Compact RTP Furnace with 4" Quartz Tube & Digital Vacuum Gauge up to 1100ºC

OTF-1200X-4-RTP

Operation manual

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Thank you for purchasing MTI’s products, please read this manual before using the furnace, we have no responsibility for any damage caused by misuse.
MTI has right to update the product without informing the customer which means the data in this manual may vary some time, please termly visit www.mtixtl.com for the latest information.
Introduction

RTP-1000D4 is compact rapid thermal processing tube furnace with 4" I.D. processing quartz tube and vacuum flange. It is designed for annealing semiconductor wafer or solar cell up to 3" diameter. RTP-1000D4 is heated by 10KW halogen light with max. 120°C/s heating rate. 30 segments precision temperature controller is built in with +/-1°C accuracy. RS485 port and control software are included to allow you running furnace and monitoring temperature profile via PC.

Technical Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace structure</td>
<td>Double layer steel case with alumina liner.</td>
</tr>
<tr>
<td>Heating element</td>
<td>8 pcs Halogen light tube (D=10 L=300 T=200, mm)</td>
</tr>
<tr>
<td>Heating zone</td>
<td>12&quot; length with 4&quot; constant temperature zone within +/-1°C uniformity</td>
</tr>
<tr>
<td>Quartz Tube size</td>
<td>4.33&quot; O.D x 4.05&quot; I.D x 15&quot; Length</td>
</tr>
<tr>
<td>Vacuum Flange</td>
<td>Made of stainless steel with double hi-temp, silicone O-ring, ball valves and built-in water cooling jacket.</td>
</tr>
<tr>
<td>Water Cooling Jacket</td>
<td>• It's necessary to implement cooling water during operation.</td>
</tr>
<tr>
<td></td>
<td>• Please make sure the source of cooling water you intent to follow in meets this requirement. (following rate &gt;= 3L/min, temp.&lt; 20°C @ pressure &gt;25 PSI)</td>
</tr>
<tr>
<td></td>
<td>• We suggest you using recirculating water chiller.</td>
</tr>
<tr>
<td></td>
<td>• You can use flowing tap water as cooling at flowing rate &gt; 8 Liter/minute.</td>
</tr>
<tr>
<td></td>
<td>• ! Attention: This RTP furnace's Max holding time at 1000 - 1100°C should be less than 600 seconds, otherwise O-ring may get melting.</td>
</tr>
<tr>
<td>Flow Meter</td>
<td>One flow meter is installed on the front panel to adjust gas flow from 16 -160 ml/min.</td>
</tr>
<tr>
<td>Vacuum gauge</td>
<td>CE certified vacuum gauge with a measurement range from 1 mtorr~800 torr is installed with the furnace.</td>
</tr>
<tr>
<td>Vacuum pressure</td>
<td>• Pressure can reach 50 mtorr by using mechanical vacuum pump with KF-25 adapter.</td>
</tr>
<tr>
<td></td>
<td>• Pressure can reach 10⁻³ torr by molecular pump with KF-25 adapter.</td>
</tr>
</tbody>
</table>
| **Temperature control** | • PID automatic control via SCR (Silicon Controlled Rectifier) power control, e.g. current limiting phase angle fired the resistor.  
• 30 segments programmable precision controller with auto tune function.  
• Built in protection from overheated and broken thermal couple.  
• Temperature control accuracy: +/- 0.5 °C.  
• Built in RS485 port for PC control.  
• Software is included (Window XP English version required, computer is not included, but 9" screen laptop with operation software installed is available as option at $900 extra cost). |
| **Thermal Couple** | K type, the head of the thermocouple touches the Aluminum Nitride sample holder from underneath. |
| **Max. Heating Rate** | 50 °C /sec. |
| **Working Temperature** | • 1100°C Max. for < 10 minutes  
• 800°C Max. for < 120 minutes  
• 600°C Max. for Continuous |
| **Power Input** | 208-240 AC, 50/60 Hz single phase, 9 KW Max. ( > 60A breaker required) |
| **Dimension** | Flange closed: 760 X 330 X 530 mm (30"W x 13"L x 21" H); Flange opened: 1200 X 330 X 530 mm (47"W x 13"L x 21" H) |
| **Net weight** | 45 kg ( 100 lbs ) |
| **Warranty** | One year limited (not including halogen light damaged by user) |
Furnace Structure

