VTC-1RF

1" COMPACT RF PLASMA MAGETRON

Sputtering Coater

OPERATION MANUAL

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IMPORTANT NOTES

Thank you for purchasing from Materials Technology International Corporation. This manual contains important operation and safety information prepared for those intending to operate and utilize the equipment. The prospective user is responsible for carefully reading and understanding the contents of this manual prior to operating the equipment.

MTI reserves the right to update or upgrade the product without informing customers of the data change(s) in this manual. Please visit www.mtixtl.com frequently for the latest information and manual.

GENERAL WARNINGS

MTI will not be responsible for equipment damage, accidents leading to minor or fatal injuries, and etc. caused by the user's negligence or lack of knowledge. Always read the manual fully beforehand and exercise the best judgment when handling the equipment.

⚠ TO PREVENT ELECTRICAL SHOCKS:

- Always consult a certified electrician to perform the electrical connections in order to ensure proper power requirements and safety conditions are met or satisfied.
- Use a properly grounded electrical outlet of correct voltage and current handling capacity and away from sources of electromagnetic interference.
- Connect the equipment to a dedicated / separate power outlet and make sure that the electrical loads on the power supply system are distributed evenly.
- Equipment must be disconnected from the power supply before servicing.

⚠ TUBE REPLACEMENT OR INSTALLATION:

- Use extreme cautions and be aware of the surroundings when replacing or installing a tube.
- Read the installation instructions listed in the dedicated section prior to installation.

⚠ TO AVOID PHYSICAL INJURIES:

- Do not put this equipment near flammable or explosive environments and substances.
- Do not leave the internal circuit exposed after disassembly.
- Power should be cut off when 1) performing external maintenance or cleaning, 2) if the product is not being used for a long period of time, and 3) when the unit is being moved.
- Do not place the instrument too close to the wall or obstruct the air vents. Keep the instrument at least 1 meter in distance from the wall to get enough clearance for safe operations.
- Always operate the equipment in the company of others and do not operate it alone so that accidents can be addressed quickly.

WARRANTY

MTI Corporation provides one year limited warranty for equipment (consumable accessories and parts not covered) from date the product is shipped out. Any defective part(s) will be replaced free of charge during the warranty period. However, the warranty does NOT cover any equipment damage caused by misuse or negligence. After expiration of warranty, MTI will continue to provide technical support and spare parts at a reasonable cost.

EQUIPMENT INFORMATION

INTRODUCTION

VTC-1RF is a compact 1" single head RF Plasma magnetron sputtering system designed for coating non- metallic (mainly oxide) thin films. All vital components (100W RF generator, quartz vacuum chamber, vacuum pump, recirculating water chiller, film thickness monitor, and etc.) are integrated into one floor stand cabinet. It is an excellent and cost effective coater for coating thin films of non-conductive materials in R & D.

SPECIFICATIONS

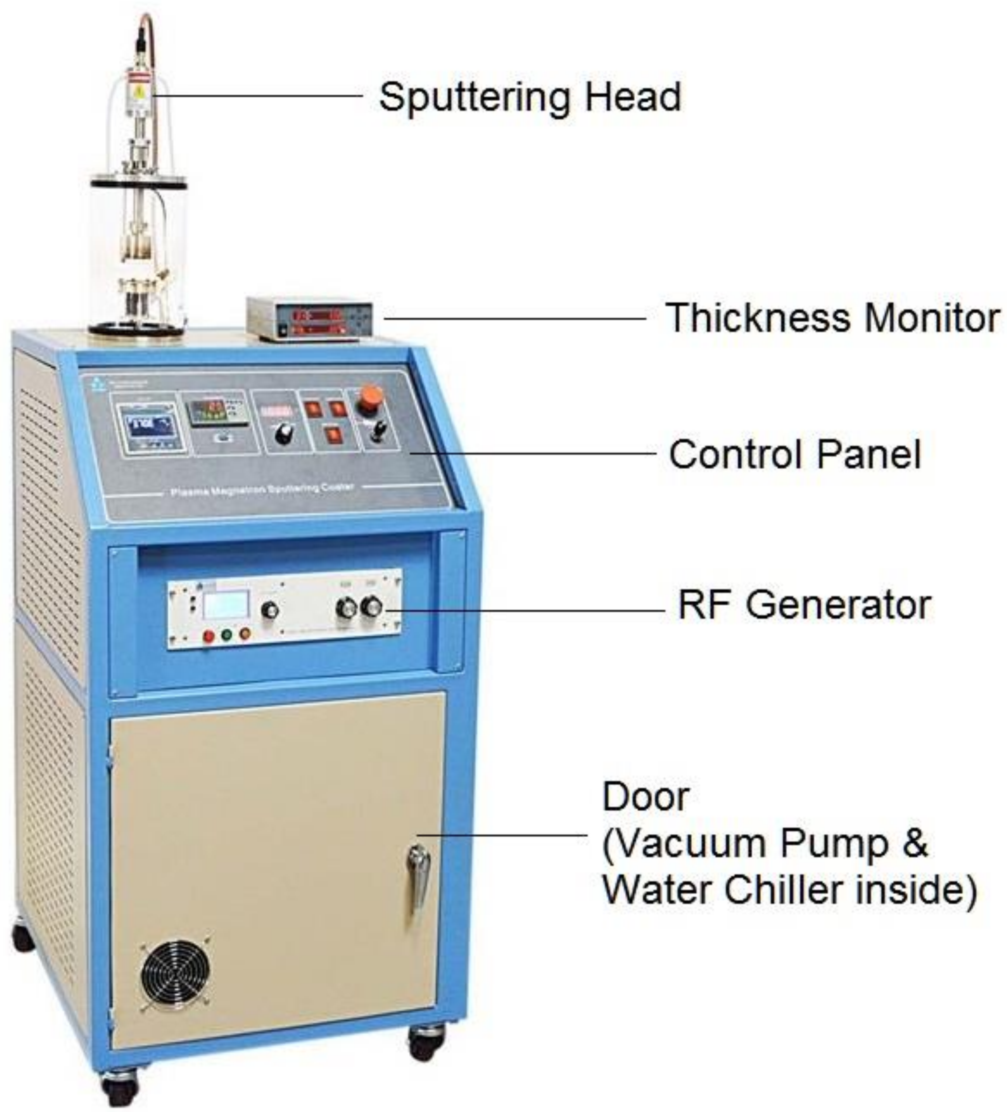
Input Power	▪ 220V AC 50/60Hz, single phase ▪ 800W (including pump)
Source Power	▪ 13.5 MHz, 100W RF Generator with manual matching is included and connected to 1" sputtering head.
Magnetron Sputtering Head	▪ One 1" Magnetron Sputtering Heads with water cooling jackets are included and inserted into quartz chamber via quick clamp. ▪ One shutter is built on the flange (manually operated). ▪ One 10 L/min digitally controlled recirculating water chiller is included for cooling sputtering heads.
Sputtering Target	▪ Target size requirement: 1" diameter x 1/8" thickness Max. ▪ One Al2O3 ceramic targets with copper packing plate are included for demo testing
Vacuum Chamber	▪ Vacuum Chamber: 160 mm OD x 150 mm ID x 250mm Height. made of high purity quartz. ▪ Sealing Flange: 165 mm Dia. made of Aluminum with high temperature silicone O-ring ▪ Stainless steel mesh cover is included for 100% shielding RF radiation from chamber ▪ Max. vacuum level: 10^-6 torr with chamber baking
Sample Holder	▪ Sample holder is rotatable and heatable made of ceramic heater with stainless steel cover. ▪ Sample holder size: 50 mm dia. for. 2" wafer max ▪ Rotation speed is adjustable: 1 - 10 rpm for uniform coating ▪ The holder temperature is adjustable from RT to 700°C Max with accuracy +/- 1.0 °C via digital temperature controller.

Thickness Monitor	▪ One Precision quartz thickness sensor is built into the chamber to monitor coating thickness with accuracy 0.10 Å
	▪ LED Display Unit outside chamber can:
	  ○ Input material to be coated according to data base included
	  ○ Display total thickness coated and coating speed
	▪ 5 pcs quartz sensors (consumable) are included
	▪ Water cooling is required

