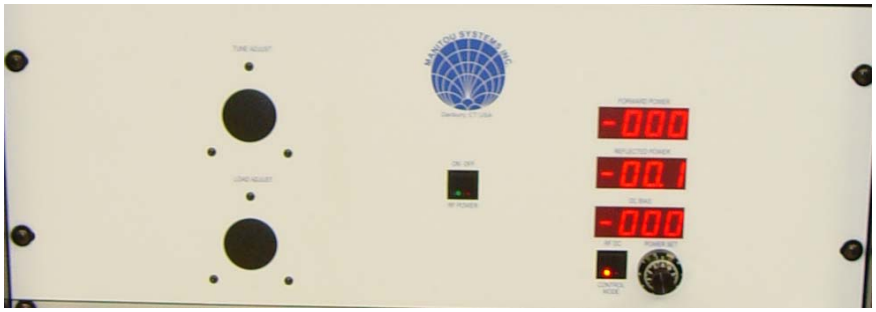
An optional Advanced Energy SPARC-LE pulse generator may be provided in conjunction with one of the MDX DC supplies. This provides either pure DC output or pulsed DC output at a frequency of 20kHz.

3.10.6. Inficon XTM



One Inficon XTM deposition monitor may be included with the system. This unit includes a Quartz Crystal Microbalance and all necessary cables. The XTM is interfaced to the system computer for monitoring of the deposition rate and thickness. The thickness setpoint can be used to close the source shutters through the software interface.

3.10.7. Substrate RF Bias Supply



A Mantiou Systems RF power supply may be included for biasing of the substrate. The unit can be run in either RF power (max 100-300 W) or DC bias (max 1000 V) control mode. The user must select the control mode by use of the mode switch on the front panel. This is the only way to select the control mode, as it cannot be changed remotely through the computer.

When the green LED is lit on the RF Power switch, this indicates that the interlock conditions are satisfied (water flow and pressure) and RF output will be allowed. In its present configuration the RF output can only be turned on from the system computer, but the RF Power switch must also be pressed on the front panel to allow the output. This switch can be left in the ON position if the user so desires. The control setpoint (either RF Forward Power or DC Bias voltage) is sent from the computer as well.

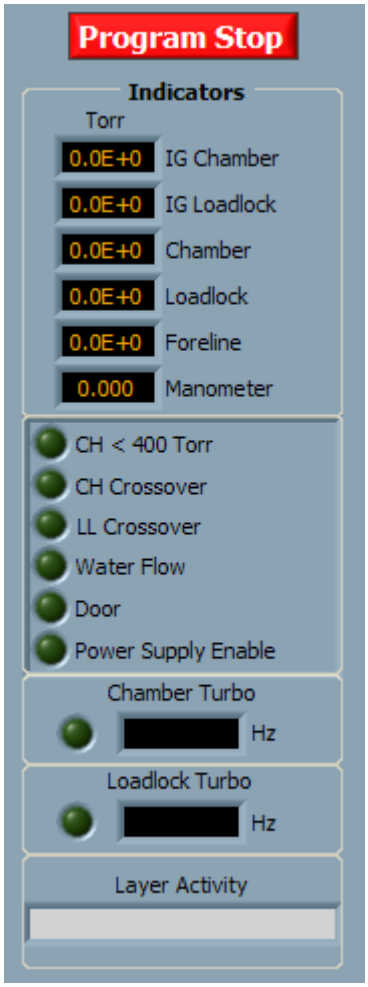
4 Software Control

4.1. Overview

This section will describe the software control package for the PLD system. A computer running Windows 2000 or above with 512 MB RAM and RS232/RS485 serial ports is provided. All the necessary software can be located on the provided PVD Products CD. The software has been pre-installed at the factory. Double click the control file to see the following window (all controls may not be available, depending on the system configuration and options):

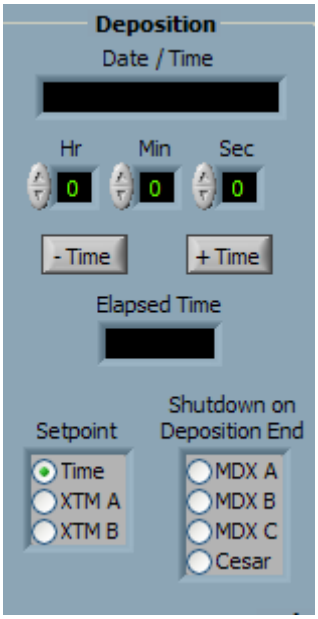
When you double click the application, the program will open and the user will need to click the white arrow to begin execution. This will be evident by the "moving" black arrow in the menu bar  and the time advancing in the **Date/Time** window. In the above picture, the program is not running (indicated by a solid white arrow ). Once the program is running, all the switches, buttons, and indicators become active.

4.2. Program Stop / Indicators



This section contains the **Program Stop** button as well as various indicator lights and data for system status. Clicking the **Program Stop** button is the correct way to "stop" the program, as this will initiate a "shutdown" sequence for the program, stopping motion, closing serial ports, etc. The stop sign in the menu bar is actually an "abort" button and should only be used in extreme circumstances if the program is not responding.