- Halogen Light Tube
- Digital Press Gauge
- Sample Holder
- Flow Meter
- Temp. Controller
- RS485 Port
- Turn On
- Turn Off
- Lock
- Working Indicator
- Wafer Feeder
- Gas Outlet and Valve
- Right Angle Valve
- KF-25 Vacuum Port
- Insertable Thermal Couple
- Gas Inlet Tube
- Cooling Water Inlet/Outlet
Operating environment

- Place the device on a dry, hard and flat surface;
- The device is for indoor use with nice ventilation and avoided direct sunlight;
- Operating temperature: 50°C ~ 350°C;
- Relative humidity (no condensing): 10% ~ 85%;
- Dust-free.

⚠️ WARNING: To reduce the possibility of heat-related injuries or overheating the instrument, 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.

Preparations

Once you received MTI furnace, please follow these steps to set up the furnace.

- Open the shipping case to check whether the products & accessories match with the packing list accordingly.

MTI Recommended Compact Cooling System (Optional)

- **Attention:** Please be advised that it's necessary to implement cooling water during operation, please visit: [http://mtixtl.com/ThermolysisWater-cooledChiller-EQ-CW5000DI-220.aspx](http://mtixtl.com/ThermolysisWater-cooledChiller-EQ-CW5000DI-220.aspx) for more information about the Digital Temperature Controlled Recirculation Water Chiller (6 Liter Tank, 16L/min Flow).
Cooling Jacket Installation

- Connect the cooling pipe to the back of the furnace as following and tighten up

![Cooling Jacket Installation Image]

- Please ask a licensed electrician to do the power cord connection according to the "knowledge on AC power connection" at the end of this manual (60A air breaker is required).
- Install the CE Certified Vacuum Gauge and please well connect its power as the picture below.

![CE Certified Vacuum Gauge Image]
Attention: Please make sure the valve of the digital gauge is closed when feeding any gases into the tube. You may open the valve to read vacuum level when vacuuming. Otherwise, the chemical gases could cause permanent damage to the gauge sensor.

Sample Holder Installation

Please follow the instructions below to install the sample holder:

1. Loosen the hexagon screws on the right flange to pull out the wafer holder.

2. Please assemble the sample holder by following the drawing below.
3. Place the wafer on the holder and then push back the flange (one wafer per time processing).
4. Tighten the hexagon screws with hexagon screwdriver.

**General Operation**

- Place the test sample on the sample holder, slightly insert the foam block and then seal both ends of the tube with flanges;
- If you are going to set up the Vacuum/Gas Flow system with the furnace, please properly set the vacuum level / flowing rate when you need to purge and charge the inert gas into the tube. It is highly recommended to utilize vacuum grease on the flange joint, please visit: [http://www.mtiixtl.com/furnaceaccessories.aspx](http://www.mtiixtl.com/furnaceaccessories.aspx) for more information;
- Properly connect to the power supply and make sure it is well grounded;
- Power on the instrument and you will see the control panel start to blink;
- Please refer to the following part “Temperature Controller Instruction” for how to set the temperature curve.

**NOTE:** Once you finish the set up, we strongly recommend our customer FIRSTLY read the handbook and then follow the temperature controller instructions to perform a quick test to check the heating condition of the furnace.

**CAUTION:** To reduce the risk of electric shock or damage to your instrument during your quick test, pay extremally attention to these practices:

- The outer plate of the instrument must be grounded properly, for safety of operation;
- The instrument shall be kept indoor with nice ventilation;
- To reduce potential safety issues, do not place flammable and explosive materials around the instrument;
- No explosion-proof, do not put any flammable and explosive materials into the chamber.

**Temperature Controller Instruction**

**708P Temperature Controller**

1. Specification
   b. Measurement Accuracy: 0.3;
   c. Power Input: Single phase 220V AC (±10%) / 50~60Hz;
   d. Power: ≤5W;
   f. 30 Programmable Segments.