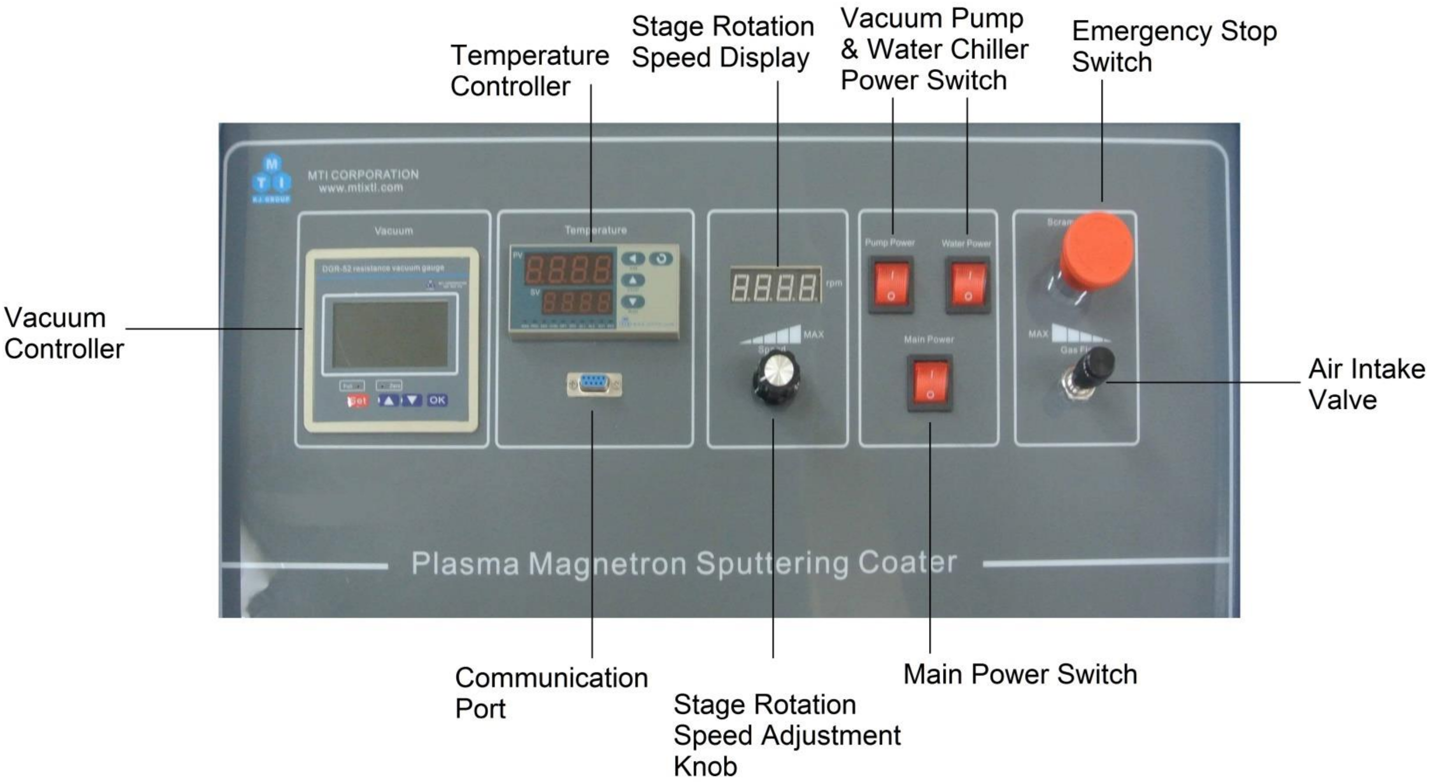
Vacuum Pump	▪ KF25 Vacuum port is built in for connecting to a Vacuum Pump. Please click picture left to view mechanical pump ▪ Vacuum level: 10-3 Torr with included dual stage mechanical pump. ▪ 10^-5 torr with optional turbo pump
Warranty & Compliance	▪ One years limited warranty with lifetime support ▪ CE certified
Application Notes	▪ This compact 2" RF coater is designed for coating oxide thin film on oxide single crystal substrate, which usually don't need high vacuum set-up. ▪ In order to remove oxygen from the chamber, suggest you use 5% Hydrogen + 95 %

	Nitrogen to clan chamber 2-3 times, which can reduce oxygen to below 10 ppm ▪ Please use > 5N purity Argon gas for plasma sputtering. Even though 5N purity Ar, usually contain 10- 100 ppm oxygen and H2O dependent on supplier. Strongly suggest you use gas purification device listed below to purify gas before filling in: (click pic to order) ▪ MTI supply single crystal substrate from A to Z (click picture left to order). For best performance, non-conductive target must install a copper backing plate. . Please click Picture below - left to see how to install backing plate on a target ▪ MTI RF Plasma Sputtering Coaters have successfully coated ZnO on the Al2O3 substrate at 500C, please click the picture below to view its XRD profile. ▪ HIGH VOLTAGE! Sputtering head connects to high voltage. For the purposes of safety, the operator must be required to wear gloves during operation.

STRUCTURE



Front View



Control Panel

ASSEMBLY & OPERATION INSTRUCTIONS

EQUIPMENT INSPECTION

Upon receiving the equipment, please inspect the components and all accessories for damage that could be incurred from shipping and check the packing list for any missing items. If anything is damaged or missing, please inform MTI immediately at info@mtixtl.com.

⚠ **Attention:**

> Retain the original packaging material if a return related to shipping damage is foreseeable or required. MTI will not supply additional packaging materials in the event of post-sale equipment service.

OPERATING ENVIRONMENT

The operating environment information listed below may be helpful for safely operating the instrument:

- The instrument should be secured on a dry, hard and flat surface that is free of vibration
- Use should be limited to indoor only with adequate ventilation and away from direct sunlight
- Environment should be dust-free and without explosive and corrosive gases
- Relative humidity (non-condensing): 10%～85%

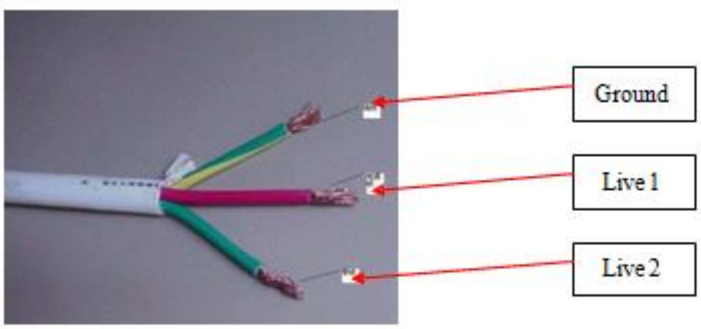
- Ambient temperature: -10~75 ^{o}C

WARNINGS:

- To reduce the possibility of heat-related injuries or equipment malfunction, do not place the instrument too close to the side wall or obstruct the air vents. Keep the instrument at least 1 meter in distance from the side wall.
- Do not allow metallic objects to fall inside the device. Otherwise, short circuit could occur and cause the equipment to catch fire.
- Do not allow water to enter the device to prevent fire or electric shock hazards.
- Gas tanks should be secured to a tank carrying cart or wall with harness to prevent falling.

POWER CONNECTION

Please make sure that the power source in your lab is sufficient to meet the power requirement listed for the equipment. The following picture shows the three wires of the power cable: Ground, Live 1, and Live 2. We strongly suggest consulting a professional or licensed electrician to perform the power connections. For more information, please refer to the "**AC Power**" section below.



AC POWER

For power connection, a licensed electrician should be consulted to meet and comply with the local electrical codes and requirements. Proper electrical power handling and knowledge are crucial for both safety and thorough application of the equipment.

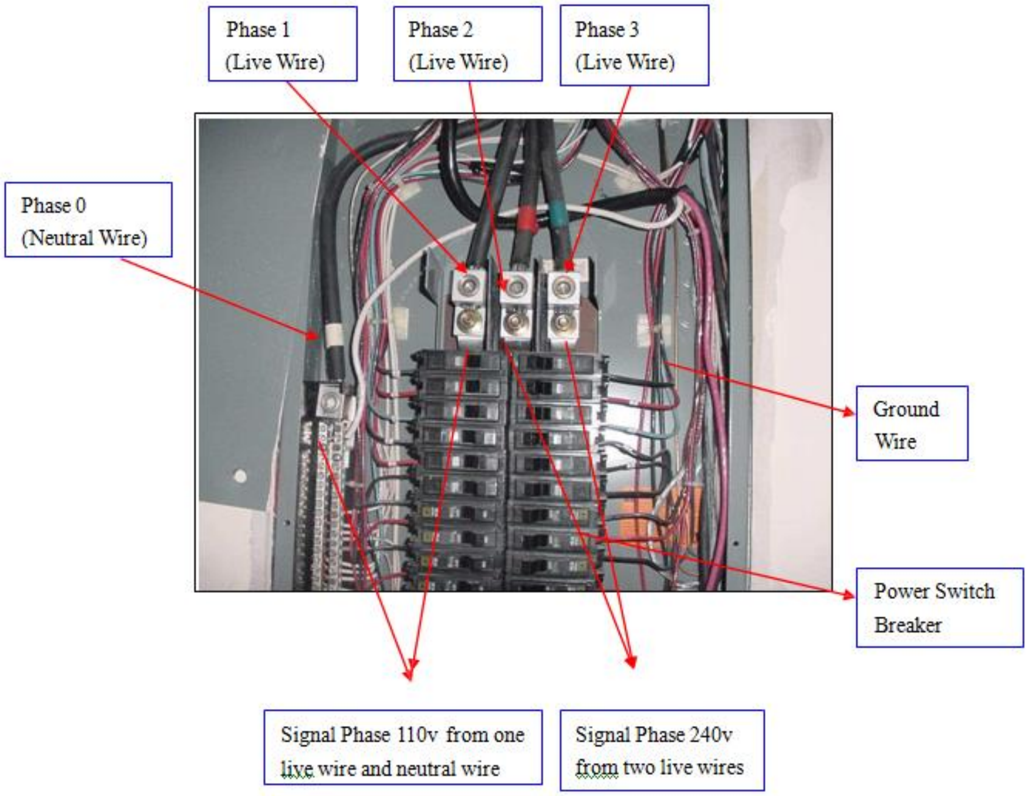
Attention:

For countries that use 220V, the furnace's power supply is already configured to work with this input voltage. However, in countries that use 110V, a 208~240V single phase AC power line needs to be setup.

