Allwin21 Corporation

AccuThermo®
AW410 / AW610
Rapid Thermal Process System

Operation Manual

Allwin21 Corporation
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ALLWIN21
ACCUTHERMO®
AW410 / AW610

RAPID THERMAL PROCESS SYSTEM

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Document #: AW-900-707 Rev. H
Written by: Rick Forney
February, 2017

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PREFACE

INTENDED AUDIENCE

This Operation Manual has been written for technicians and process development engineers working with the AccuThermo® AW410 or the AccuThermo® AW610 Rapid Thermal Processing (RTP) System. It provides an overview of the system operation procedures, as well as a troubleshooting guide for processing. Please read this manual carefully before operating the AccuThermo® RTP System.

DOCUMENT CONVENTIONS

FONT CONVENTIONS

The following font conventions are used in this manual.

Bold	Software screen selections are represented in **bold** type.
Italic	Screen names are shown in *italic* type.
First Letter Capitalized	Operating modes are shown in normal type with the first letter capitalized.
Italic and Bold	References to other sections, chapters, and manuals are shown in both ***italic and bold*** type.
"*Main menu/Italic/Italic2*"	The hierarchy of screen names are shown in italic separated by '/' and encapsulated by double quote.
For example:	"Select **Recipe** from the *Main Menu* screen to enter the Recipe Programming mode."
Another example:	Click the "*Main menu/Process for engineer/Recipe Edit"* button.

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1. INTRODUCTION

Chapter 1: Chapter 1

1.1 SYSTEM DESCRIPTION

The AccuThermo AW410 and the AccuThermo AW610 are rapid thermal processing (RTP) systems, which uses high intensity visible radiation to heat single wafers for short process periods of time at precisely controlled temperatures. The process periods are typically 1-600 seconds in duration, although periods of up to 9999 seconds can be selected.

NOTE

Process periods longer than 600 seconds in duration are normally used only for maintenance testing purposes at low lamp intensity settings.

These capabilities, combined with the heating chamber's cold-wall design and superior heating uniformity, provide significant advantages over conventional furnace processing.

AccuThermo AW410 / AW610 Systems

Figure 1-1: *Multiple gas system with attached gas box*

The AccuThermo RTP system, figures 1-1, consists of an oven unit and a controller computer running the Allwin21 RTAPRO controller software. The wafer to be processed is placed on a quartz tray that slides into a quartz isolation tube in the oven unit. Two banks of lamps, one above the quartz tube and one below it, provide the source of energy for heating the wafer. The lamps can be controlled manually and automatically from the controller computer.

The RTAPRO control software allows full control and diagnostics of the AccuThermo RTP system. In addition, it allows the creation of recipes for automated control of the temperature and, optionally, process gas flow.

The control software uses a set of operating instructions known as recipes to automatically control the AccuThermo RTP system. These recipes are created by the Process Engineer to monitor and control the parameters of the processing cycle. The Operator then uses the software to select and run the process parameters (steady state temperature, process time, ramp rates, etc.).

The RTAPRO software is also used to create, delete, copy, modify and store the recipes and to execute system diagnostics.

1.2 FEATURES

KEY FEATURES

- Closed-loop temperature control with pyrometer or thermocouple temperature sensing.
- Precise time-temperature profiles tailored to suit specific process requirements.
- Fast heating and cooling rates unobtainable with conventional technologies.
- Consistent wafer-to-wafer process cycle repeatability.
- Elimination of external contamination.
- Small footprint and energy efficiency.
- The watchdog timer shuts down the lamps to prevent run-away heating of the wafer.

APPLICATIONS

The AccuThermo RTP system is a versatile tool that is useful for many applications:

- Ion Implant Activation
- Polysilicon Annealing
- Oxide Reflow
- Silicide Formation
- Contact Alloying
- Oxidation and Nitridation
- GaAs Processing

HEATING, COOLING, AND TEMPERATURE MEASUREMENT

The following list contains the key features of the AccuThermo RTP system heating, cooling and temperature measurement systems:

- High-intensity visible radiation heats wafers for short periods of 1 to 9999 seconds at precisely controlled temperatures in the 400°C to 1200°C range. (1 to 600 second heating periods are used typically.)
- Tungsten halogen lamps and cold heating chamber walls respectively allow fast wafer heating and cooling rates.
- The system delivers time and temperature profiles tailored to suit specific process requirements.
- Pyrometer or thermocouple sensing offers precise closed-loop temperature control.
- Cooling N2 flows around the lamps and quartz isolation tube
- MFC controlled gases (up to four) flow through the heating chamber for purge and/or process purposes.

1.3 SYSTEM PROCESS SPECIFICATIONS

Following are the specifications for the AccuThermo Rapid Thermal Processor (RTP) system.

- **Wafer handling:** Manual loading of wafer into the oven, single wafer processing.
- **Wafer sizes:** 2", 3", 4", 5" and 6" wafers.
- **Ramp up rate:** Programmable, 10°C to 200°C per second.
- **Recommended steady state duration:** 0-300 seconds per step.
- **Ramp down rate:** Programmable, 10°C to 250°C per second. Ramp down rate is temperature-and-radiation-dependent and the maximum is 125°C per second.
- **Recommended steady state temperature range:** 150°C - 1150°C
- **ERP temperature accuracy:** ±1°C, when calibrated against an instrumented thermocouple wafer (ITC).
- **Thermocouple temperature accuracy:** ±0.5°C
- **Temperature repeatability:** ±0.5°C or better at 1150°C wafer-to-wafer. (Repetition specifications are based on a 100-wafer set.)
- **Temperature uniformity:** ±5°C across a 6" (150 mm) wafer at 1150°C. (This is a one sigma deviation 100 angstrom oxide.) For a titanium silicide process, no more than 4% increase in non-uniformity during the first anneal at 650°C to 700°C.
- **Process/Purge gas inputs:** Any inert and/or non-toxic gas regulated to 30 PSIG and pre-filtered to 1 micron. Typically, Nitrogen (N2), oxygen (O2), argon (Ar), and/or helium (He) are used.

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2. SAFETY PRECAUTIONS

Chapter 2: Chapter 2

2.1 OVERVIEW

This section provides information intended to prevent damage to the AccuThermo RTP system and injury to operation and maintenance personnel. All hazards are not covered, only those most prevalent and serious. Your full understanding of the capabilities and limitations of this equipment is necessary for safe and efficient operation.

☠ WARNING

Only ALLWIN21 or qualified personnel should install, start up, operate and/or repair the AccuThermo RTP system. Damage to the system or injury to personnel could result if the preceding actions are carried out by unqualified personnel.

Prior to applying power or starting up the AccuThermo RTP system, follow these safety precautions:

- Check all utilities for proper connections. Connect only those gases specified for use in the system.
- Make sure the cabinet cover is on.
- Check the scrubber exhaust to make sure it is properly connected to the facility scrubber. Ensure the facility scrubber is operating properly. Check the purge outlet for any restrictions.

2.2 NOTES, CAUTIONS AND WARNINGS

When operating and maintaining the AccuThermo RTP system, the following safety procedures and precautions must be followed to avoid certain hazards. Observe all warnings and cautions. Their purpose is to protect personnel from injury and long term health hazards and to protect the machine from damage.

Pay special attention to notes, cautions and warnings located in appropriate areas in this manual.

NOTE

Notes provide additional important information which requires special attention.

CAUTION

Cautions alert you to avoid system damage.

WARNING

Warnings are given for personnel safety to prevent bodily harm.

2.3 SAFETY FEATURES

- There is a watchdog timer on the AccuThermo RTP system control board that will shut off the lamps if the software or computer freezes.
- Chamber Door Interlock Switch: This interlock detects if the chamber door is closed. If the chamber door is not closed, then the heating source will not come on. This cannot be bypassed. The process gases will be turned off if the chamber door is open. This is hardware and software controlled. The hardware will close the pneumatic shutoff valves and set the MFC setpoint control to 0 volts (close). The software will logically reset the gas flow to 0 slpm and close the gas pneumatic valves.
- Cabinet Cover Interlock Switch: This interlock detects if the cabinet cover has been removed. If the cabinet cover has been removed, then the heating source is turned off by disengaging the power contactor. This can be bypassed by a maintenance person by pulling up on the switch into the maintenance position. As soon as the cabinet cover is replaced, the cabinet cover interlock switch is automatically reset to detect the removal of the cabinet cover. If the cabinet cover is removed, the process gases will be turned off.
- EMO (Emergency Off): When the EMO is depressed, the power to the entire machine is turned off.
- Overheat Thermal Switch: If the oven overheats (>150°F), there is a thermal switch that opens and the heating source is turned off by disengaging the power contactor. Once the chamber has cooled below 135°F, the thermal switch can be reset by pressing on the thermal switch reset button.
- Water Flow Switch: The water needs to flow at the recommended rate that is specified in the Installation chapter of this manual. If the flow rate drops below this, the heating source is turned off by disabling the lamp control circuit. However, if the oven plates are below 95°F (35°C), the water may not need to flow. This is to prevent condensation on the oven in an un-air-conditioned facility. If the oven plates are less than 50°F (10°C), the water valve is closed, preventing the oven from being cooled more. If this happens, the chiller control temperature has been set too low.
- Electrical: The main circuit breaker on the rear panel of the chassis removes all electrical power from the machine. There are no storage devices (e.g. capacitors) within the machine.
- Pneumatic: The pneumatics is used to operate the Positive Shut-off valves. If there is no air pressure, these valves will close. If the power is removed from the AccuThermo RTP system, then the pneumatic gas valves close automatically.

2.4 UTILITIES INSPECTION

Inspect the system utility connections and sources before switching on the AccuThermo® system.

Visually inspect the following utilities to make sure connections are secure:

- Electrical power.
- Gas-handling inlets.
- Cooling water inlet and outlet for chamber cooling
- Nitrogen or Clean Dry Air (CDA) inlet for system pneumatics
- Pump outlet
- Scrubber connection
- Scrubber Exhaust
- Cooling Exhaust

CAUTION

Make sure the purge outlet is not restricted. If this outlet is restricted, the increased pressure inside the quartz chamber will cause it to break.

Check for possible water leaks at the cooling water inlet and water outlet connections.

If any of the utilities are disconnected or any connections appear to be leaking, correct the problem. Make sure the house scrubber is operating if processing with hazardous gases or processing wafer which outgas.

NOTE

Before applying power to the system, the PC-controller computer must be connected; the purge gas and cooling water must be turned on.

2.5 SYSTEM OPERATION

During system operation, be aware of the following:

- Experimental substrates contain unknown impurities which may outgas during processing.

☠ WARNING

Allwin21 cannot anticipate the number and variety of materials a user may experiment with, and is not responsible for any potential hazards which may result from wafer outgassing.

2.6 MAINTENANCE

During the maintenance operation, observe the following precautions:

- Do not use replacement parts not provided or recommended by Allwin21.

☠ WARNING

Allwin21 is not liable for any damage or injury which may occur when unauthorized parts are used.

- Disconnect power to the system before performing any maintenance activity requiring the removal of access covers.
- Whenever the quartz isolation tube is changed, perform a gas leak test on the process chamber. Replace the O-rings on the isolation tube.

2.7 GAS HANDLING

Be aware of the following cautions when working with gases in the AccuThermo RTP system:

- Only use gases that have been specified for use in the AccuThermo RTP system. Typically these include nitrogen (N_2), argon (Ar), Forming Gas, oxygen (O_2) and helium (He).

CAUTION

Allwin21 Corp. is not liable for the use of gases not recommended by the factory.

- Make sure the specified gases are connected to the proper inlets on the rear panel.

WARNING

Failure to properly connect the gas lines may result in dangerous gas mixture that could cause harm to personnel and/or the system.

WARNING

There will be no chemical exposures during normal routine maintenance. However, if the need arises that a gas valve has to be changed, then it is the maintenance person's responsibility to follow all safety procedures for gas exposure.

2.8 HAZARDS

The AccuThermo RTP system presents certain hazards if operated or maintained improperly. These fall into the following categories:

- Electrical shock hazards
- Process gas hazards
- Process byproduct hazards
- Oxygen hazards
- Thermal hazards.

2.8.1 ELECTRICAL SHOCK HAZARDS

The AccuThermo RTP system requires electrical power which is distributed through the machine. Safety interlocks are installed to shut off electrical power to the system when the cover is removed. Only qualified troubleshooting maintenance technicians should be permitted to work on an uncovered AccuThermo RTP system. Allwin21 assumes no liability for injuries or deaths caused by operation with interlocking devices defeated. Caution and safety measures characteristically taken with AC and DC circuitry are imperative.

2.8.2 PROCESS GAS HAZARDS

An AccuThermo RTP system process may use these two complex process gases: 02 or forming gas (5% to 12% H2 in N2 or Ar), depending on user application. 02 is an oxidant and it supports combustion. It must be handled with care. Forming gas is non-toxic and odorless. It is flammable and never should be stored at 125°F or greater. Inhalation of forming gas should be avoided.

Make sure the forming gas mixture is correct.

2.8.3 PROCESS BYPRODUCT HAZARDS

The process byproducts found in the chamber surfaces of the AccuThermo RTP system should be treated as potentially hazardous.

☠ WARNING

Avoid skin, eye, and respiratory contact with process byproducts. Some byproduct chemistries have hazardous characteristics. Failure to avoid skin, eye, and respiratory contact with process byproducts may result in injury or death of personnel.

Due to the variations in chemistry employed to meet application requirements, the exact constituents of effluents from the process family cannot be defined. However, the following general precautions should be observed:

- Solvent-proof neoprene or viton gloves should be worn while maintaining the chamber surfaces and its accessories.

Allwin21 Corp. claims no responsibility for the safety of the byproducts of the AccuThermo Rapid Thermal Processor system.

2.8.4 OXYGEN HAZARDS

In RTP systems, oxygen (O_2) may be utilized as a process gas, either alone or in conjunction with other gases. A possible EXPLOSIVE condition exists.

Oxygen is an oxidizing agent which vigorously accelerates combustion. Contact with flammable materials may cause fire or explosion. Any time there is heat, and if the concentration of oxygen is greater the 21% of the volume, the condition for an explosion exists. It should be noted this potential condition exists anytime oxygen is connected to the system.