2. Structure
MTI has three kinds of temperature controller with the same function as below:

Here we take the first one as default to describe the operation:

- **Present Value**
- **Cursor moving/Setting Access button**
- **Setting/confirmation button**
- **Setting Value (Target Value)**
- **Function Indicator**
- **Increase button (Stop)**
- **Decrease button (Run/Holder)**
Temperature Controller Setting

Startup state
When turn on 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 stop state.

![Meter type & Program version](image1)
![Normal state](image2)

Displaying switch
- In the “normal state” or “program running state”, press “SET” key for 1 second to switch to “executing program segment” (Set executing segment or display the ongoing temperature segment).
- Press “SET” key again for 1 second to switch to “running time state” (Display the total running time PV xxxx min. and the elapsed time SV xxxx min.)
- Press “SET” key again for 1 second to get back to “normal state”.

Temperature Segment Setting
LTDE 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 “↓”;
• Press “Set” to display “C03” on PV window, Set the actual working temperature for the third segment;
• Press “Set” to display “t03” on PV window; Set heat-up time from initial temperature to target temperature;
• Press “Set” to display “C04” on PV window, Set the actual working temperature for the fourth segment;
• Press “Set” to display “t04” on PV window, Use Keystrokes : “←”, “↑” or “↓” to set duration for “C04”;
• By pressing “Set”, you can get into the following segments (C05&t05…C06&t06…C07&t07…) for temperature and time setting;
• Press “Set” to display “Cxx” on PV window (xx could be any values among 01~30);
• Press “←”, “↑” or “↓” to set “-121” in the last segment in order to shut down the furnace;

**Illustration of Temperature Segment Setting**

Setting Example:

![Temperature Control Program with 8-segments](image)

**According to figure I above, all segments was recorded in the following:**
<table>
<thead>
<tr>
<th>Prompt</th>
<th>Input Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C01</td>
<td>0</td>
<td>Initial Temperature</td>
</tr>
<tr>
<td>T01</td>
<td>45</td>
<td>Heat-up time 45 seconds from 0-450 °C in the first segment</td>
</tr>
<tr>
<td>C02</td>
<td>450</td>
<td>Target temperature of the first heat-up stage</td>
</tr>
<tr>
<td>T02</td>
<td>20</td>
<td>Heat-up time 20 seconds from 450-500 °C in the second segment</td>
</tr>
<tr>
<td>C03</td>
<td>500</td>
<td>Target temperature of the second heat-up stage</td>
</tr>
<tr>
<td>T03</td>
<td>40</td>
<td>Keep 40 seconds at 500 °C</td>
</tr>
<tr>
<td>C04</td>
<td>500</td>
<td>Constant temperature of the third stage</td>
</tr>
<tr>
<td>T04</td>
<td>30</td>
<td>Heat-up time 30 seconds from 500-1000 °C in the fourth segment</td>
</tr>
<tr>
<td>C05</td>
<td>1000</td>
<td>Target temperature of the fourth heat-up stage</td>
</tr>
<tr>
<td>T05</td>
<td>25</td>
<td>Keep 25 seconds at 1000 °C</td>
</tr>
<tr>
<td>C06</td>
<td>1000</td>
<td>Constant temperature of the fourth stage</td>
</tr>
<tr>
<td>T06</td>
<td>20</td>
<td>Cooling time 20 seconds from 1000 to 800 °C</td>
</tr>
<tr>
<td>C07</td>
<td>800</td>
<td>Target temperature of the fifth heat-up stage</td>
</tr>
<tr>
<td>T07</td>
<td>25</td>
<td>Keep 25 seconds at 800 °C</td>
</tr>
<tr>
<td>C08</td>
<td>800</td>
<td>Constant temperature of the sixth stage</td>
</tr>
<tr>
<td>T08</td>
<td>-121</td>
<td>Program end, Out-put power off. Furnace cooling down naturally. (t08 = -121 is an order to stop running)</td>
</tr>
</tbody>
</table>

Run the program

- When temperature program setting up is ready, wait until “STOP” shows on SV window again, then press “↓” and hold it for two seconds to display “Run” on SV window;

- Furnace will run automatically segment by segment according to the program setting;
- PV window displays increasing temperature at this moment;
- If you need to hold the furnace at certain temperature when the program is running, press “↓” for 2 sec to hold the program and again press it to continue.
- You can stop the program either from running or hold state by pressing “↑” for 2 seconds.
Attention:
- When finish setting all the segments you need, please end the last segment with -121;
- It is not suggested to modify any parameters during the execution if you are not familiar with the furnace operation. If it’s necessary, please first stop the program.