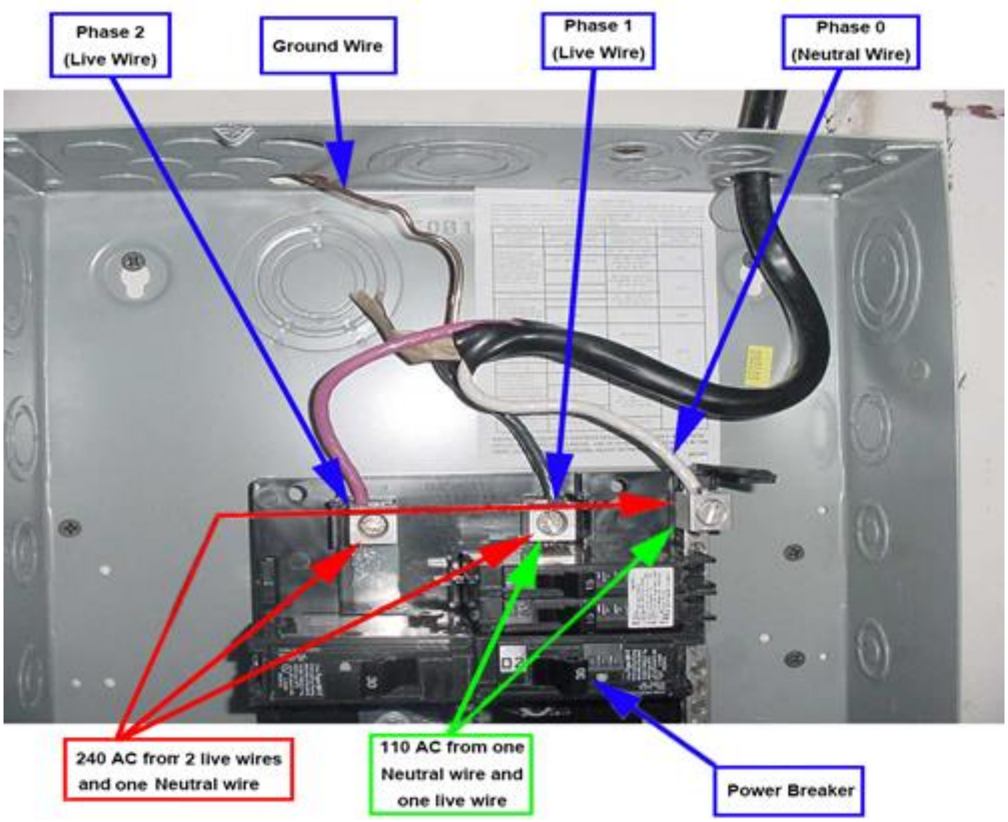
The following knowledge may be useful for configuring a single phase 208~240V power line from various electrical panels. A three phase 240V AC electrical panel generally found in most laboratories can be configured to output a single phase 208~240V power line. To do this, two of the three live wires from the panel need to be configured with the neutral wire. Please refer to the illustrations below to get an idea of the connections for the three phase and as well as the single phase 208~240V AC.

Attention:

MTI Corporation will not be responsible for any equipment or property damage that results from improper or incorrect power connections.



Typical Three Phases AC Power in US

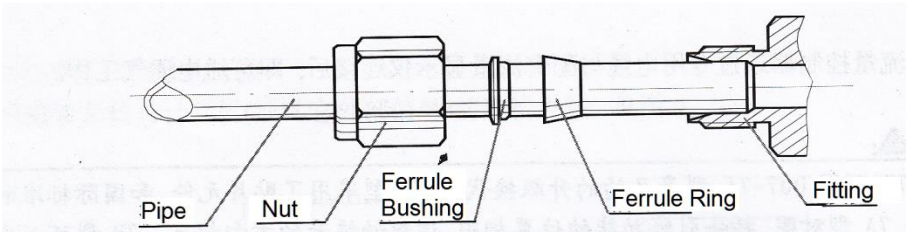


Typical Single Phase AC Power In US

INSTALLATION & SET UP

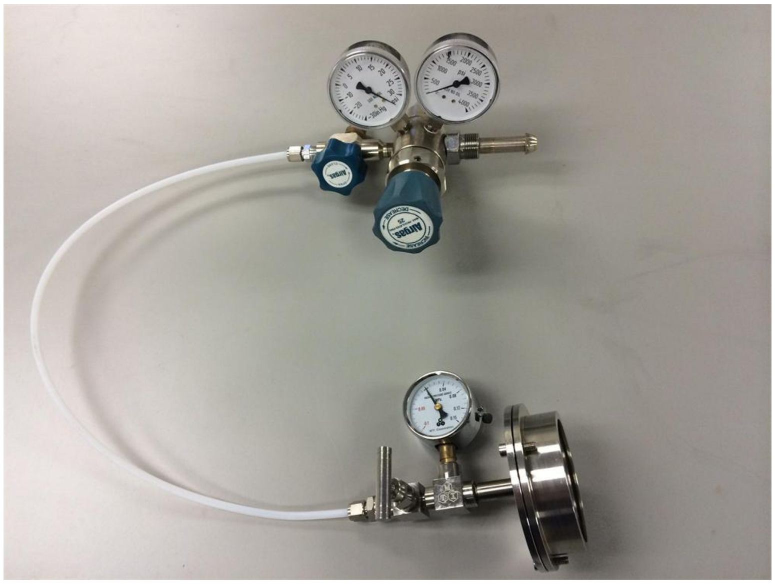
Gas Tube Connection

Connect the instrument to the gas source by connecting the end of a pipe to the gas inlet port on the back and the other end to the gas cylinder.



NOTE:

A two stage pressure regulator should be installed on gas cylinder to limit the output pressure of gas to below 0.02MPa for safe usage.



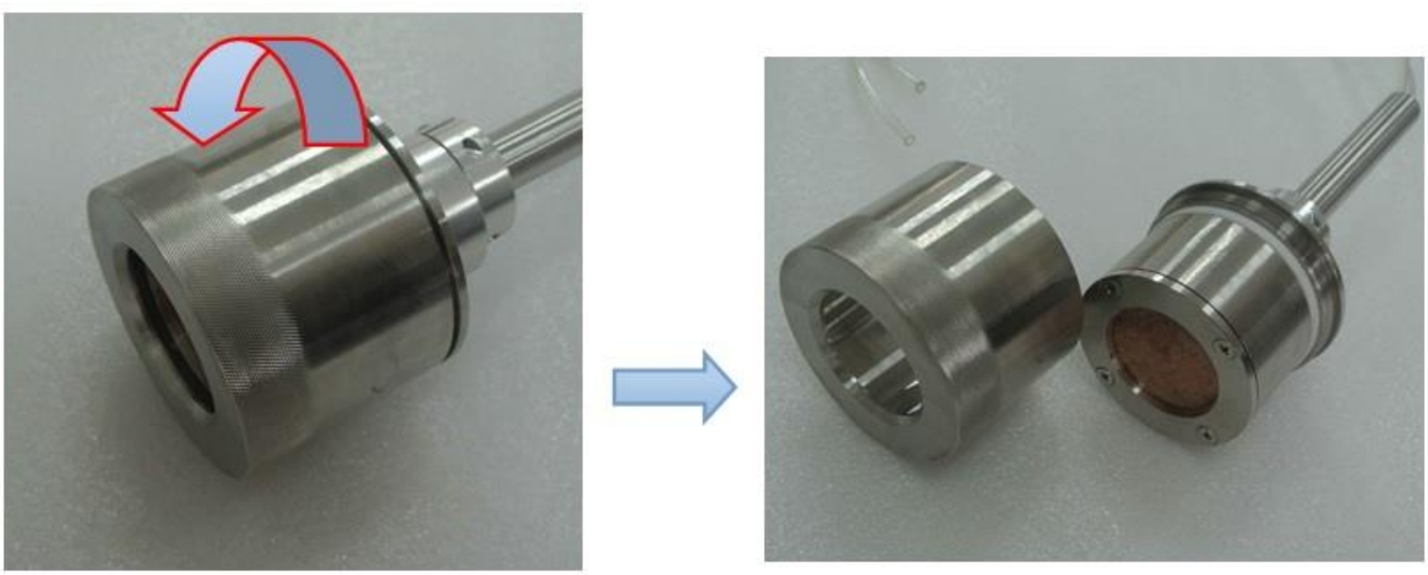
Water Tube Connection

Connect the water pipes to sputtering head on the machine as shown below.