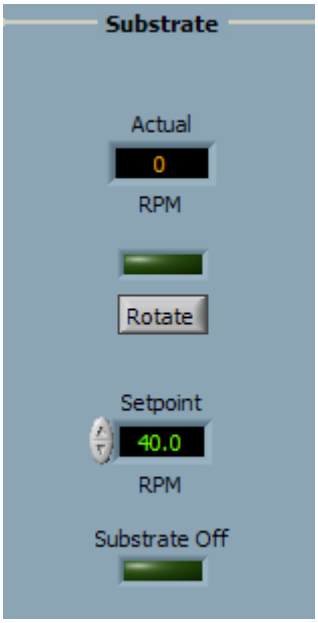
4.3. Deposition



This section controls the program deposition timer and setpoint selection, as well as displaying the date and time. The timer is triggered by opening any of the source shutters and can be used as a deposition time monitor or countdown. To use the timer to control a deposition, the **Time** button must be selected in the **Setpoint** selection control (this will be the default setting if the optional Inficon XTM monitor is not present). Entering a value of zero for the **Deposition Time** and opening a source shutter will cause the **Elapsed Time** to count up, giving an indication of the length of the particular deposition. In this case, the user must "manually" end the deposition. Entering a value for the **Deposition Time** and opening a source shutter will start a countdown timer for the particular deposition and will close the source shutters and shutdown any selected features when it reaches zero. The **+Time** and **–Time** buttons can be used to add or subtract time from a current deposition.

If **Inficon Thickness** is selected as the setpoint (optional), the deposition will continue until the desired thickness (as indicated by the Inficon monitor) has been reached. As with the time-controlled deposition, the source shutters will close and any selected features will be turned off when the thickness has been reached. The user will first want to zero the thickness value in the Inficon either through the software, or the front panel of the unit.

4.4. Substrate Rotation



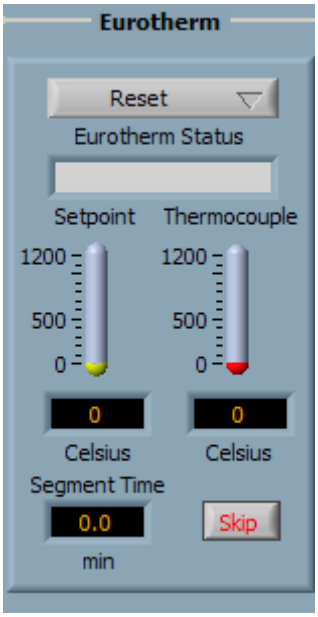
This section controls the substrate rotation. Turning the **Rotate** button on will cause the substrate to rotate at the RPM setpoint entered in the numeric control. The actual RPM will be displayed in the indicator window. When the button is turned off, the substrate holder will decelerate and start a search for the "home" position, which is setup for substrate loading (either "manually" or from a loadlock). Stopping the program will turn all servomotors off, enabling manual movement of an axis. Starting the program (clicking the white arrow button) will initiate a search for the home position for the substrate holder.

CAUTION
Never try to manually turn the rotation feedthrough without turning the motor off! This can damage the servomotor and invalidate the warranty!

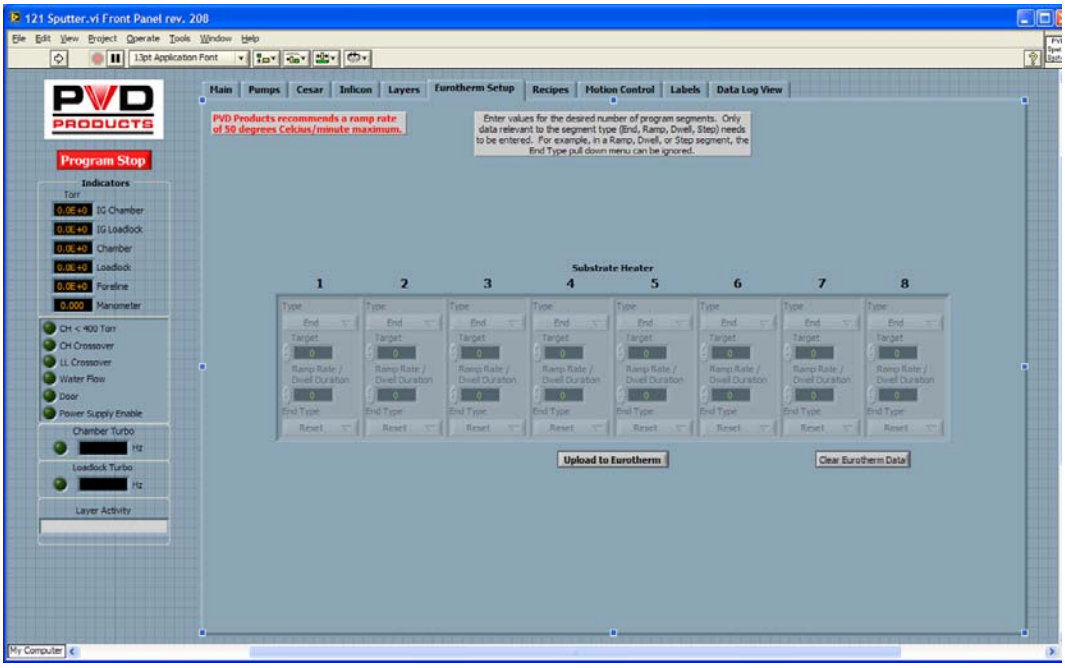
4.5. Mass Flow Control

This section controls the system Mass Flow Controller(s) (MFC). Turning the button on will cause the specific gas connected to flow at the selected sccm value. Placing a checkmark in the **Wink** box will cause the light on top of the MFC itself to blink at a set rate. This can be useful to check the validity of the RS485 serial connection or to physically distinguish between multiple MFCs in a larger system. The MFC hard shut-off valves will open automatically when the MFCs are turned on.

4.6. Eurotherm



This section controls the Eurotherm temperature controllers for the bake-out lamps (optional) and the heater power supply. Time, setpoint temperature, and actual temperature are displayed in the appropriate numeric indicator. The pull down menu displays three modes of operation: reset, run, and hold. The **Eurotherm Setup** tab will display a screen in which the temperature program profile can be entered.