Temperature Controller Parameters

Introduction:

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Parameter Function</th>
<th>Setting Range</th>
<th>Unit</th>
<th>Default Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>M5</td>
<td>Maintain parameter</td>
<td>1 — 9999</td>
<td>°C or definable unit</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Speed</td>
<td>1 — 9999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t</td>
<td>Delay time</td>
<td>1 — 2000</td>
<td>second</td>
<td></td>
</tr>
<tr>
<td>Ctrl</td>
<td>Control type</td>
<td>2, 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOC</td>
<td>Parameter lock</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

Parameter Function

Maintain parameter M5:
Like integral time of PID calibration, this parameter is mainly in charge of the integral work during the adjustment process, for instance, the smaller the M5 is set, the stronger the system integral effect is, vice versa. When M5=0, the system will cancel integral and intelligent adjustment, leave only proportion and differential (PD) function.
Speed parameter P:
Parameter p has nothing to do with integral function. The bigger the p is, the stronger the proportion and differential function are, vice versa.

Delay time t:
It is defined as the time spent when the heating rate reaches to 63.5% of the maximum value with assumption that there is no heat dissipation. Remember, this parameter affects the three functions such as integral, proportion and differential, the smaller the t is, the stronger both the proportion and the integral function are but weaken the differential, after all, the system feedback is promoted, vice versa. If t≤1, the differential function will be off.

Control type CtrlL:
(Do follow the default setting, or the system may be unable to work) When CtrlL=2, startup auto-tune function, after that, system will go to 3.
When CtrlL=3, adopts advanced AI adjustment, after auto-tune, the system goes to this setting mode, note that in this mode, you can not startup auto-tune function from the panel by holding button, for a protection of repeating auto-tune.

Parameters lock LOC:
Please keep the default setting “0”.
Parameter Setting

- In the “normal state”, press an hold “SET” key for 2 seconds, you will see parameter “M5” pops up and press “←”, “↑” or “↓” to modify the parameter.
- Press “SET” key for 1 second to go to next parameter and hold “←” for 2 seconds to back to preceding parameter.
- Press “←” and then press “SET” key to get back to “normal state”. Without any operation on the keys for about 30 minutes, the meter will automatically exit from “parameter setting state”.

Auto-tune

In order to get a precise temperature control, customer should pay more attention to the parameters of M5, P and t. Actually, MTI’s engineers have already made a strict high temperature pre-heating test (rate: 5°C/min) and fixed on these three parameters according to each furnace’s condition before shipping it out. Therefore, we have a confidence of satisfying over 95% customers.

However, the diversity of environment and the distinction in manufacturing for each customer, may seriously affect the operation, so, using auto-tune function to decide these parameters for a perfect result when the temperature is not stable and the error is big:

- Run the program and wait until the furnace temperature reaches to 80% of your desired temperature.
- Set the control parameter ‘Ctrl’ as 2 and then press “←” then “SET” key to switch back to “Running State”.
- You will see the meter flashes with “AT”, it indicates the meter has been in the “auto-tune state”. Then, system begins to oscillate 2-3 times and the meter automatically analyzes the furnace’s temperature controlling period, amplitude, wave type and coefficient of heat preservation at current temperature segment, finally, yields the three parameters as M5, P and t. Press “←” for 2 seconds to force the meter to stop flashing at any time you want.
- Due to different temperature, the time spent for “auto-tune” may be distinct.

Note: that the parameter “Cont” will be set as 3 by the system after “auto-tune”, therefore, if the customer needs more “auto-tune” operation for the furnace please reset the “Cont” to 2.

Tips for Auto-Tune

- Short oscillating period, you can decrease P (priority), increase M5 and t.
Long oscillating period, you can increase P (priority) as well as M5 and t.
No oscillating but offset is large, decrease M5 (priority), increase P.
Stable controlling but time-consume is too long, decrease t (priority) as well as M5, increase P.