Use appropriate procedures when processing with oxygen.

2.8.5 THERMAL HAZARDS

The quartz tray and quartz isolation tube must be allowed to cool down before they are serviced. Allow 20 to 30 minutes for the system to cool before servicing. Burns may result if the system is touched before it has been allowed to cool sufficiently.

In addition, use of solvents, such as IPA (isopropyl alcohol) or acetone to clean the chamber, may pose a hazard if used while the chamber is still hot.

☜ NOTE

The control system contains three safety shutoffs. The first is a watchdog timer that turns OFF the heating lamps if the control software has been interrupted for more than approximately 2 seconds.

The second shutoff shuts down the heating lamps and the MFC's if the measured temperature is above 1250°C. These high readings indicate that the thermocouple is broken or disconnected from the Controller board, in which case the interface reads something greater than 1250°C.

The third safety shutoff shuts down the heating lamps if the outer chamber walls exceed 65°C. This would only happen if there was no water flow.

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3. SYSTEM START-UP

Chapter 3: Chapter 3

3.1 OVERVIEW

This section describes how to power-up and power-down the AccuThermo RTP system on a daily basis. Prior to applying power to the system, a visual inspection of the facilities is required. It is also recommended that you read the list of safety precautions given in the *Safety Precautions* section of this manual.

To complete the following procedures, you must first be familiar with the use of the menu screens to execute and interrupt a cycle in Run mode.

If any irregularities occur during power-up, power down the system and immediately notify the service engineer in charge.

☠ WARNING

Check the system utility connections and sources before switching on the AccuThermo RTP system.

3.2 UTILITIES INSPECTION

Inspect the system utility connections and sources before switching on the AccuThermo RTP system. Refer to figure 3-1 for the location of each utility connection on the rear of the oven unit.

Visually inspect the following utilities to make sure connections are secure:

- Electrical power.
- Gas-handling inlets.
- Purge Gas outlet.
- Cooling water inlet and outlet for chamber cooling.
- Nitrogen or Clean Dry Air (CDA) inlet for tube cooling.
- Nitrogen or Clean Dry Air (CDA) inlet for system pneumatics.
- Scrubber connection.
- Cabinet Exhaust.

Check the Utilities Specifications in the ***Installation Manual*** for proper settings.

CAUTION

Make sure the purge outlet is not restricted. A restricted purge outlet will cause the quartz isolation tube to over pressurize and it will break.

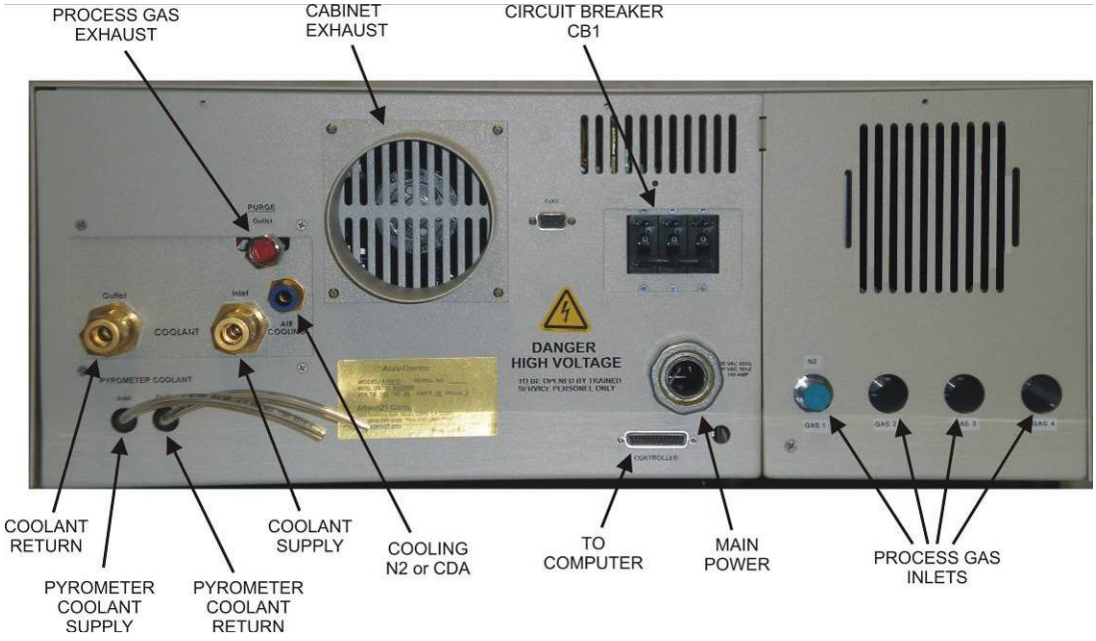


Figure 3-1: *Rear Utility Panel Connections*

Check for possible water leaks at the cooling water inlet and water outlet connections.

If any of the utilities are disconnected or any connections appear to be leaking, have the problem corrected. Make sure the house scrubber is operating if processing with hazardous gases or processing a wafer which outgases.

NOTE

Before applying power to the system, the computer must be connected; the cooling water and cooling air must be turned on.

3.3 FRONT CONTROL PANEL

The front control panel houses the controls and meters that indicates system status and provides manual control over the system. Refer to figure 3-2.

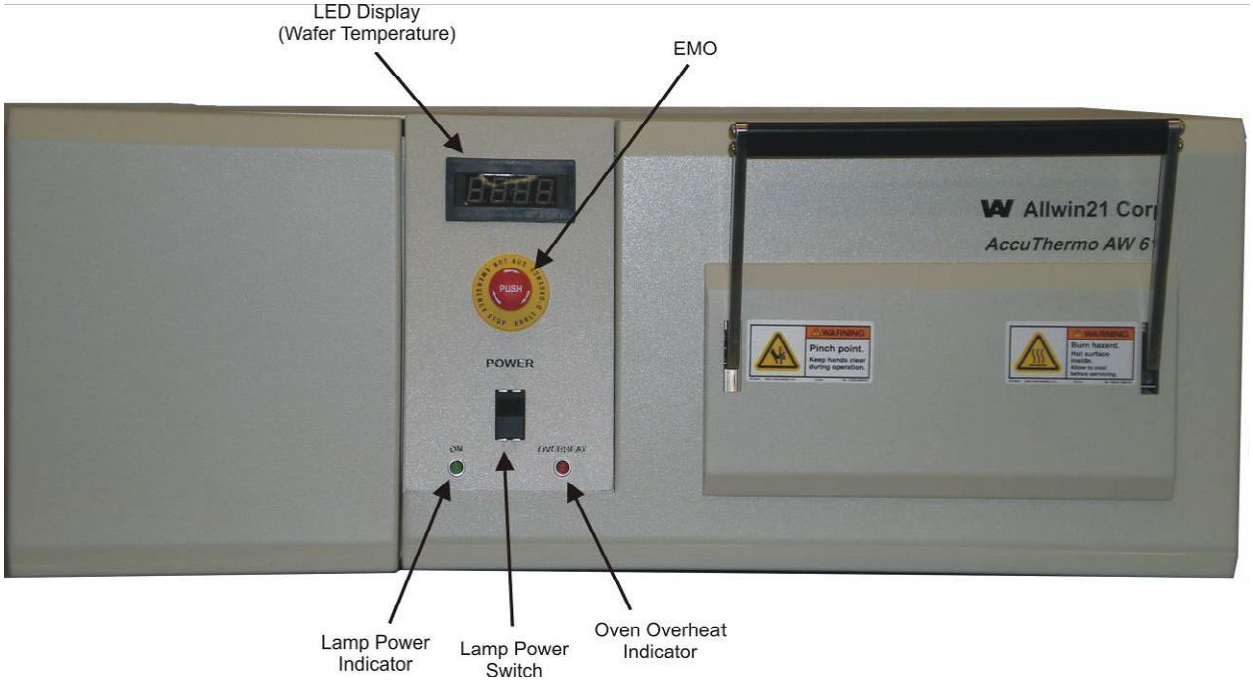


Figure 3-2: *Front Control Panel*

The features of the front control panel are:

LED Display This shows the temperature of the wafer inside the chamber. (Disregard the decimal point.)

EMO (Emergency Off) Shuts down the lamps.

Lamp Power Indicator The green LED indicates when power is available to the lamps for heating the sample inside the chamber.

Lamp Power Switch This ON/OFF switch controls power to the lamps for heating the sample inside the chamber.

Overheat Indicator This red LED is lit when either of the following two conditions occur:

- The outside surface of the oven chamber bottom plate is equal to or greater than 65°C.
- The wafer temperature exceeds the set point of the Wafer High Temperature Interlock.

3.4 POWER-UP, DAILY

The following steps describe the proper power-up sequence for the AccuThermo RTP system after a "Daily Power-Down".

CAUTION

Be alert at all times during power-up. If at any time during these procedures the lamps turn on at high intensity unexpectedly, immediately turn the power switch OFF. The system can very rapidly heat up a wafer until it melts. This can cause extensive damage to the AccuThermo RTP system.

Step 1. Ensure all gas valves are turned off.

Step 2. Make sure the EMO button is reset.

Step 3. Verify there is no restriction to the process exhaust. Verify it is set to the proper requirements.

Step 4. Verify there is no restriction to the cabinet exhaust. Verify it is set to the proper flow rate.

Step 5. Turn on the chamber **cooling water**. Verify it is set to the proper flow rate, pressure and temperature.

Step 6. Turn on the quartz isolation tube **cooling CDA/nitrogen**. Verify it is set to the proper flow rate and pressure.

Step 7. Make sure the pyrometer chiller is on.

Step 8. Check the pyrometer chiller water level.

Step 9. Verify the pyrometer chiller temperature is set to 20 °C.

CAUTION

Do not operate the system under pyrometer control until the pyrometer cooling water temperature has stabilized.

Step 10. Enable the lamps using the front control panel Lamp Power switch. The green Lamp ON light indicates the lamps are enabled. You will also hear a "clunk" when the switch is turned on. This is the sound of the contactor engaging.

Step 11. Open the chamber door about 1 cm. This is a precaution in case there is a problem with the gas control or exhaust.

CAUTION

Open the chamber door 1 cm prior to turning on the process gases. This will ensure the quartz chamber will not over pressurize if there is a problem with the gas system.

Step 12. Turn on the gas valves. Verify the input pressure is set to the proper pressure.

The AccuThermo RTP system is now ready for operation.

3.5 SYSTEM OPERATION

During system operation, be aware of the following:

- The cooling subsystems must be used at all times and should be operational for at least 5 minutes following the last cycle of the lamps.
- Experimental substrates contain unknown impurities which may outgas during processing.

☠ WARNING

Allwin21 cannot anticipate the number and variety of materials a user may experiment with, and is not responsible for any potential hazards which may result from wafer outgas.

CAUTION

Make sure both Water Cooling and Air Cooling are on before doing anything where the lamps will come on. Cooling both the chamber and quartz isolation tube is very important to prevent breaking the quartz isolation tube and destroying the water seals.

3.6 POWER-DOWN, DAILY

The AccuThermo RTP system may be left with power on continuously, unless maintenance to the system requires removing power from the system.

CAUTION

Do Not Power-Down the AccuThermo RTP system unless it has been more than 5 minutes since the last use of the unit. Let the system cool down with cooling water and cooling air.

Step 1. Turn off the gas valves.

Step 2. Turn off the LAMP POWER switch on the oven unit (front control panel.)

Step 3. Turn off the quartz isolation tube cooling CDA/nitrogen.

Step 4. Turn off the oven cooling water chiller if the chiller is dedicated to the AccuThermo RTP system.

Step 5. If any accessories are being used with the system, turn them off as necessary.

NOTE

The pyrometer chiller should be left on to ensure a quick start-up for the next time the system will be used.

NOTE

If the AccuThermo RTP system will be idle for extended periods, it is advisable to do a full power down.

4. BASIC OPERATION

Chapter 4: Chapter 4

4.1 OVERVIEW

The AccuThermo RTP system is a rapid thermal processing system, which uses high intensity visible radiation to heat single wafers for short process periods of time at precisely controlled temperatures. The process periods are typically 1-600 seconds in duration, although periods of up to 9999 seconds can be selected.

NOTE

Process periods longer than 600 seconds in duration are normally used only for maintenance testing purposes at low lamp intensity settings.

These capabilities, combined with the heating chamber's cold-wall design and superior heating uniformity, provide significant advantages over conventional furnace processing.

The wafer to be processed is manually placed on a quartz tray that slides into a quartz isolation tube in the chamber.

The AccuThermo RTP system is fully controlled by a computer running the RTAPRO GUI control software and the front control panel. The RTAPRO software is an advanced control software standard on all Allwin21 AccuThermo RTP benchtop systems.

The RTAPRO uses a set of operating instructions known as recipes to control the AccuThermo RTP system. These recipes are created by the Process Engineer to monitor and control the parameters of the processing cycle. The Operator then uses the software to select and run these recipes.

The RTAPRO software program is also used to create, delete, copy, modify and store the recipes and to execute system diagnostics.

To get an understanding of how to operate the AccuThermo RTP system, you must first be familiar with the use of the menu screens to execute and interrupt a cycle in Process mode. This section provides a discussion of the operation of the AccuThermo RTP system for processing a substrate. Calibration and diagnostics of the AccuThermo RTP system are discussed in the maintenance section.

SOFTWARE FEATURES

The RTAPRO software features the following:

- Closed-loop temperature control with pyrometer or thermocouple temperature sensing.
- Precise time-temperature profiles tailored to suit specific process requirements.
- Fast heating and cooling rates unobtainable in conventional technologies.
- Consistent wafer-to-wafer process cycle repeatability.
- Elimination of external contamination.
- Small footprint and energy efficiency.
- Automated calibration of all subsystems from within the RTAPRO software. This allows faster, easier calibration, leading to enhanced process results.
- Recipe creation. It features a recipe editor to create and edit recipes to fully automate the processing of wafers inside the AccuThermo RTP system process chamber.
- Validation of the recipe so improper control sequences will be revealed.
- Storage of multiple recipes, process data and calibration files so that process and calibration results can be maintained and compared over time.
- Passwords provide security for the system, recipe editing, diagnostics, calibration and setup functions.
- Simple and easy to use menu screen which allow a process cycle to be easily defined and executed.
- Troubleshooting features which allows engineers and service personnel to activate individual subassemblies and functions.
- The RTAPRO software runs on a Pentium class PC computer with a DB-25F parallel (printer) port. The computer interfaces to the AccuThermo RTP system with only one cable: the control interface cable.
- The control board inside the machine that translates the computer commands to control the machine has a watchdog timer. If this board looses communication with the control software, it will shut down all processes and halt the system until communication is restored.