Here values can be entered for the different segments of the program. There are eight segments that can be used and the data is entered into LabVIEW® as an array. Due to the nature of LabVIEW® programming, the first element of an array is always “0” so segment number 1 in the Eurotherm program will coincide with array element 0 in the Eurotherm setup screen. Each segment in the Eurotherm program has to be of a certain type. The five types are as follows:

1. End (Make this segment the end of the program)
2. Ramp (Rate) (Ramp to a new setpoint at a set rate)
3. Ramp (Time) (Ramp to a new setpoint in a set time)
4. Dwell (Dwell for a set time)
5. Step (Step to a new setpoint)

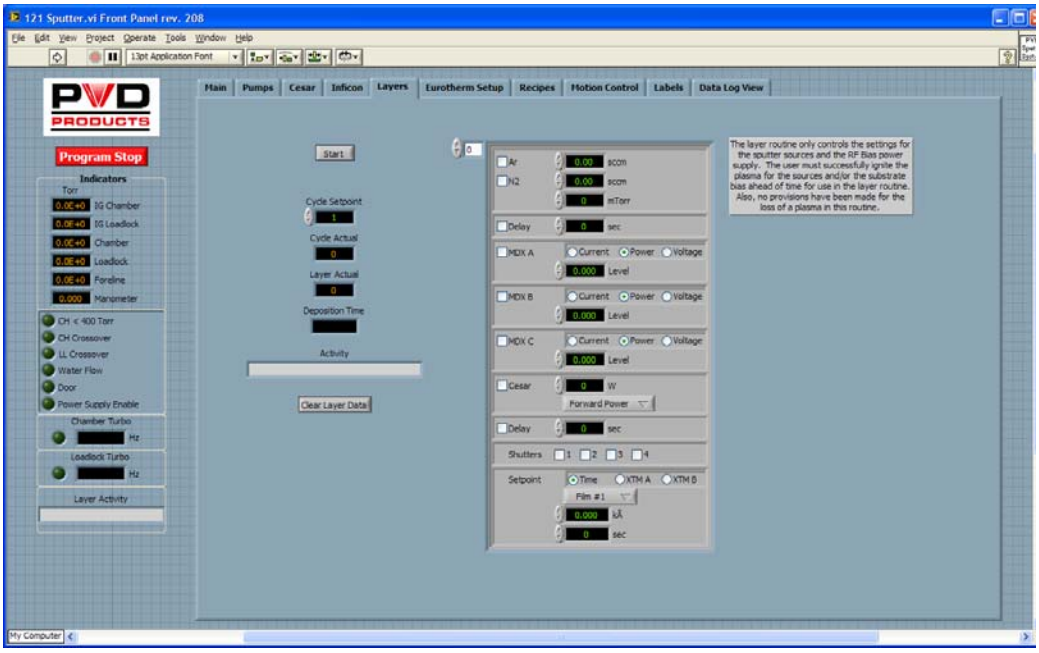
The data entered into each segment will depend on what type is selected:

1. End
   Select End Type
   - Dwell (An indefinite dwell)
   - Reset (Reset)
   - Set Output (End segment output power level, set with Eurotherm parameter EndP. See Eurotherm manual for details)
2. Ramp (Rate)
   Select Target Temperature
   Select Ramp Rate
3. Ramp (Time)
   Select Target Temperature
   Select Duration Time to Target Temperature
4. Dwell
   Select Duration Time for Dwell
5. Step
   Select Target Temperature

The user only needs to enter the relevant information for each segment type. All other information is ignored. For example, selecting End as the segment type, the user only needs to select an End Type and can leave the other fields blank. The 240X controller will only accept eight program segments, so entering more than eight array elements in the LabVIEW® program will not yield additional segments.

To prolong the heater lifetime and avoid excessive thermal shock, do not enter a ramp rate greater than 50 degrees per minute once the heater box has reached a temperature of 500 °C.

4.7. Layer Control



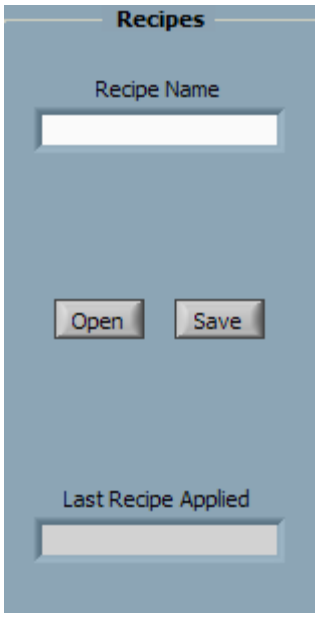
This section allows the user to specify flow rates, pressure, source power, substrate bias power (optional), and deposition times for a multi-layer process. The user can enter as many steps to the process as desired. The user also has the ability to cycle through the defined process as many times as desired. The number entered into the **Cycle** setpoint control will determine the number of cycles. It should be noted that the layer routine only controls the settings for the sputter sources and the substrate RF bias. The user must successfully ignite the sources and /or the substrate bias ahead of time. If a source is not required for a particular deposition step, the source shutter can be closed and the power set to a lower value. Also, due to the many different approaches possible for re-igniting a plasma, the are no provisions made for the loss of a plasma in the routine.

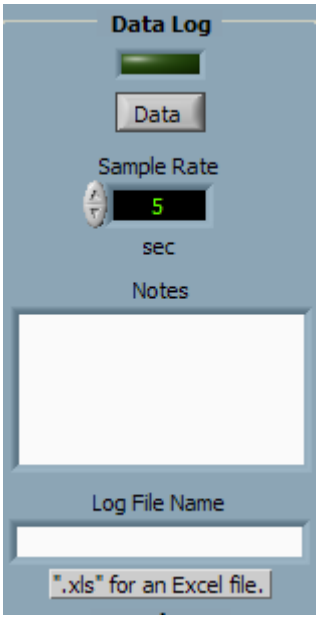
For each step in the routine, the user can select:

- Gas flow and pressure
- A delay to stabilize the pressure
- MDX DC level adjustment and control mode
- Cesar RF power adjustment and control mode
- Substrate RF Bias setpoint adjustment
- A delay to reach a steady state condition
- Particular source shutter to open
- Deposition time or desired thickness

Each source power supply must be setup beforehand for the layer routine. Only the power and control mode can be changed with each step.