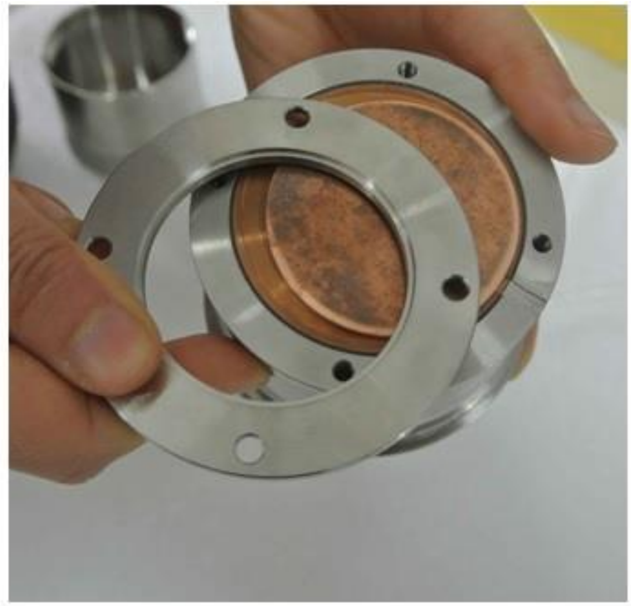
Sputtering Target Installation

Use the illustrations below to change or remove targets on the sputtering head.

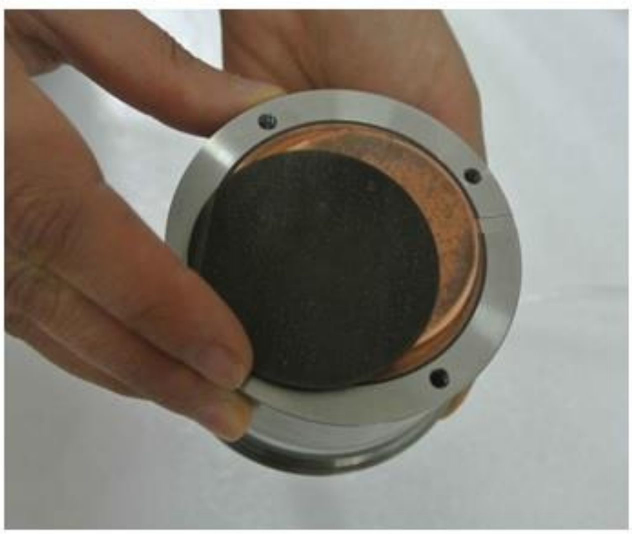
Unscrew the sputtering collar and remove it from the sputtering head:



Unscrew the cathode retaining ring:



Place the target on the sputtering gun and tighten the screws on the cathode retaining ring:



Remember to place the sputtering collar back onto the sputtering head after the last step above.

Sputtering Distance Adjustment

Adjust the distance between the sample stage and the sputtering head by sliding the head up or down:

Cable Connections

The cables need to be connected to the sputtering head and thickness monitoring system in order to power them:

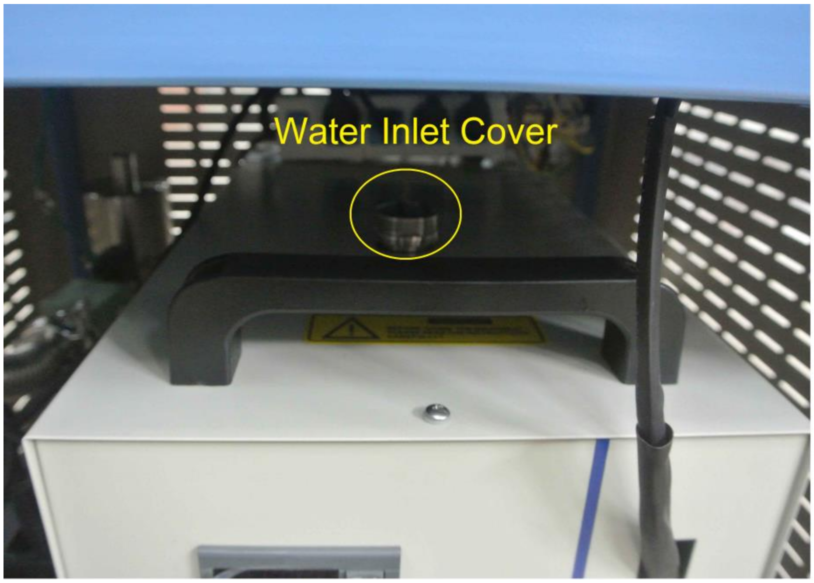
High Voltage Cable

Thickness Monitor Cables

GENERAL OPERATION

1. If using the pump for the first time after a long period of idleness, check to see if the oil level in vacuum pump is sufficient by inspecting the oil level indicator on the pump (open the door first). Replace or refill the oil as needed (see Equipment Maintenance and Troubleshooting Section - Vacuum Pump Oil Change).

2. Next, inspect the water level of the recirculating water chiller by checking the fluid observation window. Remove the water inlet cover and fill in more water as needed.



3. Open up flange of the quartz tube chamber and place the substrate onto the sample stage. Then cover the flange, tighten the release valve on it. Rotate the target block disc until the target is covered up.

   Note: If the coater has been inactive for a long time, rotate the target block disc out of the way and perform a quick sputtering to remove the contaminants on the surface of the target material.

4. Turn on the main power supply so that the displays of the temperature controller, vacuum indicator, and rotation speed indicator light up. Then turn on the power for the water chiller and vacuum pump to begin the water circulation and evacuate the chamber.

5. Observe the vacuum level on the vacuum indicator until a pressure of 1Pa is reached to verify the chamber does not have any sealing issues. Check the sealing of the quartz tube flange cover if the vacuum is experiencing difficulty.

   Note: Once the vacuum reaches 1Pa, open gas cylinder valve, pressure reduction valve, and air intake valve on the control panel until the pressure in the chamber can be maintained at about 100Pa. Let the vacuum and inert gas filling run simultaneously to purge the chamber for 5 minutes to improve coating efficiency. Adjust the air intake valve on the control panel until the desired vacuum pressure is attained at the end of chamber purge (chamber purge is recommended but not required).

6. Depending on the nature of the sample materials, the user may set a maximum heating temperature of 700 °C to heat the substrate. Limit heating rate to 5 degrees / minutes when setting the heating profile on the temperature controller (refer to the Temperature Controller Section).

   Note: A temperature lag of 5°C during the heat ramping stage is a natural phenomenon.

7. After the desired temperature is reached, adjust the cylinder output valve and air intake valve on the front panel so that the chamber pressure is maintained at about 10 Pa. This pressure range provides the best results for sputtering.

   Note: Vacuum lag may be present after adjusting the air intake valve, please wait a few seconds for the pressure change to be displayed on the vacuum controller.

8. Press the power switch of RF Power Generator to turn it on. Then press the green button to light up the “RF out” light **(see 1 in image below)** and adjust the RF power to about 30W using the RF knob **(see 2 in image below)**. The RF power must be manually matched so that the value of Pr is “0” at all times, If not use the tuning and load adjustment knobs on the right to match the RF power **(see 3 in image below).**

   Note: Increasing the RF power output above 30W will increase the intensity of the plasma and allow for faster deposition rates. However, please do not remain at a high power output setting for long durations as this may shorten the life of components drastically.

9. The sample rotation speed may be adjusted in the range of 0-20 rotations / min to provide a uniform coating on the substrate. It is recommended to perform a pre-sputtering session for 2min with the target block covering the target before performing the actual coating on the substrate.

10. Let the entire system stabilize for a few minutes (RF Generator’s power and chamber pressure running without fluctuations), and turn on the thickness monitor to set the coating material’s density and acoustic impedance ratio (refer to the Thickness Monitor Section for detailed instructions).

    Note: If the default thickness reading does not start at “0”, press 

to zero the thickness reading value first.

11. Tighten to fully close the air intake valve, close off the cylinder valve, and turn off the pump power to terminate the evacuation.

12. Lastly, turn off the main power of system, open the release valve on the flange cover of the quartz chamber to retrieve the sample.

COATING SPEED

Coating speed is dependent on target material and sputtering current and coating time. The following formula can be used to estimate gold and platinum film thickness:

D = K I T

- D= film thickness (A)
- K = material constant , for gold material in Ar gas, K ~ 0.17, and for Pt, K ~ 0.9
- I = Sputtering current (mA) , which is adjusted by Ar gas partial pressure
- t = time (S)

For example, for gold film under Ar partial pressure with current 8 mA for sputtering 100 s, film thickness is about 0.17x8x100 = 136A. You may repeat coating to obtain thick film. For different materials, you shall practice by yourselves to achieve best parameters and experience.

VACUUM CONTROLLER INSTRUCTIONS

1. Full Tune Button
2. Zero Adjust Button
3. Display for the current value of the vacuum pressure
4. Set button
5. Add / Up key
6. Reduction / Down key
7. OK key

1. Instrument Display Description

The instrument displays the degree of vacuum in the format of scientific notation.

Example: "1.00E 5Pa" on display represents the degree of vacuum of 1.0 × 10^5pa

"1.00E-1Pa" on display represents a degree of vacuum of 1.0 × 10^-1pa

2. Unit switch

The vacuum controller has three units (Pa, mbar, Torr) for users to choose from. Once the setup is complete, the selected unit will be permanently preserved until changed.

(1) Press "Set" to enter the main menu screen and "1 unit" and "2 outs" will appear on the menu. By using " ▲ " and " ▼ " to select "1 unit", and press the "OK" button to enter the menu.

(2) Press " ▲ " and " ▼ " keys to select the desired pressure unit and press the "OK" button to complete the selection and return to the main menu. Press the "Set" key to return to work interface.