Increase (or decrease) one of the three parameters by 30%-50%, if the controlling becomes better, continue increasing (or deceasing), otherwise, decrease (or increase) it till get the qualified adjustment. Commonly, M5 gets a priority, if not enough, try P and t.

Troubleshooting for typical Problems

Troubleshooting resources

- Refer to “Quick troubleshooting”, the next section in this chapter;
- Visit MTI web site link: WWW.MTIXTL.COM for additional information about the instrument through Help and Support;
- Contact us by tel: 510-525-3070 or email: info@mtixtl.com.

Maintenance and Caution

1. Never keep the furnace temperature over rated temperature for avoiding damage on heating element or cover. Do not pour any liquid or melting metal into the module to keep clean inside.
2. When utilizing the furnace with quartz tube and the temperature over 1000 °C, the high temperature part of the tube will be opaque (devitrification), it is a normal phenomenon because of quartz property.
3. Set a medium heating rate and small temperature difference between the adjacent segment when the furnace is cool. Please make a considerate setting on the heating rate in terms of the character of material sintered.
4. Termly check the wire connection and link junction of the heating element.
5. Change the silicon rubber ring inside the flange and reassemble the flange of the vacuum system if the vacuum level declines obviously.
6. Please refer to parameter “M5, P and t” setting if the temperature offset can not be eliminated and the discrepancy between PV and SV goes far at 300 °C.
7. Working environment
   a. Circumstance temperature: -10~75 °C.
   b. Relative humidity: 85%
   c. Keep away from electric dust, explosive and corrosive gas.
d. Keep the furnace stable when working.

8. MTI" furnace (not including tube and heating element) has one year warranty since it is shipped out. We will give you free maintenance if there is a quality problem. For any misuse and damage, we will make a charge according to the damage condition if repair is required.

Notice: MTI never suggest you introduce any toxic, explosive or flammable gases into the tube. Please remember that the air pressure inside the chamber should be controlled below 0.12Mpa (absolute pressure value) and overpressurization is forbidden. We aren’t liable for any lost or damage caused by misuse.

Quick Troubleshooting

The furnace is unable to start up

If the furnace can not turn on when you press the power button:

- Be sure the furnace is plugged into and AC outlet with adequate power;
- Fuse in controlling circuit might failure. Check the control circuit and replace the fuse.

The temperature inside the chamber can’t go up

- Temperature may be set too low, adjust the setting value of temperature;
- Thermocouple may be failure, check and replace the thermocouple;
- Temperature controller may be broken, check and replace the controller;

Real temperature inside the chamber does not match the setting value

- Temperature sensor may be broken, replace the temperature sensor/thermocouple;

Overheated protection alarm

- Cool furnace down, and find reason why temperature is so high (program setting may be wrong);

SV show “OraL” alternately

- Thermocouple has open circuit, inspect thermocouple;
SV show “HIAL” alternately

- Furnace temperature/tube pressure is over upper limit, Please let the furnace naturally cooling down and then check out the reason of over-heating.
Knowledge on AC Power Connection

For power connection, you must follow your local law and let a licensed electrician do it. **MTI Corporation is not responsible for any damage caused by wrong power connection.** Extra power connection knowledge is not only for you to get a better application of the product, but also for your safety.

**If your country uses 220V power, you have no problem.**
**If your country uses 110V power, you may need a 208~240V single phase AC power line.** Ask your electrician to make single phase 240V power line, similar to you set up a 240V electric washer/dryer in your home. Please prepare the following knowledge:

**Three phases (240V) AC power panel box** usually is located in the laboratory and inside wires are shown below.

**In order to get single phase 240V,** two power lines come from two live wires, Of course, a 240V switch breaker must be installed.

![AC Power Panel Diagram](image-url)

**Typical Three Phases AC Power in US**
Typical Two Phases AC Power in US

Connect the power cable of the furnace to a male plug and the two single phase wires to female and then connect them for easy and safe use:

Again, the above information is just for basic knowledge only; please contract a licensed electrician to do the connections!