4.2 MENU SCREENS

4.2.1 MENU ORGANIZATION

The operation of the AccuThermo RTP system is by using the computer keyboard, mouse and the graphical user interface (GUI) menu screens of the RTAPRO control software. The easy-to-use menu-driven display enhances reliability and greatly reduces the learning process.

The menu screens are designed to allow straightforward operation. Figure 4-1 illustrates the menu organizational map. It outlines the overall RTAPRO screen architecture.

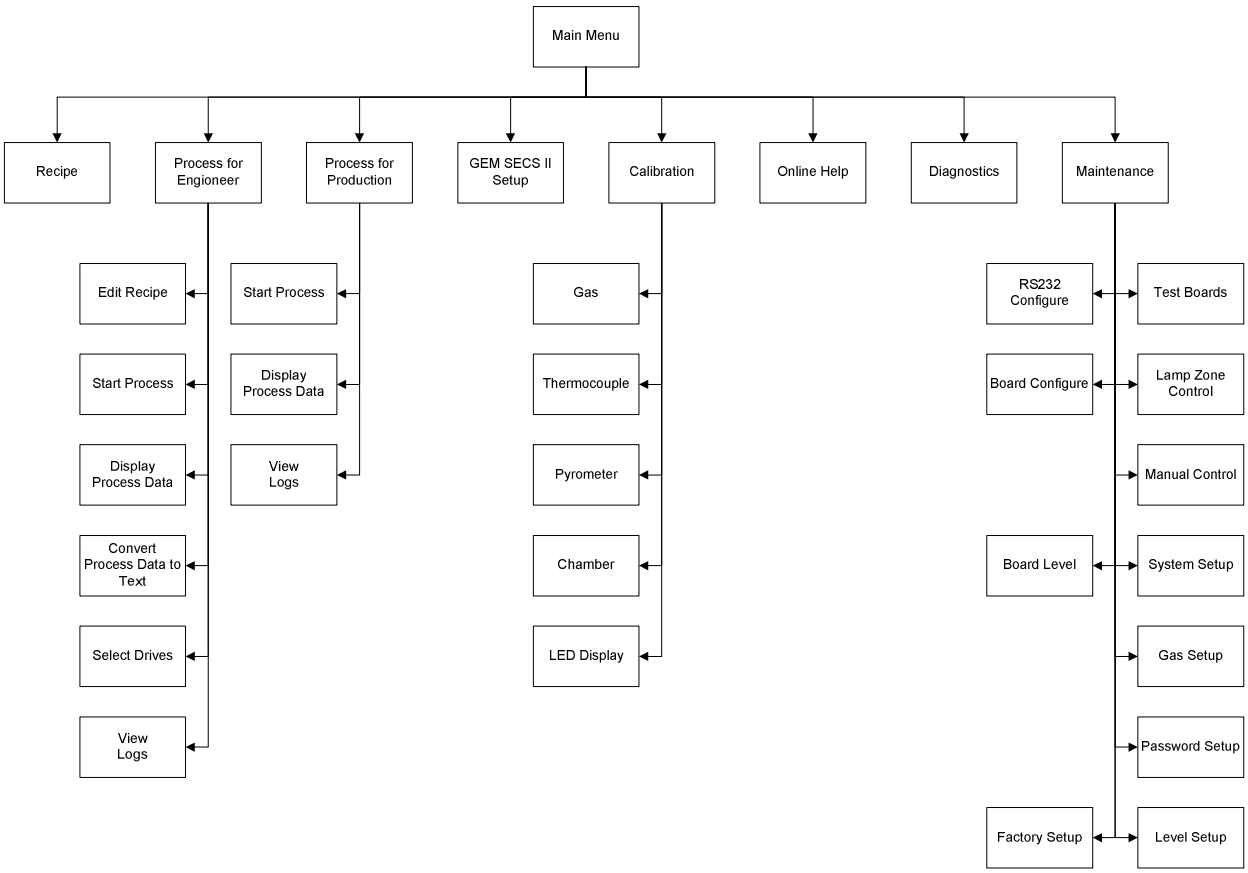


Figure 4-1: *Menu Organizational Map*

4.3 USING THE MENU SCREENS

After a successful power-up, the controller displays the *Main Menu* screen, figure 4-2. From this screen, any mode of operation can be accessed by using the mouse to click on the desired button.

Figure 4-2: *Main Menu*

This section is a general description of how to use the controls of the RTAPRO Control Software. It will cover the use of buttons, editable fields, data display fields and filename lists.

Buttons

Buttons are rectangular boxes with a phrase on them describing their function. They may also have a value on them describing its current state. The color of a button is also important. It also defines the current state of the function of the button. The color, however, is defined by the function of the button. Buttons that are gray in color are inactive and cannot be selected.

Clicking on a button changes its state. Thus, the button may change color and the value describing the current state will change.

Editable Fields

Editable Fields are data entry fields where the operator can enter and change information into the software.

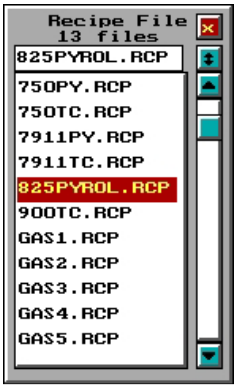
The only keyboard characters that can be entered are the upper case letters, lower case letters, numbers, dash (-) and underscore (_). All other characters are illegal and the entry will be rejected.

To edit the field, the operator must first select it by clicking on it. This enables the ability to edit the field. The operator now types in the desired information and presses ENTER when finished. The information now is displayed in the field, replacing what was there previously.

Data Display Fields

Data Display Fields are very similar to Editable Fields, except the operator cannot change the information being displayed in them. They look just like Editable Fields, except they are like a pushbutton that is always down. Also, when the operator clicks on them, nothing happens.

Filename Lists



Filename Lists display a list of filenames or directories pertaining to the type of information the file contains in a List Box. For example, filenames of files which contain recipes are only displayed in Recipe Filename Lists.

The number of filenames the Filename List can display is limited to its size on the screen. However, there may be more filenames for that type of list than can be displayed at one time. The operator can scroll through the list of filenames by using the slider to the right of the list, or using the up and down arrow keys on the keyboard.

A selected filename is highlighted in red. It may be selected by clicking on the name. It is also displayed in the field above the list of filenames. The operator can also select a filename by manually typing in the filename into the field above the list (refer to Editable Fields above).

A filename can also be deleted. The operator would first select the filename to be deleted. Then the operator would either click on the red box with an 'X' in it  (located in the upper right corner of the List Box) or press the **Delete** key on the keyboard.

NOTE

Deleting a filename will permanently remove the filename and all information it contains.

Exit a Screen

Exit the screen by clicking on the 

button or pressing **ESC** on the keyboard.

Many screens allow the user to change the values for parameters, such as the *Recipe Editor* and the *System Setup*. The user needs to save the information before exiting the screen. However, if the user didn't save the information before exiting the screen, a dialog box will appear asking if the information should be saved.

Click **Yes**	(or press **Y** on the keyboard) to save the information.
Click **No**	(or press **N** on the keyboard) to discard all changes since the last save.
Click **Cancel**	(or press **ESC** on the keyboard) to go back to the editing screen and continue editing. It does not save any changes.

4.3.1 LOG IN

The AccuThermo® RTP system can be setup to have the user log into the control software before it will allow operation. If a password is required, then only the **Log In** button is active. All other buttons have been disabled. Once the user has logged in, the *Main Menu* buttons will be enabled, depending on the user's level of access.

Step 1. Click on the **Log In** button. A pop-up dialog box will appear.

Step 2. Enter in your password and click on OK.

The system log records everyone who logs in and out and what they were doing. During the log in time, alarms might be issued. It is the user's responsibility to safely clear the alarms and remedy the cause.

4.3.2 LOG OUT

Step 1. Click on the **Log Out** button. A pop-up dialog box will appear.

Step 2. Click on OK.

4.4 PROCESS FOR PRODUCTION

The *Process for Production* screen, figure 4-3, is designed for the production operator in mind. It features a limited amount of controls so the operator only needs to press a few buttons to start running a process. It allows the selection and execution of predefined recipes. It also allows viewing graphically the process data.

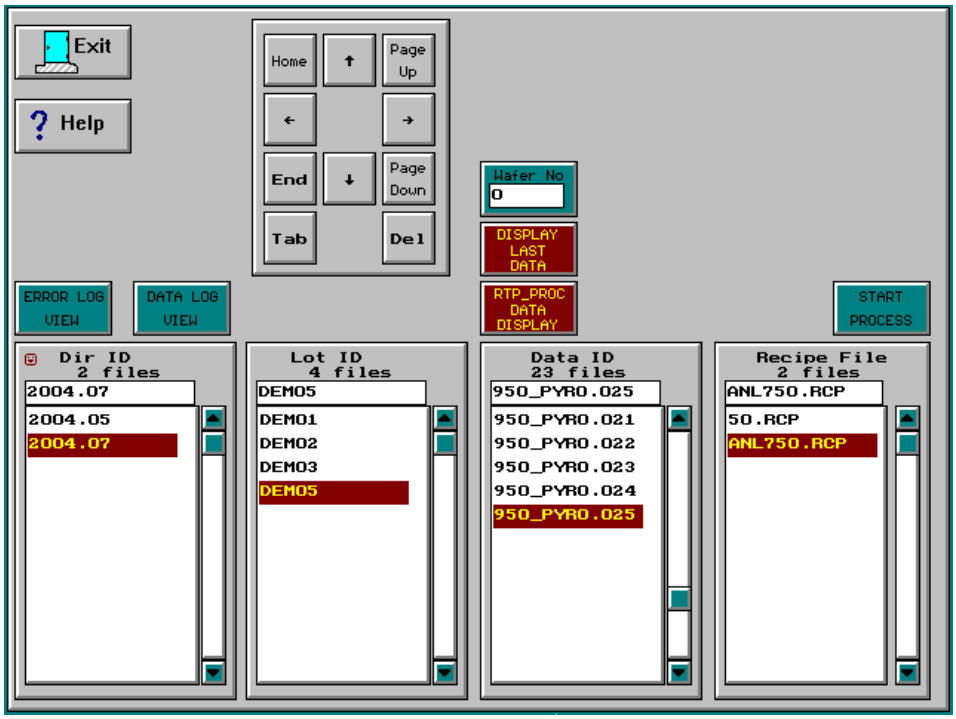


Figure 4-3: *Process for Production screen*

Location: Main Menu ➔ Process for Production

Wafer No 20	The number of wafers that have been processed for the selected recipe. This will be used for the wafer ID for the next wafer that will be processed with the selected recipe.
DISPLAY LAST DATA	View the process data graphically of the last wafer that was processed on the *Process Plotting* screen.
Display Process Data	Display the selected process data graphically on the *Process Plotting* screen.
START PROCESS	Start executing the selected recipe to process the wafer that is in the process chamber.

Dir ID	This groups certain types of lots together.
Lot ID	The user defined lot ID. All process data pertaining to this lot should be kept under here.
Data ID	The process data for each wafer is stored here. The operator can review the process of each of the process data.
Recipe File	This lists the available recipes. The operator needs to select a recipe before processing the wafer.

4.5 PROCESS FOR ENGINEER

The *Process for Engineer* screen, figure 4-4, is designed for the production and maintenance engineers in mind. It is a flexible dialog which allows the engineer to create recipes and process a wafer.

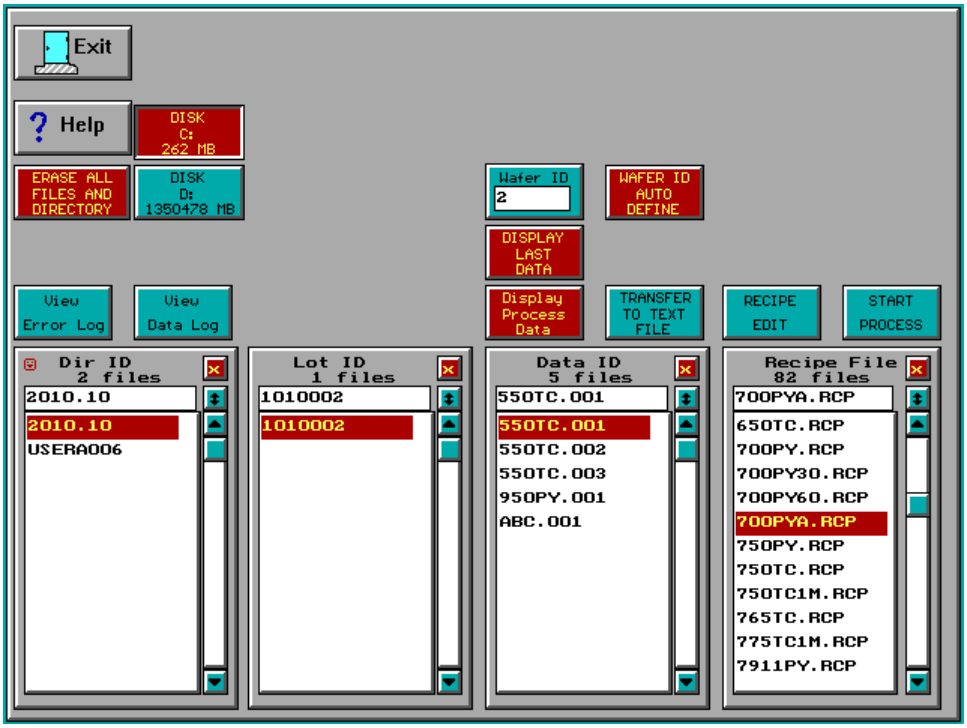
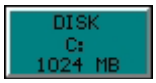


Figure 4-4: *Process for Engineer screen*

Location: Main Menu ➔ Process for Engineer

Wafer ID 3	The number of wafers that have been processed for the selected recipe. This will be used for the wafer ID for the next wafer that will be processed with the selected recipe.
WAFER ID AUTO DEFINE	Automatically increment the "Wafer No." (process wafer number) for the selected recipe, or the user has to manually change the wafer number. **Auto** Automatically increment the process wafer number **Manual** User manually changes the wafer number
DISPLAY LAST DATA	View the process data graphically of the last wafer that was processed on the *Process Plotting* screen.
Display Process Data	Display the selected process data graphically on the *Process Plotting* screen.
RECIPE EDIT	Loads the selected recipe file into the *Recipe Editor* to allow the engineer to modify the recipe.
START PROCESS	Start executing the selected recipe to process the wafer that is in the process chamber.