3. Full Tune and Zero Adjustment

(1) The full tune feature requires a standard atmospheric pressure of 1.Ox10^5Pa to be executed. Press the button beneath the small hole next to " Full " with a pin or similar size object to display "SCALE up". Then, use the " ▲ " and " ▼ " buttons to select Channel 1 or Channel 2.

(2) Press and hold "Full" button for four seconds until the selected channel is displayed as "1.0E 5" to complete the full tune of the channel. Use the same method to complete the full tune for the other channel.

(3) To perform zero adjustment, achieve a vacuum pressure of 10^-1Pa first and then press against the small hole next to "Zero" with a pin or similar size object. Once the button is released, "SCALE lo" will be displayed. Then, use the " ▲ " and " ▼ " buttons to select Channel 1 or Channel 2.

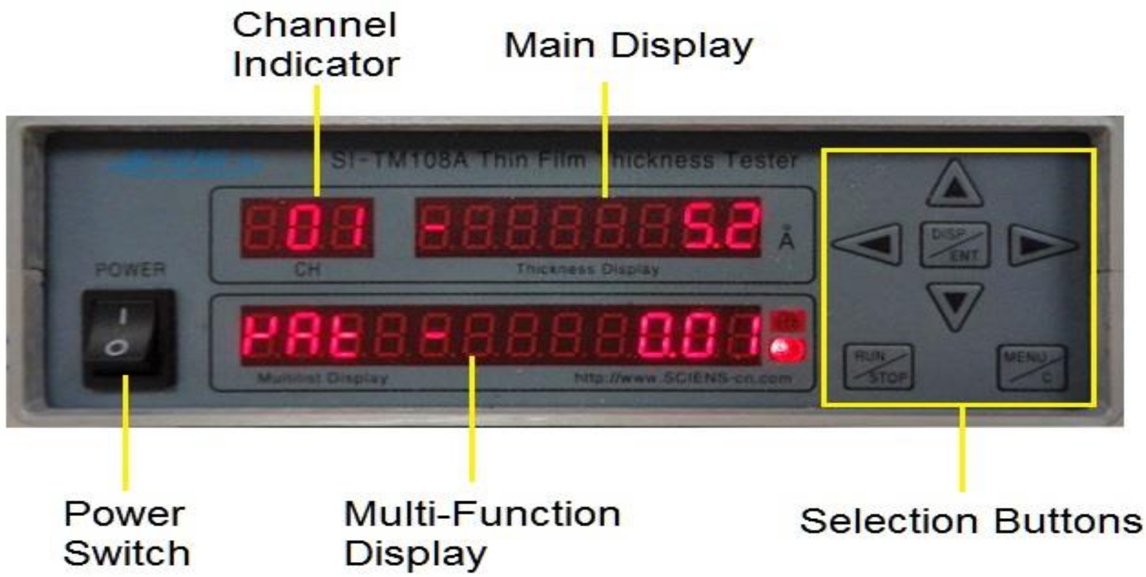
(4) Press and hold "Zero" button for 4 seconds until the selected channel displays "1.0E^ -1" to signal the completion of the zero adjustment. Use the same method to complete the zero adjustment for the other channel.

Note: For maintaining an accurate pressure reading, it is recommended that the user performs Full Tune and Zero Adjustment after the changing the air flow components inside the instrument.

An error code of “ErrO2” indicates that the current air environment inside of the testing chamber is not suitable for the adjustments above. An external pressure reading device can be used to ensure the pressure requirements mentioned above have been met while making adjustments to prevent measurement errors.

If the vacuum controller does not display 1.0x10^5 Pa or 760 Torr in normal atmospheric conditions (when turned on initially with vacuum pump and gas flow stopped completely from prior use), please perform Full Tune first followed by Zero Adjustment after vacuuming the chamber down to a pressure of 10^-1Pa or less.

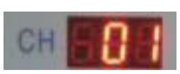
THICKNESS MONITOR



1.1 Main display

The main display shows real-time film thickness of a material being deposited. When the sensor of the thickness monitoring instrument has failed,  will be flashed on the display. On the other hand, a communication error of the instrument will render  to be displayed and flashed. The display LED will also display the corresponding selection name from the setup menu upon making a selection.

1.2 Channel Monitor:



If another thickness sensor is connected, the channel monitor will display the current channel being used. As the instrument uses only one sensor, "01" will be displayed.

1.3, Multi-Function Display:

This display is used to indicate the Frequency, Speed and Power Output % of the current channel. It will also display the selections in the Settings menu.

1) Frequency:  ,  beside the display will be lit in this mode

2) Rate: ,  beside the display will be lit in this mode

3)Power Output: 

1.4, Start, Stop button:

This button is used to start or stop the connected sensor of the current channel.

1.5, Display, Confirm key:

This button is used to display the different modes (Frequency, Speed and Power Output %) on the Multi-Function Display. It also saves any changes made in the setup menu.

1.6, Menu, Cancel button:

After pressing the Stop key, hold and press this button for more than 5 Seconds to enter the settings menu. While editing parameter values, pressing this key will exit the settings mode without saving the changed parameters.

1.7, Left and Right Arrow keys:

After entering the menu mode, press  to move down to the next selection. Press  to return to the previous menu. Press  in the main menu will exit from the menu state.

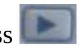
In the parameter edit mode, press  to shift between units.

1.8, Up and Down Arrow keys:

In the menu mode, these keys allow for making selections at the same level. They also modify the parameter values in parameter edit mode.

2, Menu Structure

2.1, Enter the menu. Hold and press  to enter the menu mode 

2.2, Used  to switch between the two menu modes, press  to enter the next menu level.

Main menu displays basic settings "100, BASIC" 

Thickness instrument settings "200, SEN-SET" 

2.3 Basic Settings Submenu

2.3.1, Communication Parameters Intervals 
This parameter indicates the time interval between communications of the film thickness sensor; selection can be made from 100 ~ 1000mS

2.3.2, Communication Baud Rate 
This parameter sets the external communication baud rate, the baud rate must be consistent with thickness meter settings, otherwise it may not work properly.

2.3.3, Number of Connections on Thickness Monitor 
This parameter sets the maximum number of film thickness device connections. Please note the address of a device connected to the film thickness monitor cannot be repeated for another one.

2.3.4 Time Interval for Measurement Cycles of each connected sensor:


2.4, Thickness Meter Settings Submenu

2.4.1, Sampling Time for Each Measurement 
The sampling time for the thickness measurement can be set from 100 ~ 1000mS.

2.4.2 Output Mode  

This parameter sets the three output modes: Manual, Automatic, and Stop.

2.4.3, Rate Calculation Mode:  

This parameter sets the rate calculation mode in three ways: Immediate, Weighted, and Average.

2.4.4, Material Density: 
This parameter sets the density of the material to be plated, this data can be found in the Materials Parameters table.

2.4.5, Material Acoustic Impedance Ratio: 
This parameter sets the acoustic impedance ratio (Z Factor) of the coating material, this data can be found in the Materials Parameters table.

2.4.6, Scale Factor: 
This parameter sets the ratio of the film thickness to be plated on wafer substrate and the quartz sensor. This value is obtained by testing and trials.

2.4.7 Output Range: 
This parameter sets the maximum value of the corresponding growth rate for the output in the 10 to 9999 range.

2.4.8, Instrument Communication Address: 
This parameter sets the device address (1 to 255) for the of the connected thickness measurement instrument's current channel. The same address cannot be used on another thickness measurement instrument, otherwise it will not operate properly.

2,4,9, Communication Baud Rate: 
This parameter sets the communication baud rate of the current channel on the connected thickness instrument. This baud rate must be consistent with the Baud rate set in basic settings, otherwise it will not work properly.

2.5, Menu Operation.

Press 

to enter the edit mode in the sub-menu to modify the required parameters. The multi-function will display and flash "SELE" Or "EDIT" to signal that the edit can be made. You need to select the item to be change until "SELE" or "EDIT" is flashed. Use the left and right arrow keys to shift between the digits being modified (the selected digit will blink). Then using the up and down arrow keys to select the desired value and press 

to save the change and exit the edit mode. Press 

to cancel the edit and exit the edit mode.

Note:
1, The communication address and set baud rate must be consistent with the settings of the connected monitor, to establish communication connection.

2, While the thickness monitor is in the operation state, the menu cannot be operated.

3, High temperature will affect the high oscillation frequency of the quartz used on sensor, please use away from heat, and enable water cooling at all times.

4, The monitor operates on a measuring principle that is based on quartz wafer reference measurements, this may present a deviation on the measured value of the film density. Please make adjustments to the scale factor according to the specific circumstances.

5, For parameters of materials not listed on the Material Parameters Appendix, please refer to materials that are similar.

6, For failed wafers, effective methods such as chemical cleaning and polishing can be used to remove the plated layer for reuse.