4.8. Recipes / Data Log





4.8.1. Recipes

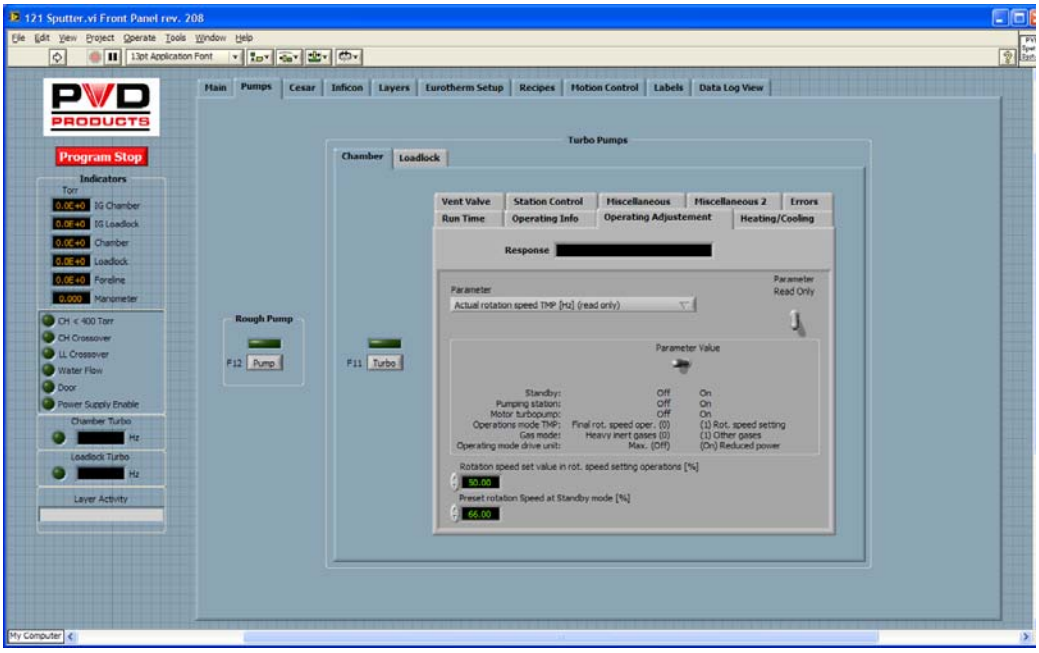
This section is for opening/saving deposition recipes. The user can open a saved recipe file or save data to a new recipe file by clicking the appropriate buttons. When saving, the user will be prompted for a file name and a location to save the new file. To open an existing file, the user must click the **Open** button and navigate to the location of the file. The **Recipe Name** indicator will show the name of the last file that was opened.

Opening a file will automatically enter the corresponding data into the main program and overwrite any existing data that is on the screen. As a precaution, the user is prompted with a dialogue box confirming that this is the correct action to take.

4.8.2. Data Log

This section controls a data log of all the relevant data during a deposition. Turning the switch on will bring up a dialogue box asking for a file name. The data will be in tab-delimited format and will be acquired at the **Sample Rate** selected. Naming the file with an ".xls" extension will create a Microsoft Excel spreadsheet file. The actual data being written to file can be viewed on the **Data Log View** tab.