Dir ID	This groups certain types of lots together.
Lot ID	The user defined lot ID. All process data pertaining to this lot should be kept under here.
Data ID	The process data from each wafer is stored here. The operator can review the process of each of the process data.
Recipe File	The list of recipes which are available to be used to process wafers in the process chamber.

	If drive C: is selected, then all process data will be saved on this drive, and will be listed in the columns below.
	If drive D: is selected, then all process data will be saved on this drive, and will be listed in the columns below. By default, drive D: is selected.
	This function will erase all files and directories from the selected Dir ID.
	View the Error Log.
	View everything in the Log file.

	This function allows the engineer to copy the selected process data as a text file. When in text format, the data can be imported into spreadsheet programs. The full path and drive letter will need to be specified.
 ***(delete)***	Delete Recipes, Data files, Lots and Directories. The delete button is located on each of the list boxes. (Refer to **Filename Lists** in the "How to Use the Menu Screens" section.) It is used to delete the selected item in the list box. Example: To delete a Data File, select the Data File and then click on the red box in the Data File list box. Note: Recipes cannot be deleted from the *Process for Engineers* screen. They can only be deleted from the *Recipe Edit Selection* screen.

4.6 START A PROCESS

The controller uses a set of operating instructions known as recipes to control processing wafers in the AccuThermo RTP system process chamber. These recipes are created by the Process Engineer to control the parameters of the processing cycle. The operator then uses the menu-driven software to select and run the recipe.

The operator can Load and Run a Recipe to process a wafer from the *Process for Production* screen (figure 4-3) or the *Process for Engineer* screen (figure 4-4), whichever security level access the operator has. The *Process for Production* screen is intended for daily operation of the AccuThermo RTP system. This mode is available to all users.

This section will explain step-by-step how to load and run a recipe. This procedure is the same for the *Process for Engineer* screen and the *Process for Production* screen.

CAUTION

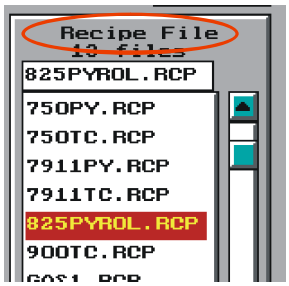
Make sure both Water Cooling and Air Cooling are on before running a recipe. Cooling both the chamber and quartz isolation tube is very important to prevent breaking the quartz isolation tube and destroying the water seals. It also provides consistent processing.

CAUTION

Both the Water Cooling and Air Cooling should be left on at least 5 minutes after the process ends. This is to make sure the oven and chamber have cooled sufficiently.

Step 1. **Select a Recipe**

The first step for using the RTAPRO software is to select a recipe. Select a Recipe from the list of Recipes in the column "**Recipe File**". A highlighted Recipe means it is selected. Use the slider to the right of the list to display Recipes that are not visible in the list window. Click on the Recipe to select it.



Step 2. **Select Where the Process Data will be Stored**

The process data is stored on the hard drive after the process ends. The place on the hard drive it will be stored needs to be specified. Select a "Dir ID" and a "Lot ID" from the list of Directory IDs and Lot IDs.

Step 3. **Run the Recipe**

To run the selected Recipe, click on the **Start Process** button. This will display the *Process Monitor* screen (figure 4-5). When this screen is displayed, the process will begin processing the wafer inside the heating chamber according to the selected Recipe.

4.7 PROCESS MONITOR SCREEN

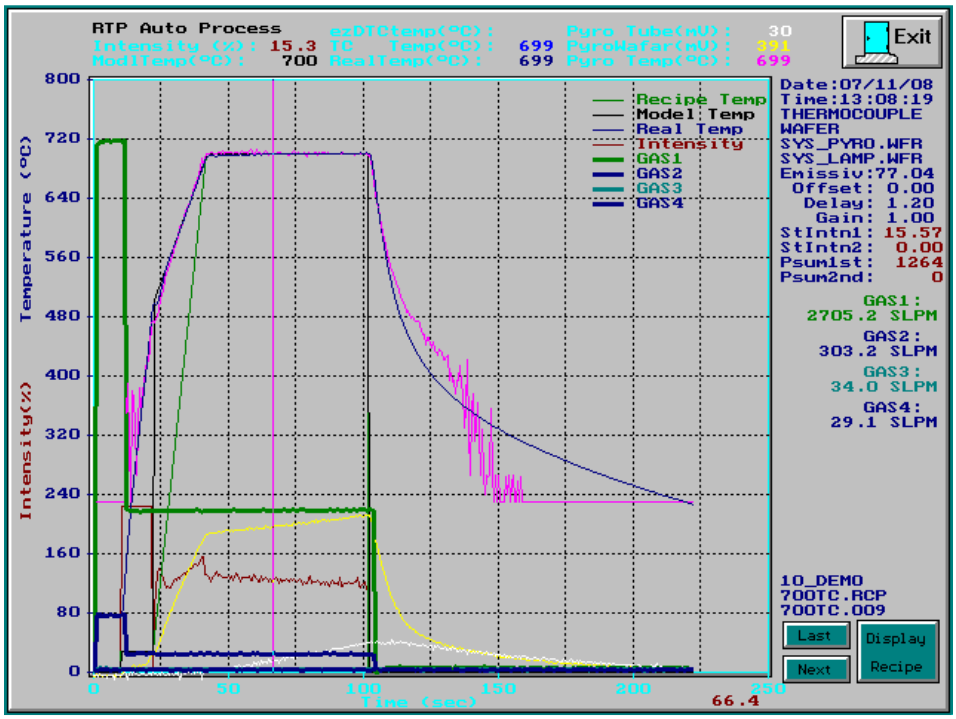


Figure 4-5: *Process Monitor screen*

The *Process Monitor* screen shows a completed process curve. In figure 4-5, the x-axis indicates the process time and the y-axis indicates the measured process temperature. There are four curves to display the monitored process:

During a Process

- The parameters are plotted in real-time.
- The values of the major parameters are shown at the top of the screen.
- The gas values are shown on the right side of the screen.
- The elapsed time is displayed below the lower right corner of the graph.

The colored curves display the different parameters of the monitored process. The gases are drawn as thick lines, while the others are plotted as thin curves.

Green	The recipe temperature as defined by the Recipe.
Black	The Model (ideal) temperature curve.
Blue	The real, measured temperature during the wafer process.
Red	The lamp intensity (power percentage) during the wafer process. The range is from 0 to 100.
Light Blue	The temperature feedback from the thermocouple.
Pink	The temperature feedback from the pyrometer. The temperature from this

pyrometer is not reliable below 450°C.

yellow output (mV) of the pyrometer that is looking at the wafer

white output (mV) of the pyrometer that is looking at the quartz tube

The values for the graph on the left are for the temperature of the substrate in °C. For the other parameters, the full height of the graph represents 100% of their respective range. The process that is represented in figure 4-5, the top of the graph (represented by 800°C) represents 100% of full scale for the other parameters, 0°C represents 0%, and the middle of the graph (represented by 400°C) represents 50% of full scale.

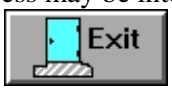
4.8 PROCESS FINISHED

At the end of the process, "Process Over" will be printed over the *Process Monitor screen* and be blinking in different colors.

Press any key and save the process data. This will also exit back to the *Process for … screen*.

If the button "Turn Off Gases After Process" in the recipe is set to NO, then the gases that are on will stay on and flow at the current flow rate. If it is set to YES, then the gases will be shut off.

4.9 STOP PROCESS

A process may be interrupted and stopped by pressing the ***ESC*** key on the keyboard, or clicking on the 

button. This will turn off all process parameters and end the process.

It is best to purge the chamber from the *Diagnostics* screen to make sure all process elements have been purged before the chamber door is open, if the process was interrupted.

CAUTION

Both the Water Cooling and Air Cooling should be left on at least 5 minutes after the process ends or is interrupted. This is to make sure the oven and chamber have cooled sufficiently.

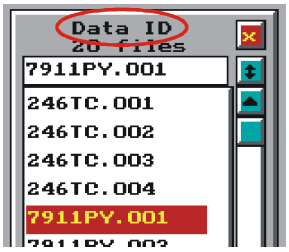
4.10 REVIEW THE PROCESS DATA

To view the process data graphically from the last run, click on the 

(Display Last Data) button. This will display the process data on a screen very similar to the *Process Monitor* screen.

To view process data from a previous run, select the process data to be viewed from the "Data ID" column, and then click on the 

button.



5. ADVANCED OPERATIONS

Chapter 5: Chapter 5

5.1 OVERVIEW

The control software uses a set of operating instructions known as recipes to automatically control the AccuThermo® RTP system. These recipes are created by the Process Engineer to monitor and control the parameters of the processing cycle (steady state temperature, process time, ramp rates, etc.). The Operator then uses the control software to select and run the recipe.

This section is designed for the process and maintenance engineers to create and edit recipes for processing wafers in the process chamber. The Recipe Editor allows specifying temperatures, and gas flow rates. It also allows the fine adjustment of temperature control parameters.

The *Recipe Editor* allows the Engineer to create and edit a Recipe for controlling the process of the wafer in the process chamber. Here, the recipe can be fine tuned to give precise control of the process.

There are global parameters that need to be setup and defined. These parameters are normally set during factory testing and machine installation and never change, unless an option is added or removed. They can be accessed from screens within the control software.

5.2 TEMPERATURE PROFILE STAGES

The temperature profile for any given recipe is shown in figure 5-1. The profile is divided into the following phases:

Delay (Purge)

Intensity (Preheat)

Ramp

Transition

Steady-State

Cool-Down

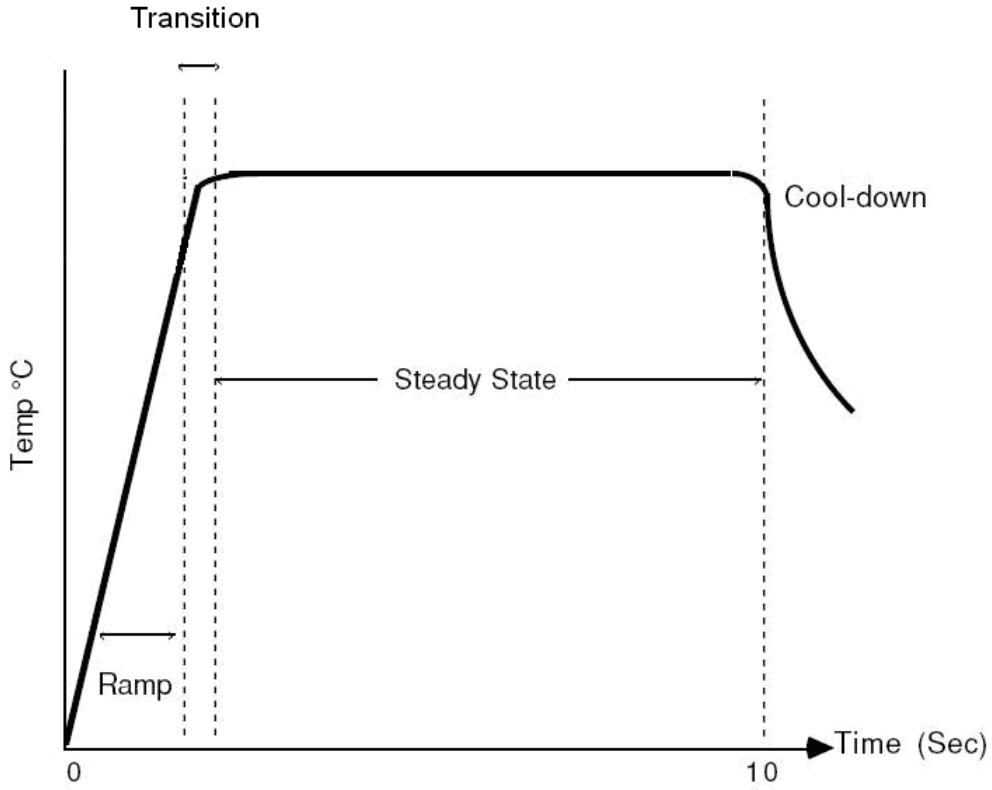


Figure 5-1: *Temperature and Time Profile in a Recipe Cycle*

Stage	Description
Delay	The Delay Stage (not shown in figure 5-1) is used to purge the chamber of ambient air at the beginning of the process by allowing gases to flow. It is also used while the wafer is cooling down at the end of the process.
Intensity	The Intensity Stage (not shown in figure 5-1) preheats the wafer above a temperature that is sufficient for the pyrometer to be reliable. This is normally used if a pyrometer is to be used.
Ramp	The first Ramp of the recipe increases (Ramp Up) the temperature at a controlled rate to a desired setpoint. There can be subsequent Ramps in a recipe, either increasing or decreasing the temperature at a controlled rate to a desired setpoint. During a ramp, the intensity is adjusted to have the real-temperature follow the model-temperature ramp rate.
Transition	The Transition Stage is a stage in which the temperature control changes from a controlled Ramp to a Steady-State control. This transition region starts "Delay" seconds before the programmed steady state value. At the beginning of the transition stage, the lamp intensity is reduced to make the change from Ramp Up to Steady-State. At the end of the transition to the Steady-State, the intensity is adjusted, usually increased, to keep the temperature from decreasing below the setpoint.
Steady-State	This is the Steady step programmed in the recipe. During Steady-State control, lamp intensity fluctuates slightly to keep the temperature constant, within the Steady-State range (±2°C or better).
Cool-Down	When the Steady-State portion of the cycle is completed, the cycle enters the cool-down phase. The rate of cool-down of the wafer is dependant on heat radiation from the ambient chamber temperature and heat dissipation from the wafer. At high temperatures, the wafer cools at a faster rate, initially, than it does at lower temperatures. The cool-down rate is therefore not linear.