TEMPERATURE CONTROLLER INSTRUCTIONS

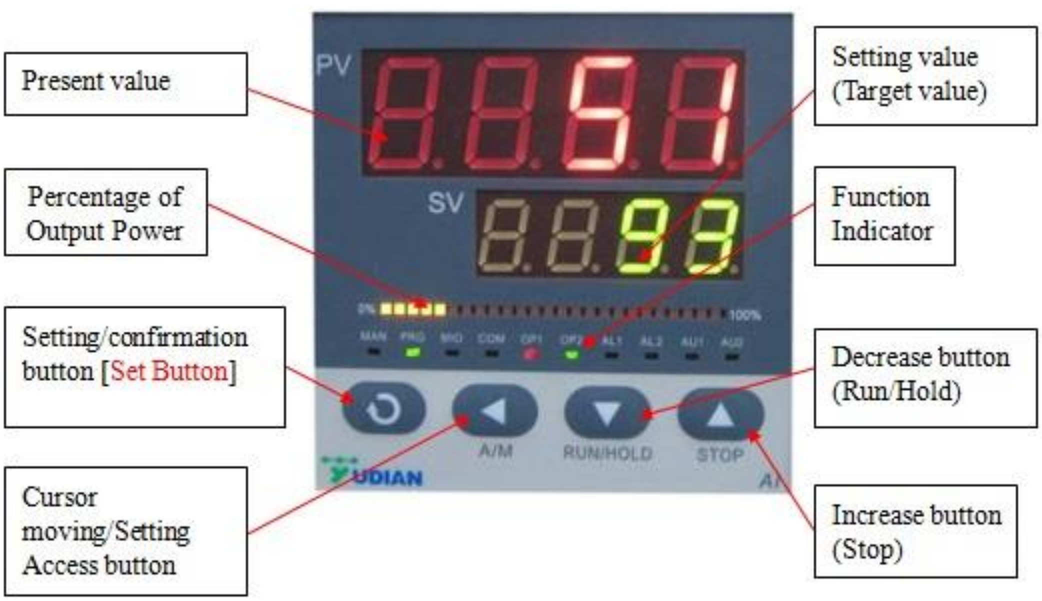
TEMPERATURE CONTROLLER

1. Specifications
   - a. Compatible Thermocouple: K、S、R、E、J、T、N;
   - b. Measurement Accuracy: 0.3;
   - c. Power Input: Single phase 220V AC (±10%) / 50~60Hz;
   - d. Power: ≤5W;
   - e. 30 Programmable Segments.
   - f. MET Certified

2. Structure

Below are the three variants of controllers commonly found on the furnaces. Though with different looks, they all share similar features and functions.

3. Functions and Indicators



SETTING THE TEMPERATURE CONTROLLER

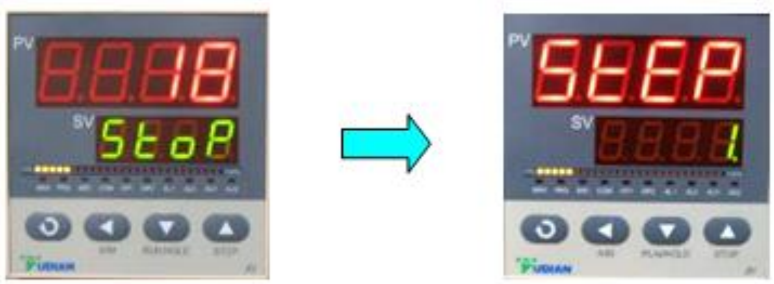
Start Up State

When starting the device, the meter type and program version will display for a few seconds, and then enter the normal state. Blinking "stop" indicates the program is in "normal state".

Meter type & Program version   Normal state

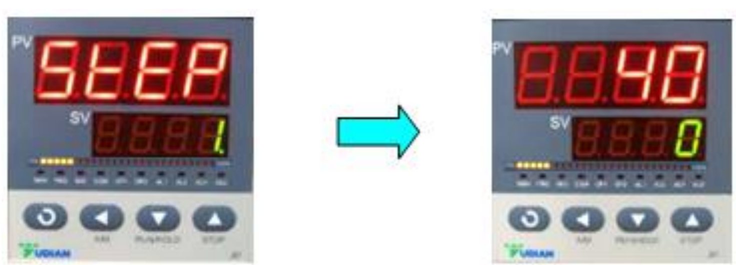
Displaying Switch

a. In the "normal state" or "program running state", press "SET" key (Button 2) for 1 second to switch to "executing program segment" (to set executing segments or display the ongoing temperature segment).



b. Press "SET" key (Button 2) again for 1 second to switch to "running time state" (to display the total running time PV xxxx min. and the elapsed time SV xxxx min.)

c. Press "SET" key again (Button 2) for 1 second to go back to "normal state".



HEATING PROFILE SETTING EXAMPLE

Programmable smart instrumentation auto-controller allows you to set the temperature profile up to 30 segments. To process this function, follow these steps:

- Power on the furnace, blinking "STOP" on the SV window indicates the Normal State;

- Press "←" once to display "C01" on PV window;
- Set initial temperature to 0 °C by using Keystrokes :"←", "↑" or "↓" ;

- Press "Set" to display "t01" on PV window;

- Set heat-up time (Usually beyond 30 minutes for this segment in case of temperature overshooting) from initial temperature to target temperature by using Keystrokes :"←", "↑" or "↓" ;
- Press "Set" to display "C02" on PV window; Set the actual working temperature for the second segment by using Keystrokes :"←", "↑" or "↓" ;

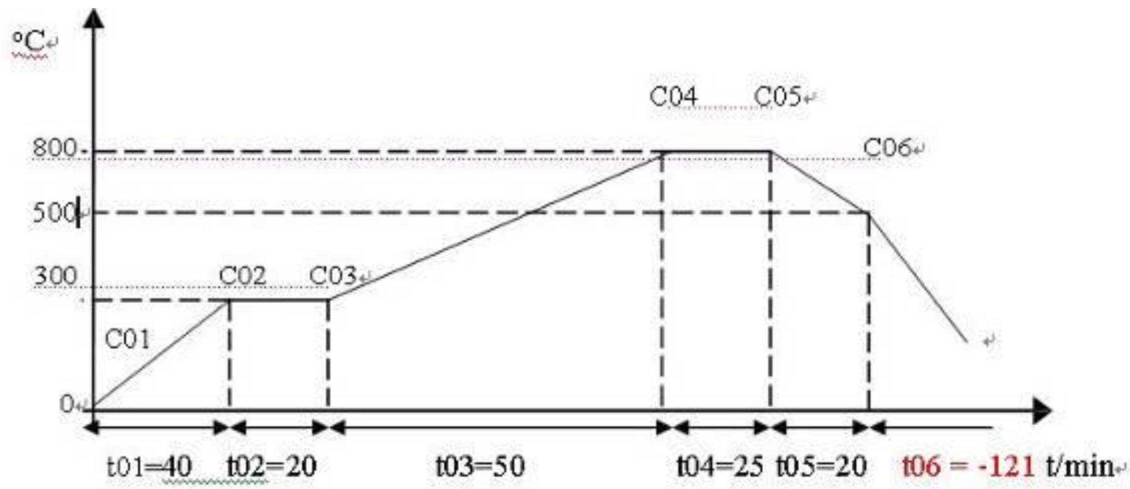
- Press "Set" to display "t02" on PV window; Set heat-up time from initial temperature to target temperature by using Keystrokes :"←", "↑" or "↓";
- By pressing "Set" , you can get into the remaining segments (C03&t03;C04&t04;C05&t05…) and set their target temperature and duration time values;
- Press "Set" to display "Cxx" on PV window (xx could be any values among 01~30);
- Press"←", "↑" or "↓" to set "-121" in the last "Txx" segment in order to shut down the furnace;

Attention:

The heating profile will stop at the first "Txx" segment that contains "-121" regardless of whether or not the latter segments have values set in them.

ILLUSTRATION OF HEATING PROFILE SETTING

Setting Example: Temperature Control Program with 6-segments



According to figure I above, all segments were recorded in the following:

Prompt	Input Data	Description
C01	0	Initial Temperature
T01	40	Heat-up time 40 minutes from 0-300 °C in the first segment
C02	300	Target temperature of the first heat-up stage
T02	20	Keep 20 minutes at 300 °C in the second segment
C03	300	Target temperature of the third stage
T03	50	Heat-up time 50 minutes from 300-800°C in the third segment
C04	800	Target temperature of the fourth stage
T04	25	Keep 25 minutes at 800°C in the fourth segment
C05	800	Target temperature of the fifth cooling stage
T05	20	Cooling time 20 minutes from 800-500°C
C06	500	Beginning temperature of the sixth stage
T06	-121	Program end, Out-put power off. Furnace cooling down naturally.(t06 = -121 is an order to stop running)

RUNNING THE PROGRAM

- When all the data is input into the temperature program, press both "Set" and "←" together, and "STOP" will show on SV window again as an indication of the controller returning to the "Normal State". Then press "↓" and hold for two seconds to display "Run" on SV window;

- Furnace will run segment by segment automatically according to the program setting;
- PV window then displays the present temperature inside the chamber;

HOLDING THE PROGRAM

- If you need to hold the furnace at certain temperature when the program is running, press "↓" for 2 sec to hold the program and press it again to continue.
- You can stop the program either from the running or holding states by pressing "↑" for 2 seconds.

Attention:

It is not suggested to modify any parameters during the execution if the operator is not familiar with the furnace operations. If it is absolutely necessary, please first stop the program first and then do the modification.