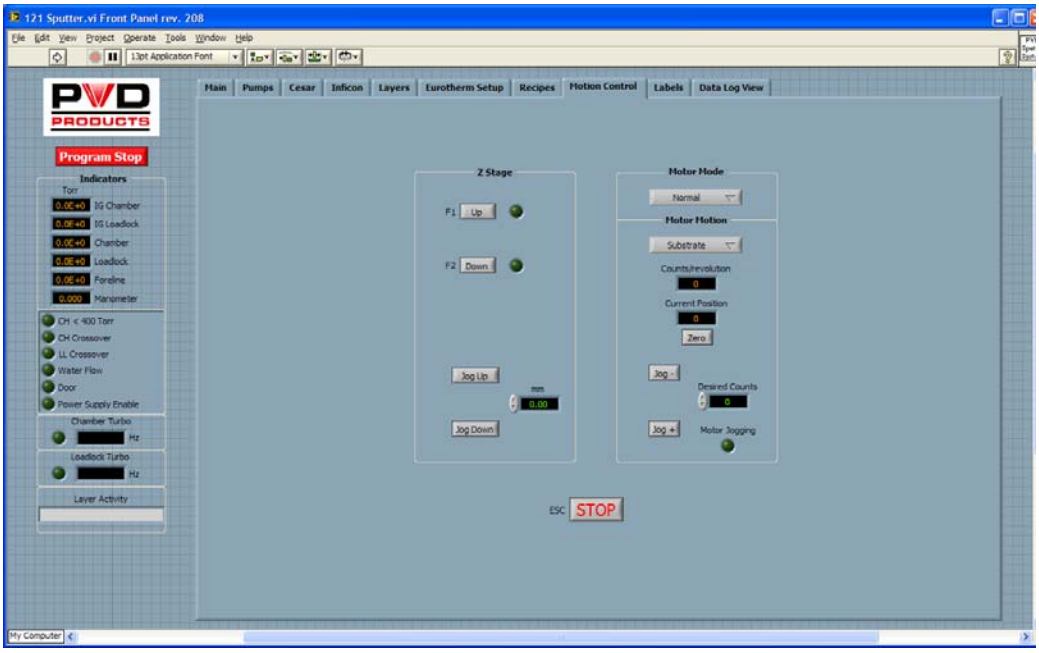
4.9. Pumps



This section controls the mechanical roughing pump and the turbo pump(s) connected to the system. The **Rough Pump** switch turns the mechanical pump on and off, with an LED indication that the electrical contactor is engaged. The **Turbo Pump** switch will spin the pump up and down, with an LED available over the switch and in the **Indicators** section (visible from all screens). There is also a green power light on the bottom of the pump itself (visible from the front of the system) that will glow steady when the pump is spinning. When powered, but not spinning (or spinning down), the light will blink green. Each "subsystem" of the turbo pump is covered in each of the tabbed screens. System parameters are "Read Only" initially. If the user wishes to change a value, or "Describe" it, the **Read/Describe** toggle switch in the upper right corner of the window should be changed to "Parameter Describe." This will then allow the user to enter a numerical value in a control box, or to switch the **Parameter Value** toggle from one value to the other for a given **Parameter** from the pull down menu. The new value will then be displayed in the **Response** indicator window. Once the value has been "Described" (written), the user should change the **Read/Describe** toggle switch back to the "Read Only" position to avoid changing parameters by mistake. The turbo pump was setup at PVD Products and parameters should not need to be changed by the user.

If there is an error in turbo pump operation, a red indicator will light on the pump itself next to the green power LED (which will blink green due to the error condition). These errors can be viewed on the **Errors** tab. The last 10 errors are stored in the pump itself. There is only a "new" error if the red light on the pump is blinking. To clear an error, go to the **Miscellaneous** tab and select "**Error Acknowledgement**." This is a write-only parameter, so once it is selected from the pull down menu, no other interaction is necessary from the user. Once the error is cleared, the pull down menu will return to its default position.

4.10. Motion Control



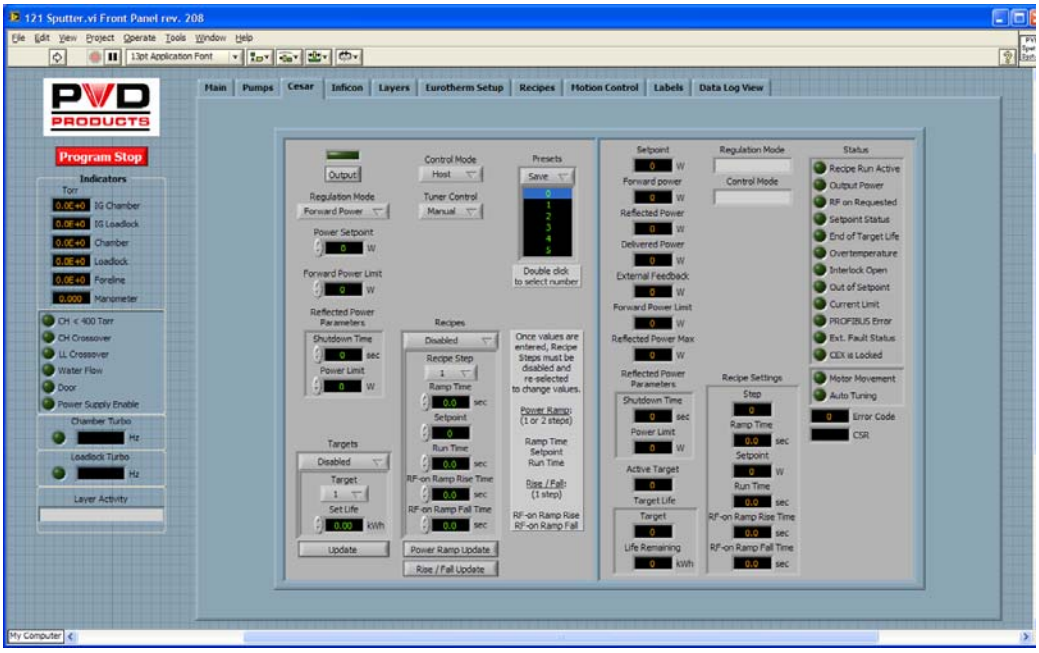
4.10.1. Z Stage

This section controls the height of the substrate holder in relation to the target material. There is approximately 2 inches (50 mm) of adjustment possible. The user can simply click the **Up** or **Down** buttons to move the holder to the highest or lowest positions allowed by the limit switches. At any time, the user can click the **Stop** button to halt movement. Also, the user can enter a relative distance for the stage to "jog" to from any given position. A maximum jog distance of 75 mm is possible, but the stage will always come to a rapid stop once either limit switch had been triggered. A safety interlock is present in the software to protect the holder from accidental closing of the substrate shutter. The holder must be in the full up position (indicated by the green LED) for the substrate shutter to close.

4.10.2. Motors

This section is used for computer "jogging" of the system servomotors. This can be useful for placing motion axes at a precise position. From this window, the user can jog the motors any number of counts in the positive or negative direction. The **Motor Mode** pull down menu can be used to turn off the servomotors for movement of the specified axis by hand. This can be useful for maintenance inside the chamber when it is easier to move pieces around by hand instead of through the software interface.

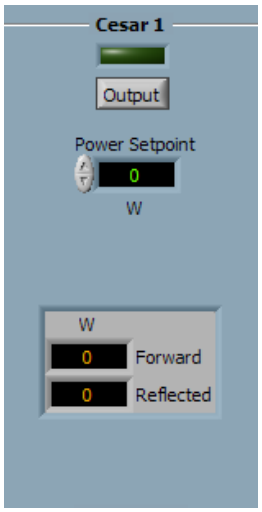
4.11. Cesar RF Source Control



This section controls the Cesar RF power supply. Depending on the number of power supplies, there will be a different tabbed page for each supply. All aspects of the power supply can be controlled from this section as well as a full display of the current status.