5.3 RECIPE PROGRAMMING

5.3.1 OVERVIEW

The control software allows the creation of recipes for automated control of the temperature, and process gas flow.

It uses a set of operating instructions known as recipes to automatically control the AW610V system. These recipes are created by the Process Engineer to monitor and control the parameters of the processing cycle. The Operator then uses the control software to select and run the recipes to control the steady state temperature, process time, ramp rates, gas flow, etc.).

The control software is also used to create, delete, copy, modify and store the recipes.

The recipe editor allows the process engineer to create and edit process recipes for desired temperature profiles, and gas flow rates. The recipe editor allows the selection of the desired temperature feedback device, and adjustment of the process control parameters.

NOTE

Each type of wafer should have its own recipe. Heating depends on the thickness, surface area, size, material, coating and heat conduction of the wafer.

The procedures for creating a new recipe and editing an existing recipe are very similar. These procedures essentially involve loading an existing recipe, editing the recipe's parameters, and then saving the changes. Creating a new recipe also involves changing the **Recipe Name** field, as discussed later in this section.

The steps to create or edit a recipe are:

1) Select a pre-existing Recipe.
2) Edit it.
   (If a new Recipe is to be created, also change the **Recipe Name** field before saving.)
3) Validate the Recipe.
4) Save the Recipe.

5.3.2 SELECTING A RECIPE

The *Recipe Edit Selection* screen, figure 5-2, and the *Process for Engineer* screen, figure 4-4, allow the engineer to select an existing recipe and load it into the recipe editor. The recipe can then be modified or a new recipe can be created based on the selected recipe.

Main Menu button

➔

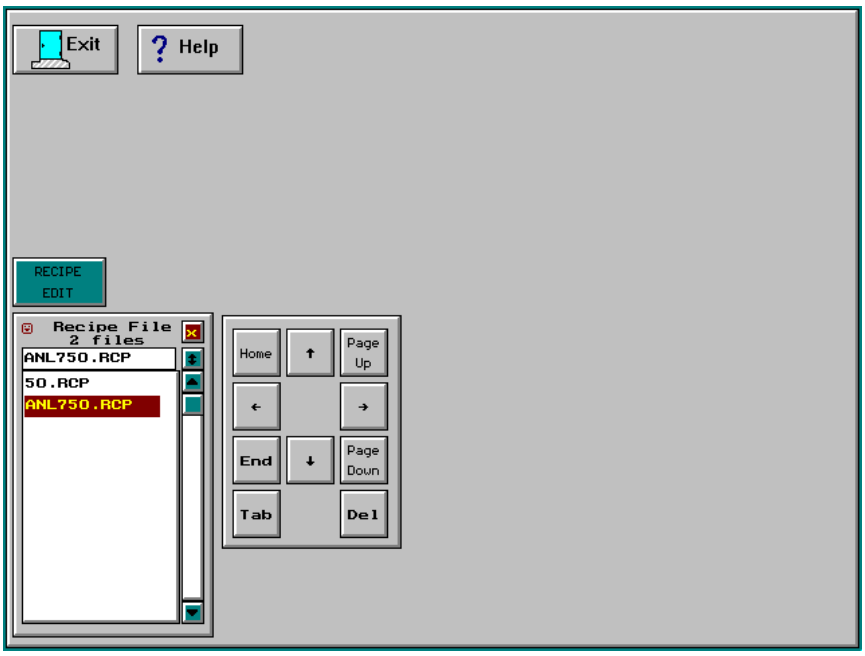


Figure 5-2: *Recipe Edit Selection screen*

Location: Main Menu ➔ Recipe

From the *Recipe Edit Selection* screen:

1) Select a Recipe. Use the slider to the right of the list to display Recipes that are not visible in the list window.
2) Click on the Recipe to select it.
3) Click on the **Recipe Edit** button to load the recipe into the recipe editor and display the Recipe Editor.

Alternatively, a Recipe can be created or modified from the *Process for Engineer* screen. First, select a recipe from the "Recipe File" list. Then click on the **Recipe Edit** button to load the selected recipe into the Recipe Editor.

5.3.3 CREATING A RECIPE

Step 1. To create a recipe, start out by selecting an existing recipe that is similar to the one that will be created.

Step 2. **Change the recipe name.**

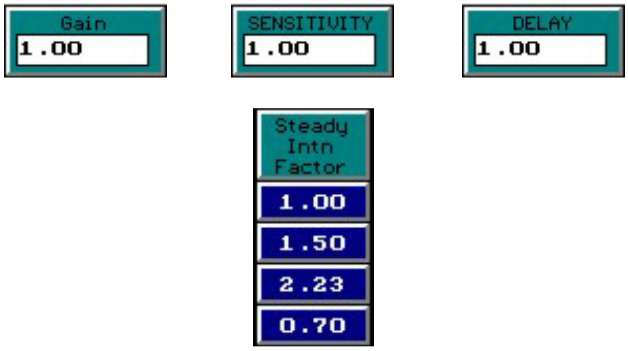
Step 3. Go to the Recipe Header screen by clicking on the button labeled "Recipe Head." Make sure all fields are filled in properly. Make sure all buttons are selected properly.

Step 4. Exit back to the recipe editor and create a recipe that ramps to the desired process temperature.

NOTE

Remember, when the recipe starts, the process chamber is at base pressure.

Step 5. If using the pyrometer as the temperature sensor device, then create an INTN (intensity) step before the first RAMP step. Set all the tuning parameters to 1.00 (GAIN, SENSITIVITY, DELAY, Steady Intn Factor).



Step 6. Specify the pressure for each step. The range of the pressure (in Torr) depends on the range of the baratron. If the step is to process at atmospheric pressure, then enter a value of 760 (760 Torr is atmospheric pressure at sea level).

Step 7. At the end of the process, the atmospheric isolation valve (if open) will close and the process gas valves will also close.

Step 8. Validate the Recipe. If there are no validation errors, the recipe is ready to be used to process wafers.

Step 9. Save the recipe and exit the *Recipe Editor*.

5.3.4 RECIPE EDITOR

The *Recipe Editor*, figure 5-3, allows the engineer to modify and validate the recipe. This editor offers a great deal of flexibility in designing time/temperature profiles to construct process cycles. The engineer can specify variable ramp rates, specify the monitor control temperature, and also specify a gas flow rate for each step.

The *Recipe Editor* is used to create and edit recipes to be run on the AccuThermo RTP system. It is designed like a spreadsheet for easy data entry and readability. The editor is divided into two main sections. The top section (header) is where the engineer inputs information pertinent to the overall recipe. The lower section (data entry area) is for the process recipe data entry.

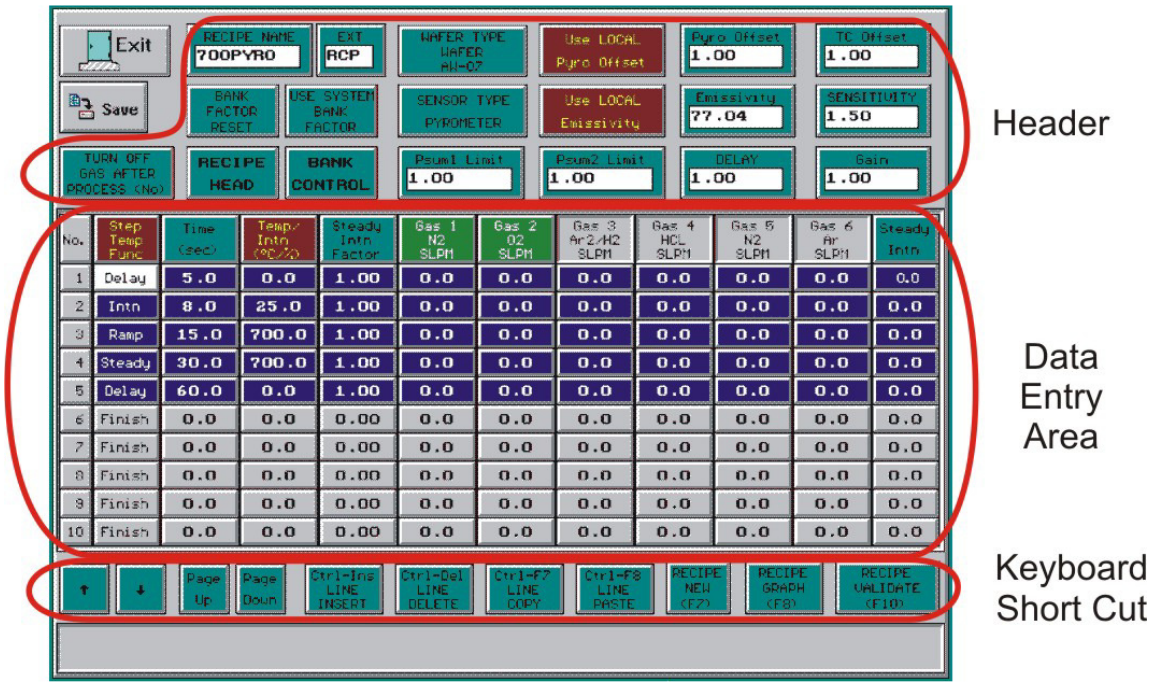
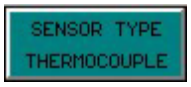


Figure 5-3: *Recipe Editor*

The Header

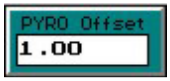
The header is the top part of the *Recipe Editor* and it describes the substrate, the sensor type and performance variables that are used during the entire process cycle of the recipe, along with the Recipe Name.

The Recipe Name can be edited. This should be done if a new recipe is to be created. However, leave the EXT field as RCP. This is the filename extension and the control software expects it to be RCP for a recipe.

	The name of the recipe when it is saved to the hard disk. The Recipe Name can be edited. This should be done if a new recipe is to be created.
	Leave the EXT field as RCP. This is the filename extension and the RTAPRO software expects it to be RCP for a recipe.
	This button toggles between "wafer" and "susceptor". Default value is "wafer". For III-V compound semiconductor wafers, it is necessary to use a susceptor to hold the wafer due to the IR transparency of the wafer.
	The temperature measurement sensor can be toggled between the TC, pyrometer and ezDTC. ezDTC is an option.

CAUTION

Make sure the proper sensor is selected. A selected sensor that is not installed could give low temperature readings. This would make the temperature control increase the lamp intensity too much and may overheat and melt the wafer. The melted wafer could drip onto the quartzware and break it.

	Toggles between the use of the "system" global value or "local" recipe value (Pyro Offset) for the pyrometer temperature measurement correcting offset.
	The "local" recipe value for the pyrometer temperature measurement correcting offset. This only works when the **Sensor Type** is the pyrometer.
	The pyrometer emissivity can use either the "system" global value or "local" recipe value (Emissivity).

The "local" recipe value for the emissivity to be used with the pyrometer. A standard silicon wafer has an emissivity of 77.04.

The software treats emissivity as a factor that offsets the pyrometer temperature reading. If the pyrometer temperature isn't the same as the real processed temperature, then adjusting the emissivity offsets the pyrometer temperature reading.

The five variables (Gain, Sensitivity, Delay, Psum1 Average and Psum2 Average) are for fine tuning the temperature control performance.

The value for the coefficient of the gain in the STEADY period of the recipe. This makes the gain for a STEADY step different from a RAMP step. The gain value for STEADY is GAIN x SENSITIVITY. If the SENSITIVITY value is 1.0, there is no difference between the gain for a RAMP and a STEADY.

This is the value for the transient period from RAMP to STEADY. Normally and default value is 1.0.

The value for the gain of the temperature PID control for the process steps RAMP and STEADY.

This checks the average intensity. If Psum1 is set larger than 10.0 and if the first steady-state step is out of range, then there will be an alarm. If Psum1 is set smaller than 10.0, then the range checking is disabled. To get some statistical data for the normal average intensity of Psum1, Psum1 should be set to 1.0 to disable the alarm.

(refer to PSum in the Process Control Alarms section for a detailed explanation of this parameter)

This checks the average intensity. If Psum2 is set larger than 10.0 and if the second steady-state step is out of range, then there will be an alarm. If Psum2 is set smaller than 10.0, then the range checking is disabled. To get some statistical data for the normal average intensity of Psum2, Psum2 should be set to 1.0 to disable the alarm.

(refer to PSum in the Process Control Alarms section for a detailed explanation)

This button toggles between **Yes** and **No**. **Yes** means that all of the gases will be turned off when the process ends. **No** means the last gas settings will remain on after the process ends. This is beneficial if the last step purges the heating chamber and it is desirable to keep purging the chamber after the process ends.

YES	(red)	turn off gases after the process has ended
NO	(cyan)	keep gases flowing after the process has ended

	This button resets all bank factors to the default value of 1.0. (refer to section ***Zone Control*** below)
	**SYSTEM** (cyan) use the default system zone factors that are defined in the ***Zone Control*** screen **LOCAL** (red) use the zone factors that are defined in the ***Recipe Header*** screen or the ***Page 2 Lamp Zone Control*** screen
	Go to the *Recipe Header* screen.
Page 1 Gas Control **Page 2 Lamp Zone Control**	This button toggles the Data Entry Area between editing the **Process Parameters** and editing the **Lamp Zone Control Factors** for the recipe. **CYAN** Edit the Process Parameters. **RED** Edit the Lamp Zone Control factors for each step of the recipe. The factor range is from 0.021 to 3.0. If the zone factor as defined in the recipe will be used, then make sure the **"Use Zone Factor"** button in the Recipe Header is set to LOCAL.

Data Entry Area

The recipe contains steps or instructions that describe the process cycle. Each step describes the state of the process for a certain amount of time. The steps are defined in the data entry area of the *Recipe Editor*. Up to 40 steps can be defined. Each column of the data entry area describes a parameter that is to be controlled or is used to describe how to control a parameter.

This is the Step Number. It denotes the step number and is non-editable.

This is the Process Function, which describes the type of process function for that step. It can be RAMP, INTN, STEADY, DELAY, or FINISH.