STOPPING THE PROGRAM/ FURNACE SHUT DOWN

- Press the "↑"key to make sure the controller is at its "STOP " state
- Push the red " Turn-Off" button to deactivate the furnace relay
- Turn the lock switch in counter clockwise direction to cut off power from the control panel
- If possible, shut off the power switch from the power cable

EQUIPMENT MAINTENANCE & TROUBLESHOOTING

MAINTENANCE AND EQUIPMENT CARE

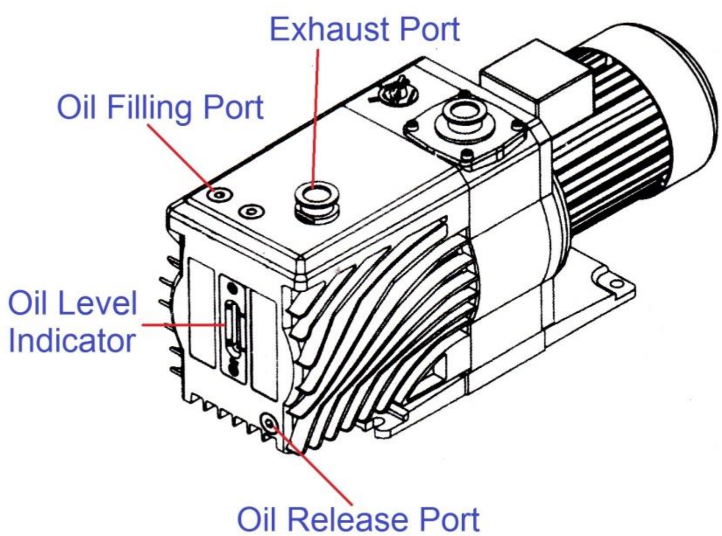
- If the instrument is being used for the first time (or use again after a long period of inactivity), please pre-heat the instrument to 200 ℃ for at least 2 hours for removing moisture inside the chamber to improve vacuum performance.
- If the vacuum performance starts to decline drastically, please replace the silicon rubber O-rings inside the flanges and then reassemble the flanges and the vacuum system.
- Please always keep inside chamber clean to avoid contamination to your sample. Furnace must be used in an environment without vibration and conductible dust, explosive, flammable and corrosive gases

VACUUM PUMP OIL CHANGE

Clean oil with the proper amount must be used to preserve the pump's function and life. Follow the guidelines below for pump maintenance:

- If the oil is contaminated, replace it with clean oil immediately.
- When the performance of the vacuum deteriorates or declines over time, an oil change is needed.

Oil change procedure:
1, The pump should be shut down and kept in a warm environment for the oil to remain its fluidity.
2, Remove the drain plug on the oil release port and drain the contaminated oil into a suitable container.
3. Remove the plug on the oil filling port (after putting the drain plug back) and fill in the new oil. Fill until the oil reaches the sufficient level on the indicator and tighten the plug on the oil filling port.



TROUBLESHOOTING RESOURCES

- Visit MTI web site link: WWW.MTIXTL.COM for additional information about the instrument
- Contact us by Tel: 510-525-3070 or email: info@mtixtl.com

MATERIAL PARAMETERS APPENDIX

In the table below, an * is used to indicate that the material's Z Factor is not known. A method of determining Z Factor empirically follows the materials table.

Formula	Density	Z-Ratio	Material Name
Ag	10.500	0.529	Silver
AgBr	6.470	1.180	Silver Bromide
AgCl	5.560	1.320	Silver Chloride
Al	2.700	1.080	Aluminum
Al_2O_3	3.970	0.336	Aluminum Oxide
Al_4C_3	2.360	*1.000	Aluminum Carbide
AlF_3	3.070	*1.000	Aluminum Fluoride
AlN	3.260	*1.000	Aluminum Nitride
AlSb	4.360	0.743	Aluminum Antimonide
As	5.730	0.966	Arsenic
As_2Se_3	4.750	*1.000	Arsenic Selenide
Au	19.300	0.381	Gold
B	2.370	0.389	Boron
B_2O_3	1.820	*1.000	Boron Oxide
B_4C	2.370	*1.000	Boron Carbide
BN	1.860	*1.000	Boron Nitride
Ba	3.500	2.100	Barium
BaF_2	4.886	0.793	Barium Fluoride
BaN_2O_6	3.244	1.261	Barium Nitrate
BaO	5.720	*1.000	Barium Oxide
$BaTiO_3$	5.999	0.464	Barium Titanate (Tetr)
$BaTiO_3$	6.035	0.412	Barium Titanate (Cubic)
Be	1.850	0.543	Beryllium
BeF_2	1.990	*1.000	Beryllium Fluoride
BeO	3.010	*1.000	Beryllium Oxide
Bi	9.800	0.790	Bismuth
Bi_2O_3	8.900	*1.000	Bismuth Oxide
Bi_2S_3	7.390	*1.000	Bismuth Trisuiphide
Bi_2Se_3	6.820	*1.000	Bismuth Selenide
Bi_2Te_3	7.700	*1.000	Bismuth Telluride
BiF_3	5.320	*1.000	Bismuth Fluoride
C	2.250	3.260	Carbon (Graphite)
C	3.520	0.220	Carbon (Diamond)
C_8H_8	1.100	*1.000	Parlyene (Union Carbide)

Ca	1.550	2.620	Calcium
CaF_2	3.180	0.775	Calcium Fluoride
CaO	3.350	*1.000	Calcium Oxide
CaO-SiO_2	2.900	*1.000	Calcium Silicate (3)
$CaSO_4$	2.962	0.955	Calcium Sulfate
$CaTiO_3$	4.100	*10~	Calcium Titanate
$CaWO_4$	6.060	*1.000	Calcium Tungstate
Cd	8.640	0.682	Cadmium
CdF_2	6.640	*1.000	Cadmium Fluoride
CdO	8.150	*1.000	Cadmium Oxide
CdS	4.830	1.020	Cadmium Sulfide
CdSe	5.810	*1.000	Cadmium Selenide,
CdTe	6.200	0.980	Cadmium Telluride
Ce	6.780	*1.000	Cerium
CeF_3	6.160	*1.000	Cerium (III) Fluoride
CeO_2	7.130	*1.000	Cerium (IV) Dioxide
Co	8.900	0.343	Cobalt
CoO	6.440	0.412	Cobalt Oxide
Cr	7.200	0.305	Chromium
Cr_2O_3	5.210	*1.000	Chromium (III) Oxide
Cr_3C_2	6.680	*1.000	Chromium Carbide
CrB	6.170	*1.000	Chromium Boride
Cs	1.870	*1.000	Cesium
Cs_2SO_4	4.243	1.212	Cesium Sulfate
CsBr	4.456	1.410	Cesium Bromide
CsCl	3.988	1.399	Cesium Chloride
CsI	4.516	1.542	Cesium Iodide
Cu	8.930	0.437	Copper
Cu_2O	6.000	*1.000	Copper Oxide
Cu_2S	5.600	0.690	Copper (I) Sulfide (Alpha)
Cu_2S	5.800	0.670	Copper (I) Sulfide (Beta)
CuS	4.600	0.820	Copper (II) Sulfide
Dy	8.550	0.600	Dysprosium
Dy_2O_3	7.810	*1.000	Dysprosium Oxide
Er	9.050	0.740	Erbium
Er_2O_3	8.640	*1.000	Erbium Oxide
Eu	5.260	*1.000	Europium
EuF_2	6.500	*1 .000	Europium Fluoride

Fe	7.860	0.349	Iron
Fe_2O_3	5.240	*1.000	Iron Oxide
FeO	5.700	*1.000	Iron Oxide
FeS	4.840	*1.000	Iron Sulphide
Ga	5.930	0.593	Gallium
Ga_2O_3	5.880	*1.000	Gallium Oxide (B)
GaAs	5.310	1.590	Gallium Arsenide
GaN	6.100	*1.000	Gallium Nitride
GaP	4.100	*1.000	Gallium Phosphide
GaSb	5.600	*1.000	Gallium Antimonide
Gd	7.890	0.670	Gadolinium
Gd_2O_3	7.410	*1.000	Gadolinium Oxide
Ge	5.350	0.516	Germanium
Ge_3N_2	5.200	*1.000	Germanium Nitride
GeO_2	6.240	*1.000	Germanium Oxide
GeTe	6.200	*1.000	Germanium Telluride
Hf	13.090	0.360	Hafnium
HfB_2	10.500	*1.000	Hafnium Boride,
HfC	12.200	*1.000	Hafnium Carbide
HfN	13.800	*1.000	Hafnium Nitride
HfO_2	9.680	*1.000	Hafnium Oxide
$HfSi_2$	7.200	*1.000	Hafnium Silicide
Hg	13.460	0.740	Mercury
Ho	8.800	0.580	Holminum
Ho_2O_3	8.410	*1.000	Holminum Oxide
In	7.300	0.841	Indium
In_2O_3	7.180	*1.000	Indium Sesquioxide
In_2Se_3	5.700	*1.000	Indium Selenide
In_2Te_3	5.800	*1.000	Indium Telluride
InAs	5.700	*1.000	Indium Arsenide
InP	4.800	*1.000	Indium Phosphide
InSb	5.760	0.769	Indium Antimonide
Ir	22.400	0.129	Iridium
K	0.860	10.189	Potassium
KBr	2.750	1.893	Potassium Bromide
KCl	1.980	2.050	Potassium Chloride
KF	2.480	*1.000	Potassium Fluoride
KI	3.128	2.077	Potassium Iodide