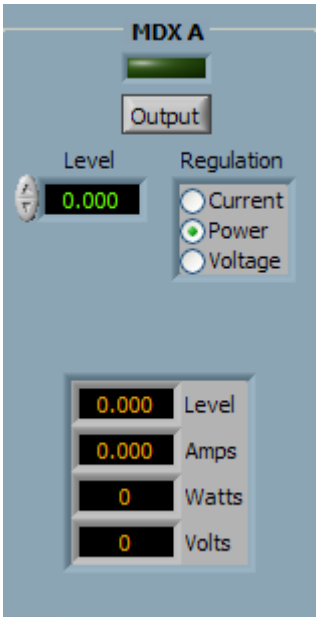
NOTE
As of this writing, there is a known error in the Cesar supply software read back of the Recipe Settings Ramp Time. The displayed value is incorrect, but the value sent from the computer is sent correctly. This issue is to be addressed in a future firmware revision from Advanced Energy.

The basic operation of setting a power setpoint and turning on the source power can also be accessed from the main page.



Please refer to the supplied Cesar power supply user manual for more details on the operation of the unit.

4.12. MDX DC Source Control

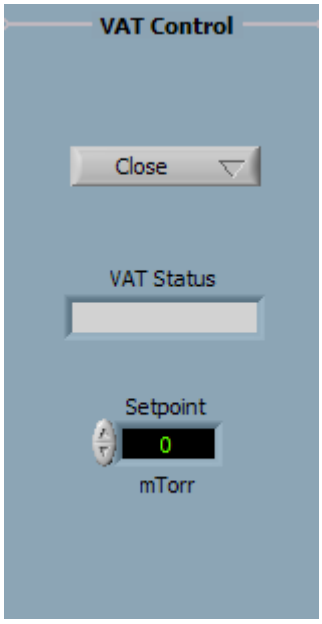


This section controls the 500 Watt Advanced Energy MDX DC power supply. The setpoint **Level** and control **Regulation** can be entered from this section. The current level, Amps, Watts, and Volts are indicated in the lower cluster.

The control mode for the MDX supply can be set for current, power, or voltage. The power range is 500 W, the voltage range is 1200 V, and the current range is 1 A. Please refer to the supplied MDX power supply user manual for more details on the operation of the unit.

4.13. Optional Controls

4.13.1. VAT Valve Control

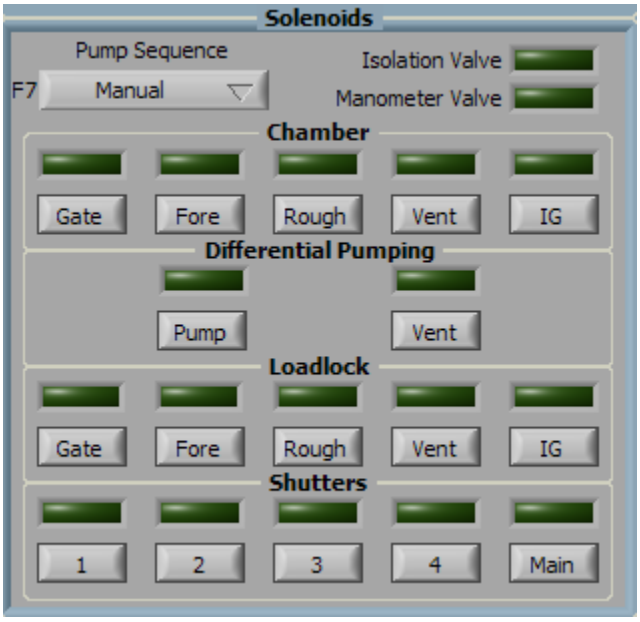


This section controls the pressure regulation feature of the turbo pump gate valve. The VAT valve has 2 functions:

1. Gate valve between the chamber and the turbo pump
2. Throttle valve to maintain system pressure

In this section, the pressure control features of the VAT valve can be adjusted. The chamber pressure must be below 1500 mTorr for these functions to be enabled. The user can enter a pressure setpoint and then select **Setpoint** from the pull down menu to maintain the system pressure at the selected pressure. The **Open** command is not allowed from this menu, as interlocks for the pumping sequence must govern this feature. Once the user is finished using the pressure control feature, the user must select **Close** from the pull down menu to close the VAT valve. If the user then wishes to open the VAT valve for system pumping, the **Gate** button must be used (Pump Control) and will be governed by the appropriate interlock (i.e. must be below crossover pressure).

4.13.2. Pump Control



This section controls the various pneumatic/electronic valves related to the vacuum control of the system. The valves can be operated manually, or in a pre-determined routine to pump down or vent the system. The **Pump Sequence** pull down menu contains three selections: **Manual**, **Auto Pump**, and **Auto Vent**. In **Auto Pump** or **Auto Vent** mode, there is no user interaction required. A description of these two functions is listed below (for cryo pumps the foreline is not applicable):

Auto Pump (Turbo Pump)

- Close **Gate** valve
- Open **Rough** valve
- Rough chamber to crossover pressure (set in Convectron® gauge to 250 mTorr)
- Close **Rough** valve
- Open **Foreline** valve
- Open **Gate** valve
- Turn on ion gauge (**IG On**) filament

Auto Vent (Turbo Pump)

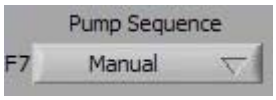
- Turn off ion gauge (**IG On**) filament
- Close **Gate** valve, leaving **Foreline** valve open
- Open **Vent** valve until chamber reaches atmosphere

After the **Auto Pump** and **Auto Vent** routines complete, the control mode is returned to **Manual**. In **Manual** mode, the user can decide which valves to open and close and can perform the same pump down and venting routines described above. However, all of the valves are governed by a set of interlocks that prevent the user from opening a valve that could do damage to the system. For example, opening the **Rough** valve and the **Foreline** valve at the same time would cause a high-pressure condition for the turbo pump and cause it to fail. Opening the **Vent** valve or the **Purge** valve while the **Gate** valve is open would cause a similar high-pressure situation and is not allowed. If an interlock condition exists, the user will notice that the button can be pressed, but the corresponding LED will not light.