During the Steady step, the controller increases and decreases the lamp intensity so the specified temperature can be maintained. It then maintains that value until the specified time spent in the step has elapsed.

The Ramp step instructs the controller to increase the temperature at a constant rate until the specified temperature has been reached. The rate is calculated by dividing the difference between the temperature specified in the step and the temperature specified in the previous step by the time specified in the step. The starting temperature is the real measured temperature at the time the step started. The gas flow is set to the specified value as in a STEADY step. **The process controller can not do two consecutive RAMP steps.**

The controller keeps the lamp power at a constant intensity during an Intensity step. It is normally used to warm up the wafer above the minimum reliable temperature (MRT) of the pyrometer, since the pyrometer is not reliable below a temperature of 400°C. If an INTN step is followed by a RAMP or STEADY step and the setpoint temperature has been achieved during the INTN step, then the temperature will be maintained at that setpoint.

The Delay step instructs the controller to turn the lamps off while setting and maintaining the setpoint of the other controlled parameters (i.e. Gases), until the specified time spent in the step has elapsed.

Finish ends the recipe. This is the last step in the recipe. Once the process controller sees a "FINISH", it stops all processing.

This is the amount of time, in seconds, to act on the current step. The time can be from 1 - 32000 seconds in increments of 1 second. If there is a need for a step that is longer than 32000 seconds, break the step into two or more steps.

CAUTION

Extremely long, high temperature processes may damage the AccuThermo RTP system.

This is the target temperature or intensity the AccuThermo RTP system strives for.

If the step function is **STEADY,** then this is the set-point temperature that is to be maintained.

If the step function is **RAMP,** then this is the ending temperature of the ramp. The control software will increase or decrease the wafer temperature linearly until the ending temperature is obtained.

If the step function is **INTN,** then this is the percentage of the lamp power intensity.

If the step function is **DELAY,** then this field has no effect if this is a DELAY step. The lamps are turned off during this step.

The Steady Intensity Factor is a coefficient used only during RAMP and STEADY steps. It is used at the beginning of the steps to correct the initial lamp power intensity. Refer to the section for fine tuning the system to understand how to use this parameter effectively.

This is the value for the flow rate of GAS 1 for the system.

This is the value for the flow rate of GAS 2 for the system.

This is the value for the flow rate of GAS 3 for the system.

This is the value for the flow rate of GAS 4 for the system.

This is the value for the flow rate of GAS 5 for the system.

	This is the value for the flow rate of GAS 6 for the system. (This is depicted as being disabled and can not be used in a process.)
	This is a legacy parameter and it is no longer used. It is now a global parameter and it is in the *System Setup screen* as the **Intn Tolerance** field. It is normally less than 20%.

When entering data values into the data entry area, the recipe editor checks for out-of-range entries. If a value is out-of-range, the editor will alert you and will advise you of the proper range.

CAUTION

The total gas flow should not exceed 20 SLPM. Greater than this may rupture the quartz isolation tube.

Keyboard Editing Keys

F2	Save recipe.	
ESC	Exit the *Recipe Editor*.	
Home	Go to the first column of the step.	
End	Go to the last column of the step.	
↑	Move up one line.	
↓	Move down one line.	
←	Move left one column.	
→	Move right one column.	
PgUp	Move up one page.	
PgDn	Move down one page.	
Ctrl + Home	Move to the top of the page yet stay in the same column.	
Ctrl + End	Move to the bottom of the page yet stay in the same column.	
Ctrl + PgUp	Go to the beginning of the recipe.	
Ctrl + PgDn	Go to the end of the recipe.	
Ctrl + Ins	**Line Insert**	Insert a step above the current step.
Ctrl + Del	**Line Delete**	Delete the current step. (click on the step number to select it).
Ctrl + F7	**Line Copy**	Copy the current line into a memory buffer. (click on the step number to select it).
Ctrl + F8	**Line Paste**	Insert a step above the current step and then Paste the step that was copied into the memory buffer into the inserted step.
F8	Show the recipe on a graph.	
F10	Validate recipe.	

While in the process function column (**Step Temp Func**), pressing the first letter of the function name is another way to select the function (i.e. S = STEADY, R = RAMP, I = IDLE, D = DELAY and F = FINISH).

Recipe Header Screen

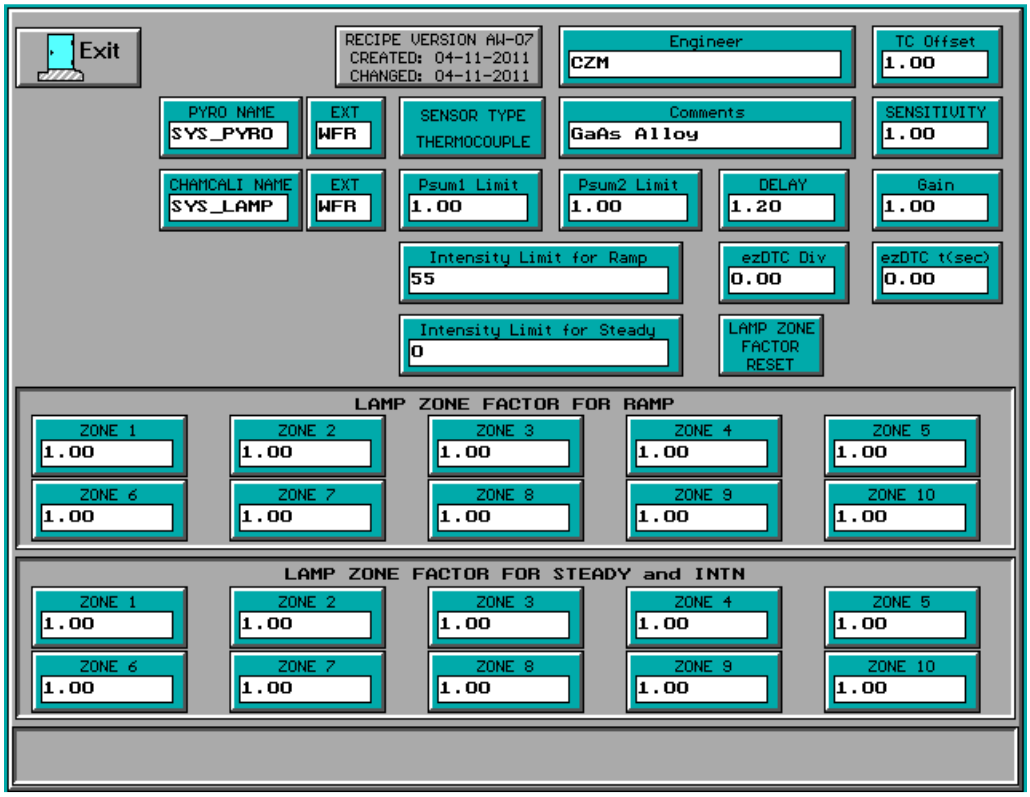
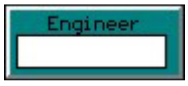
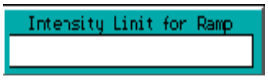
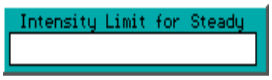


Figure 5-4: *Recipe Header screen*

The *Recipe Header* screen, figure 5-4, has parameters that are used during all steps of the process recipe. Many of the parameters, such as TC offset, Sensitivity, Gain, Delay, Psum1 Limit, and Psum2 Limit, in the top part of the *Recipe Editor* are also shown here, and can also be changed here. Besides these parameters, the *Recipe Header screen* also includes:

	This is the filename of the pyrometer calibration file for this type of substrate. If the substrate is a wafer, then the file extension (EXT) would be **WFR**. If the substrate is a susceptor, then the file extension would be **SPT**.
	This is the filename of the lamp calibration file for this type of substrate. If the substrate is a wafer, then the file extension (EXT) would be **WFR**. If the substrate is a susceptor, then the file extension would be **SPT**.
	The name or initials of the engineer creating the recipe
	A comment field about the recipe
	Intensity Limit for Ramp step (process function)
	Intensity Limit for Steady step (process function)

LAMP FACTOR FOR RAMP	Adjust the intensity of each zone of lamps with respect to the process control intensity during a RAMP step. The value is a factor of the control intensity.
LAMP FACTOR FOR STEADY and INTN	Adjust the intensity of each zone of lamps with respect to the process control intensity during a STEADY or INTN step. The value is a factor of the control intensity.

Validating the Recipe

All recipes have to be validated before they are allowed to run as a process recipe. The recipe is validated by clicking on the 

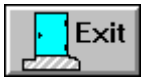
button or pressing **F10** on the keyboard. If the recipe is invalid, an error message will appear. Once the error has been corrected, validate the recipe again. It will check for more errors. All errors need to be corrected before the recipe can be used for processing.

Saving the Recipe

The recipe can be saved at anytime by clicking on the 

button or pressing **F2** on the keyboard.

Exiting the Recipe

Exit the *Recipe Editor* by clicking on the 

button or pressing **ESC** on the keyboard. If exiting the *Recipe Editor* before saving the recipe, a dialog box will appear asking if the recipe should be saved.

(or press **Y** on the keyboard) to save the recipe.

(or press **N** on the keyboard) to discard all changes since the last save.

(or press **ESC** on the keyboard) to go back to the *Recipe Editor* and continue editing the recipe. It does not save any changes.

5.3.5 PROCESS CONTROL ALARMS

Alarm Parameters

The control software has alarm parameters that will cause an alarm if a parameter goes beyond the set tolerance. These alarm parameters will warn of certain conditions developing during the process.

The values of these alarm parameters can be changed by the user to prevent a condition that may ruin a wafer or even damage the machine. It is unlikely the machine will be damaged, though, because it has built-in safeguards.

Refer to the appropriate section of an Alarm Parameter for a greater explanation of these parameters.

The following parameters can be found in the *System Setup* screen.

- MaxTemp (WFR)
- MaxTemp (SPT)
- Trmp Tolerance
- Tstd Tolerance
- ez-P Tolerance
- Psum1 Tolerance
- Psum2 Tolerance
- Intn Tolerance

The following parameters can be found in the *Gas Setup* screen.

- Gas Tolerance
- Check Gas

The following parameters can be found in the *Recipe Editor* screen. More information can be found in the *Recipe Editor Header* section and the *PSum* section of this manual.

- PSum1 Average
- PSum2 Average

PSum

PSum is the integration of the intensity starting from the beginning of a ramp step and ending at the end of the following steady-state step. This, basically, measures the amount of energy applied to the wafer. For the same kind of wafer with the same recipe, PSum with one wafer should be repeatable for another similar wafer, under perfect conditions. Factors affecting repeatability can be a dirty quartz isolation tube, a lamp failure, or an improperly functioning temperature sensor.

After processing several wafers and the processes went well, the engineer can calculate the average PSum from these processed wafers. Processing subsequent wafers will reveal degradation with the machine. If the measured temperature from the sensor is higher than the real temperature of the wafer, PSum will be smaller than the average PSum. If the measured temperature is lower than the real temperature, PSum will be larger than the average PSum. To get the same temperature control if the quartz isolation tube is dirty, PSum will be larger than the average PSum. To get the same temperature control if some of the lamps have degraded or are bad, PSum will be larger than the average PSum.

A recipe can have more than one ramp step followed by a steady-state step. The PSum for the first ramp/steady-state pair is called PSum1. The PSum for the second ramp/steady-state pair is called PSum2. The benefit to using PSum1 and PSum2 is to avoid damaging any single wafer, since it will stop the process during the steady-state steps if Psum1 or Psum2 are out of range. It is believed that only 2 PSum's are needed.

The engineer can set parameters which use the PSum information to alarm and abort the process if PSum1 or PSum2 exceed a specified tolerance from that of the average PSum1 or PSum2. These parameters are **PSum1 Average** (Limit), **PSum1 Tolerance**, **PSum2 Average** (Limit) and **PSum2 Tolerance**.

The average PSum is determined by averaging the PSum from several wafers. Once the average of PSum1 has been determined by the engineer, it can be entered into the **PSum1 Average** field in the *Recipe Editor*. **PSum2 Average** is done the same way for PSum2. **PSum1 Average** and **PSum2 Average** can be any positive value.

The tolerance of PSum is a window that encompasses the average PSum. If PSum is either too large or too small so that it is above or below this window, then an alarm will be issued. The tolerance of PSum is specified as a percentage of the average PSum. Therefore, the tolerance of PSum is **PSum1 Tolerance** or **PSum2 Tolerance**, which are found in the *System Setup* screen. By default, **PSum1 Tolerance** and **PSum2 Tolerance** are set to 20%.

The alarm can be disabled by making **PSum1 Average** and **PSum2 Average** less than 10.0. This is necessary for the first several wafers in order to get some statistical data to determine the average PSum for **PSum1 Average** and **PSum2 Average**.