La	6.170	0.920	Lanthanum
La_2O_3	6.510	*1.000	Lanthanum Oxide
LaB_6	2.610	*1.000	Lanthanum Boride
LaF_3	5.940	*1.000	Lanthanum Fluoride
Li	0.530	5.900	Lithium
LiBr	3.470	1.230	Lithium Bromide
LiF	2.638	0.778	Lithium Fluoride
$LiNbO_3$	4.700	0.463	Lithium Niobate
Lu	9.840	*1.000	Lutetium
Mg	1.740	1.610	Magnesium
$MgAl_2O_4$	3.600	*1.000	Magnesium Aluminate
$MgAl_2O_6$	8.000	*1.000	Spinel
MgF_2	3.180	0.637	Magnesium Fluoride
MgO	3.580	0.411	Magnesium Oxide
Mn	7.200	0.377	Manganese
MnO	5.390	0.467	Manganese Oxide
MnS	3.990	0.940	Manganese (II) Sulfide
Mo	10.200	0.257	Molybdenum
Mo_2C	9.180	*1.000	Molybdenum Carbide
MoB_2	7.120	*1.000	Molybdenum Boride
MoO_3	4.700	*1.000	Molybdenum Trioxdide
MoS_2	4.800	*1.000	Molybdenum Disulfide
Na	0.970	4.800	Sodium
Na_3AlF_6	2.900	*1.000	Cryolite
$Na_5AL_3F_{14}$	2.900	*1.000	Chiolite
NaBr	3.200	*1.000	Sodium Bromide
NaCl	2.170	1.570	Sodium Chloride
$NaClO_3$	2.164	1.565	Sodium Chlorate
NaF	2.558	0.949	Sodium Fluoride
$NaNO_3$	2.270	1.194	Sodium Nitrate
Nb	8.578	0.492	Niobium (Columbium)
Nb_2O_3	7.500	*1.000	Niobium Trioxide
Nb_2O_5	4.470	*1.000	Niobium (V) Oxide
NbB_2	6.970	*1.000	Niobium Boride
NbC	7.820	*1.000	Niobium Carbide
NbN	8.400	*1.000	Niobium Nitride
Nd	7.000	*1.000	Neodynium
Nd_2O_3	7.240	*1.000	Neodynium Oxide
NdF_3	6.506	*1.000	Neodynium Fluoride

Ni	8910	0.331	Nickel
NiCr	8.500	*1.000	Nichrome
NiCrFe	8.500	*10~	Inconel
NiFe	8.700	*1.000	Permalloy
NiFeMo	8.900	*10~	Supermalloy
NiO	7.450	*1.000	Nickel Oxide
P_3N_5	2.510	*1.000	Phosphorus Nitride
Pb	11.300	1.130	Lead
$PbCl_2$	5.850	*1.000	Lead Chloride
PbF_2	8.240	0.661	Lead Fluoride
PbO	9.530	*1.000	Lead Oxide
PbS	7.500	0.566	Lead Sulfide
PbSe	8.100	*1.000	Lead Selenide
$PbSnO_3$	8.100	*1.000	Lead Stannate
PbTe	8.160	0.651	Lead Telluride
Pd	12.038	0.357	Palladium
PdO	8.310	*1.000	Palladium Oxide
Po	9.400	*1.000	Polonium
Pr	6.780	*1.000	Praseodymium
Pr_2O_3	6.880	*1.000	Praseodymium Oxide
Pt	21.400	0.245	Platinum
PtO_2	10.200	*1.000	Platinum Oxide
Ra	5.000	*1.000	Radium
Rb	1.530	2.540	Rubidium
RbI	3.550	*1.000	Rubidium Iodide
Re	21.040	0.150	Rhenium
Rh	12.410	0.210	Rhodium
Ru	12.362	0.182	Ruthenium
S8	2.070	2.290	Sulphur
Sb	6.620	0.768	Antimony
Sb_2O_3	5.200	*1.000	Antimony Trioxide
Sb_2S_3	4.640	*1.000	Antimony Trisulfide
Sc	3.000	0.910	Scandium
Sc_2O_3	3.860	*1.000	Scandium Oxide
Se	4.810	0.864	Selenium
Si	2.320	0.712	Silicon
Si_3N_4	3.440	*1000	Silicon Nitride
SiC	3.220	*1.000	Silicon Carbide
SiO	2.130	0.870	Silicon (II) Oxide
SiO_2	2.648	1.000	Silicon Dioxide

Sm	7.540	0.890	Samarium
Sm_2O_3	7.430	*1.000	Samarium Oxide
Sn	7.300	0.724	Tin
SnO_2	6.950	*1.000	Tin Oxide
SnS	5.080	*1.000	Tin Sulfide
SnSe	6.180	*1.000	Tin Selenide
SnTe	6.440	*1.000	Tin Telluride
Sr	2.600	*1.000	Strontium
SrF_2	4.277	0.727	Strontium Fluroide
SrO	4.990	0.517	Strontium Oxide
Ta	16.600	0.262	Tantalum
Ta_2O_5	8.200	0.300	Tantalum (V) Oxide
TaB_2	11.150	*1.000	Tantalum Boride
TaC	13.900	*1.000	Tantalum Carbide
TaN	16.300	*1.000	Tantalum Nitride
Tb	8.270	0.660	Terbium
Tc	11.500	*1.000	Technetium
Te	6.250	0.900	Tellurium
TeO_2	5.990	0.862	Tellurium Oxide
Th	11.694	0.484	Thorium
ThF_4	6.320	*1.000	Thorium.(IV) Fluoride
ThO_2	9.860	0.284	Thorium Dioxide
$ThOF_2$	9.100	*1.000	Thorium Oxyfluoride
Ti	4.500	0.628	Titanium
Ti_2O_3	4.600	*1.000	Titanium Sesquioxide
TiB_2	4.500	*1.000	Titanium Boride
TiC	4.930	*1.000	Titanium Carbide
TiN	5.430	*1.000	Titanium Nitride
TiO	4.900	*1.000	Titanium Oxide
TiO_2	4.260	0.400	Titanium (IV) Oxide
Tl	11.850	1.550	Thallium
TlBr	7.560	*1.000	Thallium Bromide
TlCl	7.000	*1.000	Thallium Chloride
TlI	7.090	*1.000	Thallium Iodide (B)
U	19.050	0.238	Uranium
U_3O_8	8.300	*1 .000	Tri Uranium Octoxide
U_4O_9	10.969	0.348	Uranium Oxide
UO_2	10.970	0.286	Uranium Dioxide

V	5.960	0.530	Vanadium
V_2O_5	3.360	*1.000	Vanadium Pentoxide
VB_2	5.100	*1.000	Vanadium Boride
VC	5.770	*1.000	Vanadium Carbide
VN	6.130	*1.000	Vanadium Nitride
VO_2	4.340	*1.000	Vanadium Dioxide
W	19.300	0.163	Tungsten
WB_2	10.770	*1.000	Tungsten Boride
WC	15.600	0.151	Tungsten Carbide
WO_3	7.160	*1.000	Tungsten Trioxide
WS_2	7.500	*1.000	Tungsten Disulphide
WSi_2	9.400	*1.000	Tungsten Suicide
Y	4.340	0.835	Yttrium
Y_2O_3	5.010	*1.000	Yttrium Oxide
Yb	6.980	1.130	Ytterbium
Yb_2O_3	9.170	*1.000	Ytterbium Oxide
Zn	7.040	0.514	Zinc
Zn_3Sb_2	6.300	*1.000	Zinc Antimonide
ZnF_2	4.950	*1.000	Zinc Fluoride
ZnO	5.610	0.556	Zinc Oxide
ZnS	4.090	0.775	Zinc Sulfide
ZnSe	5.260	0.722	Zinc Selenide
ZnTe	6.340	0.770	Zinc Telluride
Zr	6.490	0.600	Zirconium
ZrB_2	6.080	*1.000	Zirconium Boride
ZrC	6.730	0.264	Zirconium Carbide
ZrN	7.090	*1.000	Zirconium Nitride
ZrO_2	5.600	*1.000	Zirconium Oxide

Z-Factor is used to match the acoustic properties of the material being deposited to the acoustic properties of the base quartz material of the sensor crystal.

Z-Factor = Zq / Zm

For example, the acoustic impedance of gold is Z=23.18, so:
Gold Z-Factor = 8.83 / 23.18 = .381

Unfortunately, Z Factor is not readily available for many materials. Z Factor can be calculated empirically using this method:

1. Deposit the material until Crystal Life is near 50%, or near the end of life, whichever is sooner.
2. Place a new substrate adjacent to the used quartz sensor.

3. Set QCM Density to the calibrated value; Tooling to 100%. Zero thickness.
4. Deposit approximately 1000 to 5000 Å of material on the substrate.
5. Use a profilometer or interferometer to measure the actual substrate film thickness.
6. Adjust the Z Factor of the instrument until the correct thickness reading is shown.

Another alternative is to change crystals frequently. For a crystal with 90% life, the error is negligible for even large errors in the programmed versus actual Z Factor.