Below is a description of each button in the Pump Control section:

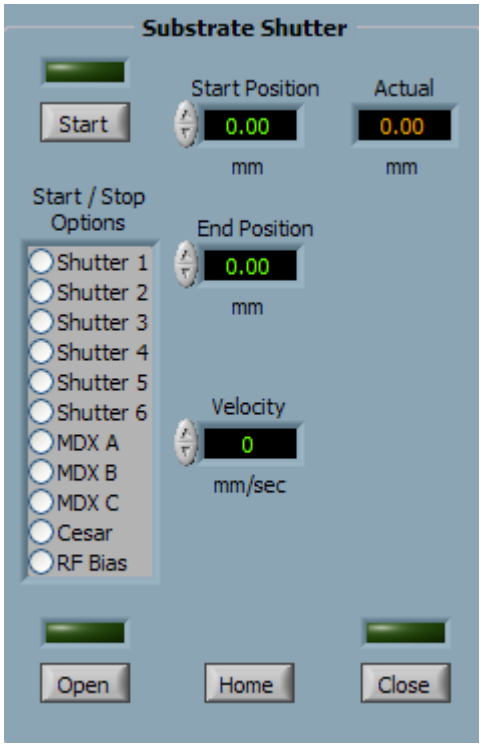
- **Gate**: open/close the gate valve
- **Fore**: open/close the foreline valve
- **Rough**: open/close the roughing valve
- **Vent**: open/close the chamber vent valve
- **IG:** turn ion gauge filament on/off, providing chamber is below crossover pressure
- **Differential Pump** open/close differential pumping valve
- **Differential Vent** open/close differential vent valve
- **Manometer Valve:** indicates if the manometer valve is open or closed (chamber pressure must be below 1 Torr for valve to open)
- **Isolation Valve** indicates that the isolation valve is open
- **Shutter Section:** open/close the corresponding shutter

4.13.3. Keyboard Shortcuts



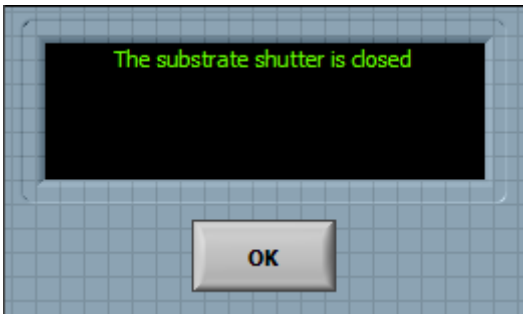
Certain controls may have keyboards shortcuts associated with their operation. These controls will have a function key label next to them. If a button has a keyboard shortcut, pressing the key will turn the button on or off. If a pull down menu has a shortcut, pressing the key will highlight the menu. Once the menu is highlighted, pressing the space bar will open the menu and the desired item can be selected using the up/down arrow keys and the enter key.

4.13.4. Substrate Shutter

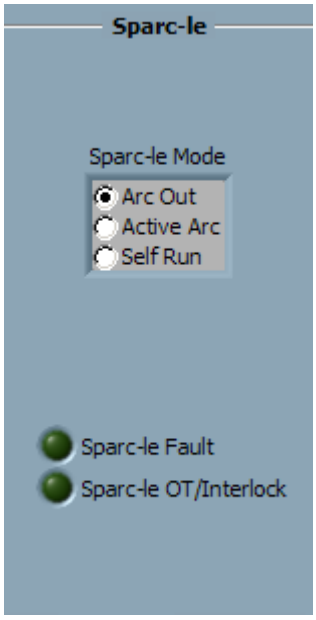


This section controls the optional substrate shutter(s) that may be installed in the system. From this screen the user can enter start and stop positions for the shutter as well as a velocity for the trajectory. The user can also select to optionally start other deposition parameters with the start of a trajectory. The shutter trajectory will begin when the **Start** button is clicked and when the shutter has completed its trajectory, the deposition is complete and any parameters (if selected) are ended.

The user can also use the **Open** and **Close** buttons to fully open or close the substrate shutter. There is also a **Home** button that will re-calibrate the shutter "home" or zero position (fully open). This calibration is also performed every time the system software is started. The calibration procedure will rotate the shutter until it touches the back wall of the chamber (hard stop) and then reset the position to zero (fully open). Once this calibration has been completed, the corresponding open and closed LEDs will light on the screen. This calibration is important for synchronization of movement with the Z stage. The substrate shutter must be fully open (calibration complete and at position zero) for the software to allow the Z stage to be moved up or down. A dialogue box will appear on the screen if this interlock condition is not met and the user tries to move the Z stage.