5.4 TEMPERATURE PROFILE OPTIMIZING

5.4.1 TEMPERATURE CURVES

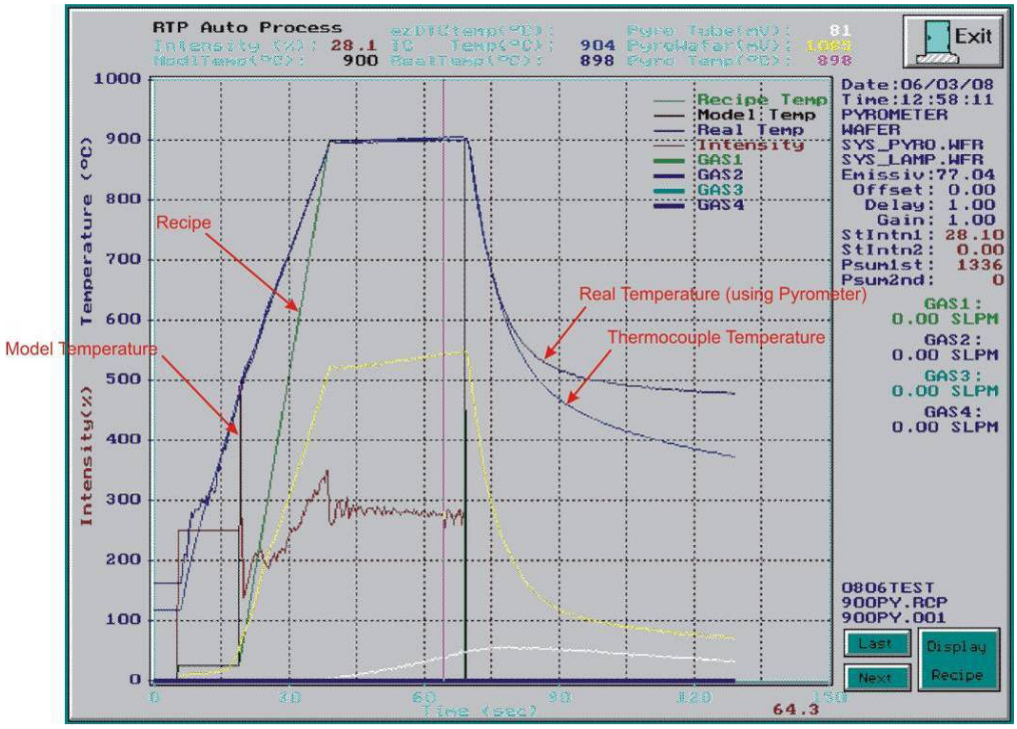


Figure 5-5: *Temperature Curves*

In figure 5-5, the right area of the screen shows the pyrometer has been selected as the temperature feedback sensor to control the temperature. The thin dark blue line plot is the "Real Temperature". It is also the same as the pyrometer.

The selected “Sensor Type” in the recipe determines which temperature feedback sensor will be used as the “Real Temperature”. In this case, the pyrometer is used as the “Real Temperature” sensor. The Real Temperature plot overwrites the pyrometer temperature plot. The light blue line is the thermocouple plot. If the thermocouple was selected as the temperature feedback sensor, then the Real Temperature plot will be the same as the thermocouple plot and the pyrometer plot would be visible as a pink line plot.

The Pink vertical line is an indicator line. It is only shown when the process data is reviewed. It may be moved either left or right by pressing the left or right arrow keys. It can also move to the mouse pointer when the right button of the mouse is clicked. Where ever the pink vertical line intersects a plot, the value of that plot is displayed at the top of the graph. The position this line is at on this plot shows the time to be 64.3 seconds (lower right corner of the graph in red) from the beginning of the start of the process, the intensity to be 28.1%, the model temperature to be 900°C, the real temperature to be 898°C, the TC to be 904°C and the pyrometer to be 898°C.

The first step is a “Delay” step which is used to purge the chamber. The lamps are always off during this step.

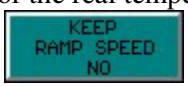
If the pyrometer is being used as the temperature feedback sensor, then it is not advisable to follow the purge step with a ramp step. Below the Minimum Reliable Temperature (MRT), the

pyrometer is “noisy” (refer to the section “Pyrometer Calibration”). This makes it very difficult for the control software to control the temperature at first. Above the MRT, the pyrometer gives a smooth signal, which can then be used to control the temperature and have repeatable results. The temperature of the substrate needs to be raised above the MRT without relying on a temperature feedback from the pyrometer. Therefore, the “Intn” (intensity) step must be used before the ramp step.

The intensity step is used to get the temperature of the wafer above the MRT of the pyrometer, so the system can track the temperature of the wafer reliably. The “Intn” step blindly increases the temperature of the wafer. The person writing the recipe must determine the time and intensity for this step so the temperature doesn’t go too high or is below the MRT when the “Intn” step ends. (There is no need to use the intensity step if the TC has been selected as the temperature feedback sensor, but it does help if a fast ramp is desired.)

The third step is the “Ramp” step. This step increases the temperature of the wafer at a specific rate to the setpoint. This graph shows the starting temperature for the ramp is about 475°C, the Real Temperature.

For this graph, the control software is setup to follow the "Model Temperature" (black plot). The Model Temperature is normally the same as the Recipe Temperature (green plot) except for the first ramp step. Before the first ramp step, the recipe says the temperature is 0°C. But the real temperature is anywhere from 20°C to over 400°C. This depends on the temperature of the system when the ramp starts. At the beginning of the first ramp step, the Model Temperature is "seeded" with the real temperature of the wafer. At this point, a line (internal in the software) is drawn to the setpoint, where the steady step begins. This is the line the process will use to control the rate of the temperature during the first ramp step. This plot is doing exactly what it is suppose to do very well.

If it is desirable for the real temperature to follow only the recipe, then go to the *System Setup* screen and make 

to **YES**. Leaving this **NO** may give better results during the transition.

At the end of the ramp step, the process control transitions for 1-2 seconds to the “Steady” step.

The “Steady” step keeps the temperature of the wafer steady at the setpoint temperature.

This recipe shows that the step after the steady step is a delay step. During the delay step, the lamps are turned off. Now the wafer is naturally cooling. The control software is not controlling the cooling rate of the wafer. This is the fastest cooling rate the wafer can achieve without additional cooling methods. At first, the temperature will drop very fast. After a few seconds, the rate of cooling will slow, as this graph shows. It may take from 5 to 15 minutes for a substrate to cool below 100°C. This depends on the volume, surface area and thermo conduction of the substrate (wafer, susceptor). A small volume with a small surface area will cool much slower than one with a large surface area. A large surface area can exchange its heat energy with the surrounding gas faster. So a susceptor will cool much slower than a wafer.

Most processes are sensitive at a very narrow temperature window. If the temperature is too low, then nothing will happen. If it is too high, then the sample is destroyed. The rate to get to a setpoint temperature isn't as important as how long it is spent at the desired setpoint temperature. Also, the process results are much more repeatable if the first ramp step starts at the same temperature as the real temperature. It is also easier to control the temperature from this point.

5.4.2 RECIPE PARAMETERS

This section guides the process engineer to optimize the temperature control parameters for the recipe. The parameters in the recipe are used to fine-tune the process to provide the desirable temperature profile.

Recipe Parameters optimize the temperature profile. When troubleshooting the temperature control, make sure the following parameters are selected correctly.

- Wafer Type
- Sensor Type
- Pyrometer Calibration File (this is usually the system calibration file)
- Chamber Calibration File (this is usually the system calibration file)
- Emissivity

Wafer Type

This button toggles between "wafer" and "susceptor". Default value is "wafer".

Make sure this parameter is properly selected for the type of substrate that is to be processed.

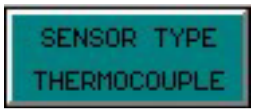
If **WAFER** is selected, but a susceptor is to be processed, then the control will be too week and sluggish, and will undershoot. It may never reach the steady state temperature from a RAMP.

If **SUSCEPTOR** is selected when this recipe is for a wafer, then the control of the temperature will be too strong, and it will overshoot, undershoot and oscillate.

NOTE

For III-V compound semiconductor wafers, it may be necessary to use a susceptor to hold the wafer due to the IR transparency of the wafer. GaAr and InP do need to use a susceptor.

Sensor Type



The temperature measurement sensor can be toggled between the TC and pyrometer. The thermocouple is used for processes below 700°C, while the pyrometer is used for processes between 550°C and 1250°C.

NOTE

Remember, the lamps will automatically shut down if the temperature is above 1250°C. So, if the process temperature is defined to be 1250°C and if there is any overshoot, the lamps will shut down.

CAUTION

Make sure the proper sensor is selected. A selected sensor that is not installed could give low temperature readings. This would make the temperature control increase the lamp intensity too much and may overheat and melt the wafer. The melted wafer could drip onto the quartz ware and break it.

NOTE

There is a difference in response times when running in thermocouple mode versus pyrometer mode. The pyrometer detector has a faster response time which means the temperature control parameters may be different between the thermocouple and the pyrometer.

Pyrometer Calibration File

Also known as "Pyro Name". It is located in the Recipe Header screen.

Enter in the filename of the pyrometer calibration file for this type of substrate. If the substrate is a wafer, then the file extension (EXT) would be **WFR**. If the substrate is a susceptor, then the file extension would be **SPT**.

The default pyrometer calibration file is called "SYS_PYRO".

NOTE

Make sure the proper Pyrometer Calibration file is used. This will reduce the invalid temperature measurement due to the difference in backside roughness and doping.

Chamber Calibration File

Also known as "LampCali Name". It is located in the Recipe Header screen.

Enter in the filename of the chamber calibration file for this type of substrate. If the substrate is a wafer, then the file extension (EXT) would be **WFR**. If the substrate is a susceptor, then the file extension would be **SPT**.

The default pyrometer calibration file is called "SYS_LAMP".

NOTE

Make sure the proper Chamber Calibration file is selected. This compensates for the thermal capacitance of the chamber and substrate.

Emissivity

The Process Engineer needs to provide the system software with empirical information in the form of emissivity. This value compensates for the reflective properties that are different from the "standard" wafer. A standard wafer of pure silicon has an emissivity of 77%.

Compensating for Emissivity

When the pyrometer is used as the temperature sensor for temperature control, the EMISSIVITY compensation must be set to suit the emissivity of the type of wafer being processed.

To determine the correct EMISSIVITY setting, you will need a TC wafer thermocouple assembly or a cantilever thermocouple wafer with its bead in contact with a process wafer. The thermocouple is used to indicate the true temperature in the oven while the oven is run under pyrometer control.

The wafer is heated to the processing temperature that will be used. The output of the thermocouple is read by the control software.

When the steady-state temperature is reached, read the TC temperature. Compare this reading with the pyrometer-indicated temperature. If the readings differ, the EMISSIVITY must be adjusted. The heating cycle and adjustment are repeated until the pyrometer shows the same temperature as indicated by the TC wafer.

If the TC temperature is greater than the pyrometer temperature, then decrease the emissivity.

If the Pyrometer is **less** than the Real Temperature, then **decrease** the emissivity.
If the Pyrometer is **greater** than the Real Temperature, then **increase** the emissivity.

Temperature Control Parameters

The following parameters can be found in the *Recipe Editor*. They are used to reduce and eliminate temperature control problems during a process. These parameters are discussed briefly here. The tutorial is an excellent step-by-step discussion to get a good handle on how and why to adjust these parameters.

	The Gain determines the strength of the temperature control. A strong gain will bring the temperature to the setpoint fast, but it can make the temperature oscillate.
	The Sensitivity is a factor to the GAIN during the Steady step. The Sensitivity determines the strength of the temperature control during the Steady step. A strong Sensitivity will bring the temperature to the setpoint fast, but it can make the temperature oscillate.
	The control algorithm already understands the intensity has to be reduced when the process transitions from a Ramp Up step to a Steady step. The "Steady Intn Factor" helps fine-tune the amount the intensity needs to change. For the beginning of the Steady step, it helps to determine how much to decrease the intensity to hold the temperature at the setpoint.
	This Delay is the time to spend during the transition period. During this period, the temperature control adjusts the intensity so the temperature can make a smooth transition from a ramp step to a steady step.

Lamp Zone Control

The process engineer can tailor the heating of the substrate by controlling the amount of thermal radiation on specific areas, or zones. Each individual zone can be controlled during a process by editing the zone control factor. By default, the factors are 1.0. For 3-phase systems, there are 4 zones: the upper middle zone (Bank 1), upper front and upper back zone (Bank 2), the lower middle zone (Bank 3) and the lower front and lower back zone (Bank 4).

If the uniformity of the wafer is such that an undesirable point is located at a certain zone of lamps, the lamp zone factor for that zone can be adjusted to compensate for the problem. Setting the factor for the lamp zone between 1.0 and 3.0 increases the lamp intensity and causes the temperature to increase, compared to the other zones. Setting the factor between 0.03 and 1.0 decreases the lamp intensity for that zone and causes the temperature to decrease. Default is 1.0.

For example: if the factor for lamp zone #2 is 0.5, then the intensity for the lamps in zone #2 will be 50% as compared to the other zones.

If it is desirable to only heat the top of the wafer or the bottom of the wafer, turn off those zones of lamps by setting the zones to 0.03. This essentially turns off the zone.

The Lamp Zone Control from within the *Recipe Header* screen adjusts the individual zones depending on the specific type of step function.

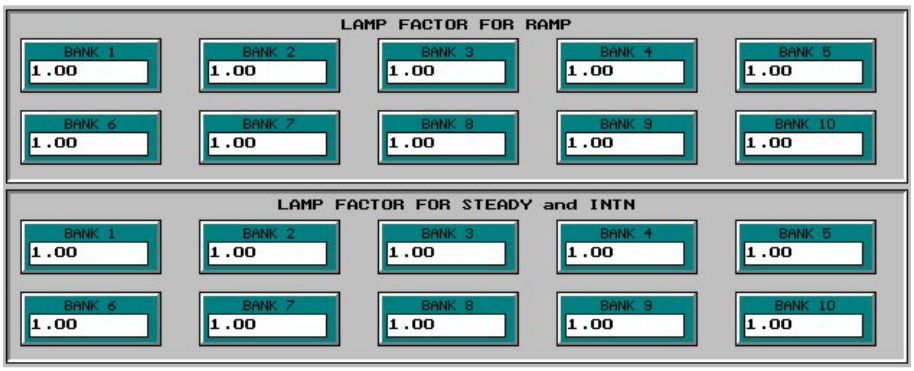


Figure 5-6: *Lamp Zone Factors in the Recipe Header screen*

LAMP ZONE FACTOR FOR RAMP	Adjust the intensity of each zone of lamps with respect to the process control intensity during a RAMP step. The value is a factor of the control intensity.
LAMP ZONE FACTOR FOR STEADY and INTN	Adjust the intensity of each zone of lamps with respect to the process control intensity during a STEADY or INTN step. The value is a factor of the control intensity.

When the **PAGE** button shows 

, then the Recipe Data Area of the Recipe Editor toggles to the *Lamp Zone Control Page*, figure 5-7, of the data area to allow editing the lamp zones for each individual step function.