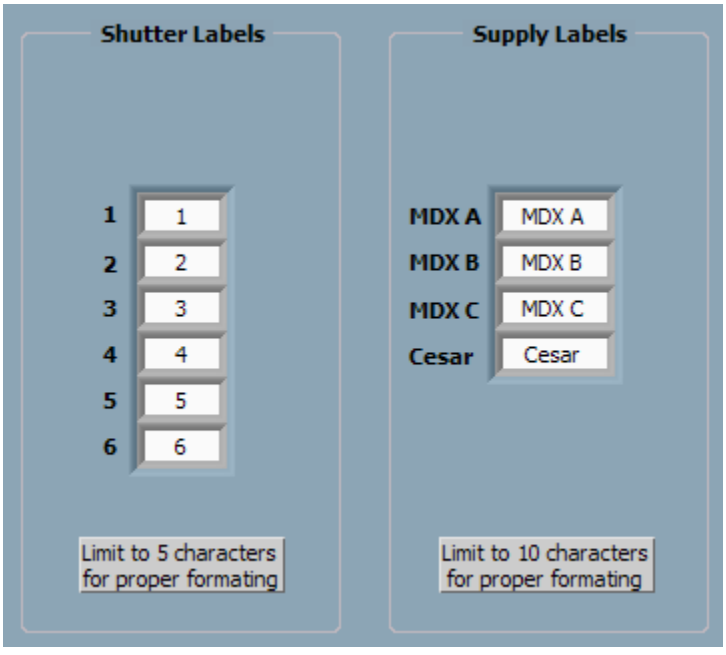


4.13.5. Sparc-le



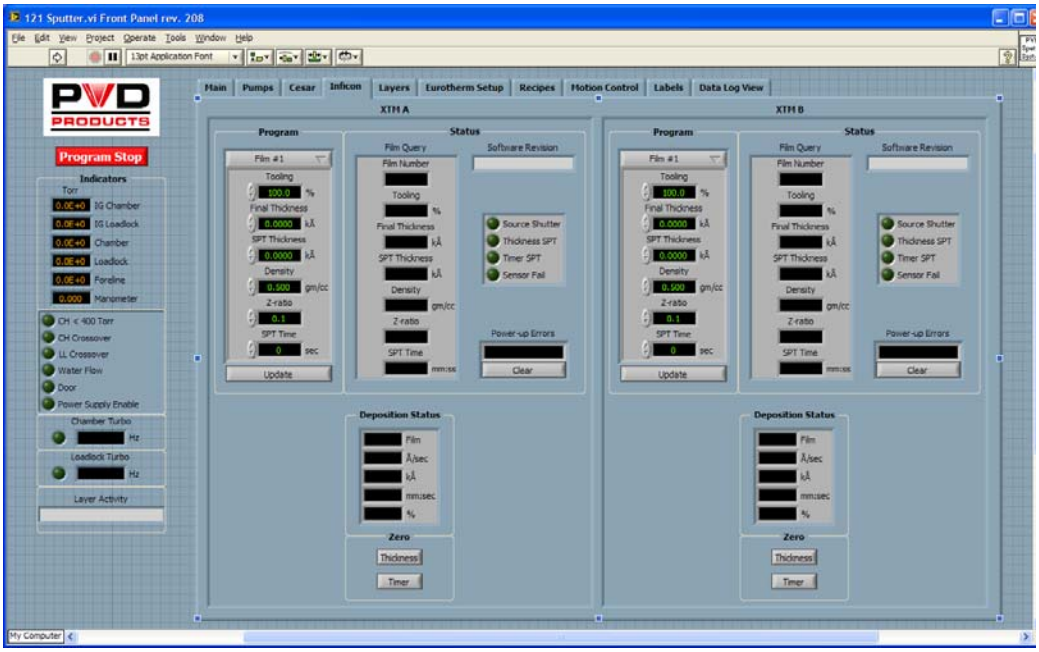
This section controls the settings for the Advanced Energy Sparc-le unit connected to one of the MDX DC power supplies. This allows the output of the DC power supply to be pulsed to simulate the output of an RF supply for use with oxide targets. The mode for the Sparc-le unit can se set for Arc Out, Active Arc, or Self Run depending on the user preference. Please refer to the supplied Sparc-le user manual for more details on the operation of the unit.

4.13.6. Labels



This section allows the user to enter labels for the shutter buttons and the power supply sections. For proper formatting, the user should limit the labels to the specified length.

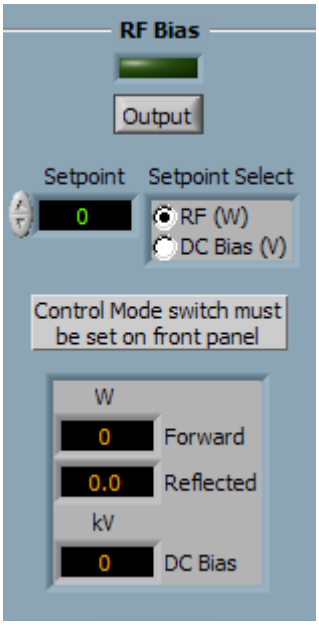
4.13.7. Inficon



This section controls the Inficon deposition controller/monitor. From this screen the user can enter specific data for up to nine films: tooling factor, final thickness, density, Z-ratio, etc. Selecting a film number, changing parameters, and clicking the **Update** button will send the data to the Inficon over the RS232 serial port. The current film parameters are also displayed as well as the status of the output connections and any error conditions that are present. The outputs of the Inficon are not physically connected to anything, but the output status for the Thickness SPT is used for depositions controlled by the final thickness value.

The **Zero Thickness** and **Zero Timer** buttons are used to reset the current film thickness and timer to zero.

4.13.8. Substrate RF Bias



This section controls the RF Bias for the substrate assembly. From this section the **Output** power can be switched on and off at the specified output setpoint. The output can only be turned on from the software interface in the current setup.

NOTE

The control mode for the power supply (RF or DC Bias) must be selected from the front panel. There is no capability to change the control mode through the software interface. Once this is set, the user must select the same control mode in this panel to insure that the properly scaled analog setpoint signal is sent to the power supply (0-5 VDC signal, 0-100/300 W RF or 1-1000 V DC Bias).

The current Forward and Reflected power as well as the DC Bias are displayed in the specified indicator windows.