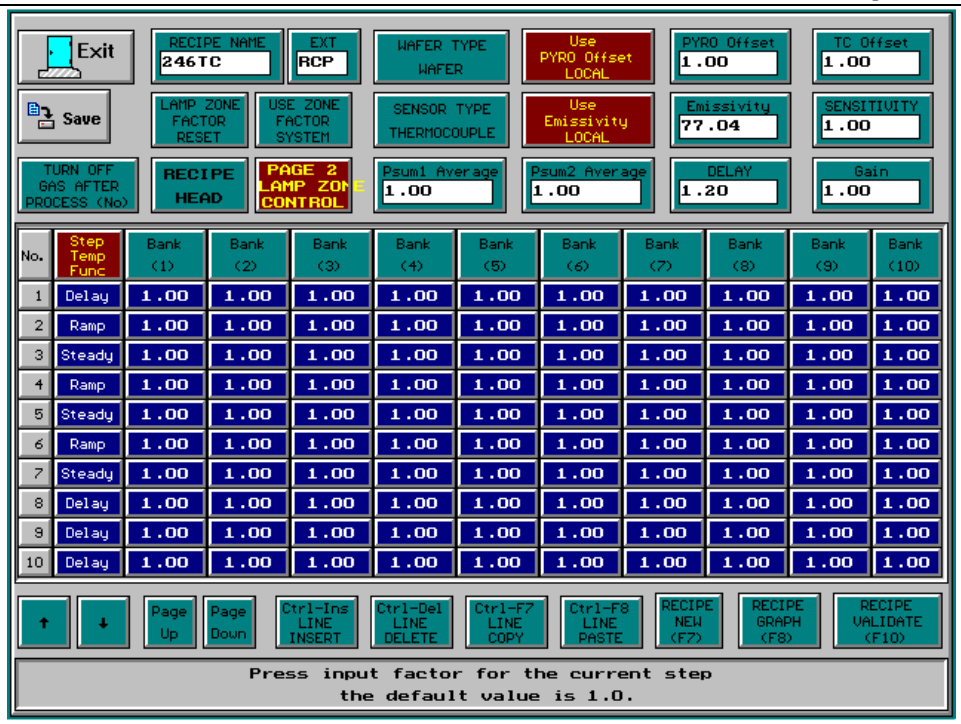


Figure 5-7: *Lamp Zone Control Page*

The factors for each zone in the **Lamp Zone Factors** in the *Recipe Header* screen (figure 5-6) and the *Lamp Zone Control Page* (figure 5-7) are combined multiplicatively. They are multiplied together to create one factor for each step of each lamp zone.

5.4.3 OPTIMIZING THE TEMPERATURE PROFILE

This section guides the process engineer to optimize the temperature control parameters to get the best temperature profile possible for the recipe.

After tuning for one recipe at a medium temperature range for the system, the parameters should be very similar for all the other recipes and wafer type. There would be very little adjustment necessary to tune other recipes if they use the same values for the tuning parameters.

Below gives a step-by-step procedure on how to tune the temperature control to give the best possible temperature profile. After each step, run the recipe to determine the extent the parameter adjustment made on the temperature control and to determine if further adjustment is necessary, before proceeding to the next step.

Review the process data by clicking on the 

button. Move the vertical pink line (using the left and right keyboard arrow keys) so it lines up at a point that is of interest. The values at the top of the screen are the values at the intersection of each curve with the vertical pink line.

Also, the temperature feedback sensor must be smooth and stable. If it isn't, then the temperature control cannot control the temperature well. If the pyrometer is selected as the temperature feedback sensor, then the real temperature has to be above the minimum reliable temperature of the pyrometer, which is usually 400°C, before the first temperature control step (**RAMP** and **STEADY**) begins.

Step 1. CREATE A RECIPE

Start out by creating a recipe that ramps to a process temperature. Refer to the section ***Creating a Recipe***.

Step 2. ADJUST THE INTN STEP

If using the pyrometer as the temperature sensor device, an ***INTN*** (intensity) step must precede the first **RAMP** or **STEADY** step.

Run the recipe until the ***INTN*** (intensity) step ends.

If the real-temperature is not above the minimum reliable temperature for the pyrometer (usually 400°C, refer to the section for calibrating a pyrometer), either increase the ***INTN*** step time or increase the intensity value.

If the real-temperature is far above the minimum reliable pyrometer temperature, either decrease the ***INTN*** step time or decrease the intensity value.

It also helps if the rate the temperature is increasing is close to the rate the process engineer desires.

Step 3. **ADJUST THE GAIN**

Run the recipe until the **RAMP** step ends. Observe the Real-Temperature curve (blue) and Intensity curve (red). The Real-Temperature curve should follow the Model-Temperature curve (black) very closely. The Intensity curve should not have large spikes and oscillations, except during the first 2 seconds.

NOTE

The real-temperature must be under control and be smooth and stable when the RAMP step ends. If not, tuning the recipe to get reliable and consistent results will be impossible.

If the real-temperature is oscillating as it ramps up, the transition from the **RAMP** step to the STEADY step will be different every time the process is run, then it will be impossible to tune the temperature control parameters.

If the real-temperature doesn't follow the model-temperature, adjust the GAIN by a value of 0.20 (0.6, 0.8, 1.0, 1.20, 1.40, etc.) until it does. Smaller adjustments can be used if necessary. Increase the ***GAIN*** if it is always too low. Reduce the ***GAIN*** if it is always too high.

If the intensity is too volatile (oscillates with large spikes), decrease the ***GAIN*** by decrements of 0.20 (1.40, 1.20, 1.00, 0.8, 0.6, etc.) until the spikes are small, yet the real-temperature should follow the model-temperature closely.

Step 4. **ADJUST "STEADY INTN FACTOR" FOR STEADY**

Now, adjust the value of the ***Steady Intn Factor*** for the **STEADY** step so the temperature doesn't overshoot or undershoot. If the temperature overshoots during testing of the recipe, reduce this value. If it undershoots during testing, increase this value. Do this in increments of 0.10. Use your judgment if you feel it needs to be adjusted more than 0.10 (0.20, 0.30, etc.).

To get an idea of how much to change it, review the process data by clicking on the **Display Last Data** button. Move the vertical magenta line (using the left and right keyboard arrow keys) so it lines up at the point the temperature starts to transition from the **RAMP** to the **STEADY** step (the intensity will suddenly drop at least 5-10% or more). Take note of the intensity. Next, move the vertical line to a point where the intensity is relatively stable during the **STEADY** step. Take note of this intensity. These 2 intensities should be almost the same value. Use the following formula to calculate the ***Steady Intn Factor***.

SIF2 = (I1/I2) * SIF1

where:

I1	intensity that is relatively stable during the **STEADY** step
I2	the intensity at the beginning of the transition, when it first decreases
SIF1	the current ***Steady Intn Factor*** for the Steady Step
SIF2	the new calculated ***Steady Intn Factor*** for the Steady Step

Normally if the chamber was calibrated with current facility conditions, this factor should be close to 1.0. This value should be between 0.5 and 2.0.

Step 5. **ADJUST DELAY**

If the temperature always overshoots, increase the value in the DELAY field at the top of the screen by increments of 0.20. If the temperature always undershoots (levels out before getting to the setpoint temperature), decrease the DELAY. You may have to adjust the **Steady Intn Factor** again.

Step 6. **ADJUST THE SENSITIVITY**

Once the **GAIN** is tuned, adjust the ***SENSITIVITY***. Adjust the ***SENSITIVITY*** so the temperature during the **STEADY** step is smooth and stable at the setpoint.

Run the recipe for about 5 – 10 seconds into the **STEADY** step. Observe the Real-Temperature curve and Intensity curve. The Real-Temperature curve should follow the Model-Temperature curve very closely. The Intensity curve should not have large spikes and oscillations.

If the real-temperature doesn't move to the setpoint quickly and control to the model-temperature, adjust the ***SENSITIVITY*** by increments of 0.20 (0.6, 0.8, 1.00, 1.20, 1.40, etc.) until it does. Smaller adjustments can be used if desired. Increase the ***SENSITIVITY*** if the temperature is always too low. Reduce the ***SENSITIVITY*** if it oscillates too much.

If the intensity is too volatile (oscillates with large spikes), decrease the ***SENSITIVITY*** by decrements of 0.20 (1.40, 1.20, 1.00, 0.8, 0.6, etc.) until the spikes are small.

The temperature should flatten-out and be stable once the real-temperature reaches the steady setpoint temperature.

Step 7. **FINE TUNING**

Once the ***Steady Intn Factor***, **DELAY** and **SENSITIVITY** parameters have been roughly tuned for the **STEADY** step, adjust them even finer, until they are acceptable.

5.4.4 TROUBLESHOOTING THE TEMPERATURE PROFILE

This section will describe the common problems with temperature control and how to correct them. These problems are temperature oscillation, overshoot and undershoot.

When diagnosing temperature control problems, refer to the process data graph and use the pink vertical line to help understand the situation. The pink vertical line can be moved with the left and right keyboard arrow keys and moving the mouse pointer to a position on the graph and clicking the left mouse button.

NOTE

Refer to the section "*Temperature*" in the "*Troubleshooting*" chapter for further information to troubleshoot the temperature response problems.

Oscillation

Oscillation occurs when the wafer temperature does not stabilize within the steady state or ramp, as shown in figure 5-8. This problem is cause by the temperature control over compensating the intensity to try to get the wafer temperature to the setpoint.

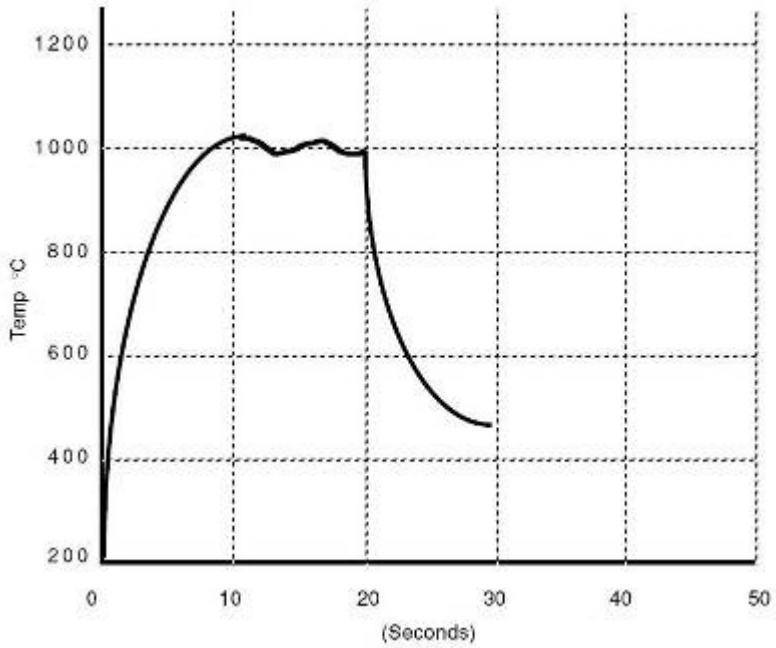


Figure 5-8: *Oscillations*

- During the Ramp step,
  - short period oscillations are eliminated by decreasing **GAIN**.
  - long period oscillations are eliminated by increasing **GAIN**.
- During the Steady step:
  - short period oscillations are eliminated by decreasing **SENSITIVITY**.
  - long period oscillations are eliminated by increasing **SENSITIVITY**.

Remember, **SENSITIVITY** is dependent on the **GAIN**. Therefore, if the **GAIN** has been changed, **SENSITIVITY** may also have to be changed.

Be careful. The oscillation of the intensity needs to be controlled. If it spikes too much, the gain needs to be reduced.

Overshoot

An overshoot is when the wafer temperature exceeds the steady state temperature during a transition and then drops back down to the steady state setpoint, as shown in figure 5-9.

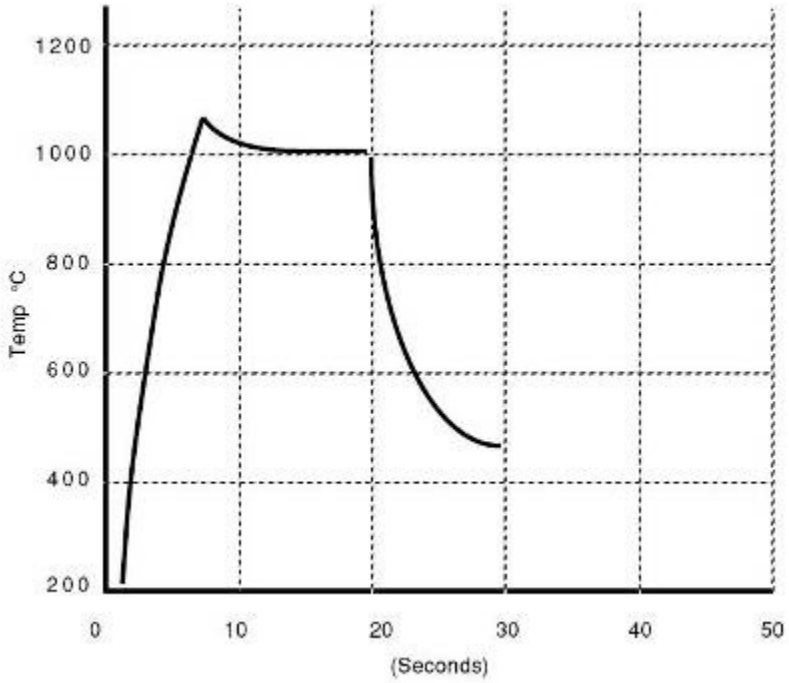


Figure 5-9: *Overshoot*

The following variables can be changed to compensate for an overshoot. Change only one variable at a time and run a few cycles. If the overshoot still occurs, change another variable.

- If the temperature is oscillating during the Ramp Up, there would be a good chance an overshoot would occur. Decrease the **GAIN** until the oscillation is eliminated (refer to the oscillation section above).
- If the overshoot is caused by the intensity being too high during the transition, decrease ***Steady-Intn-Factor*** for the RAMP step. The temperature at the end of the transition should be exactly the same as the setpoint for the Steady step.
- If the overshoot is caused by the intensity being too high at the end of the transition, decrease ***Steady-Intn-Factor*** for the STEADY step.
- If the overshoot cannot be controlled during the transition by decreasing the ***Steady-Intn-Factor*** for the RAMP step, the transition may be too short. Increase the value in the **DELAY** field.

Undershoot

An undershoot occurs when the transition from Ramp to Steady-State is too gradual and the temperature takes too long to get to the Steady-State setpoint, as shown in figure 5-10.

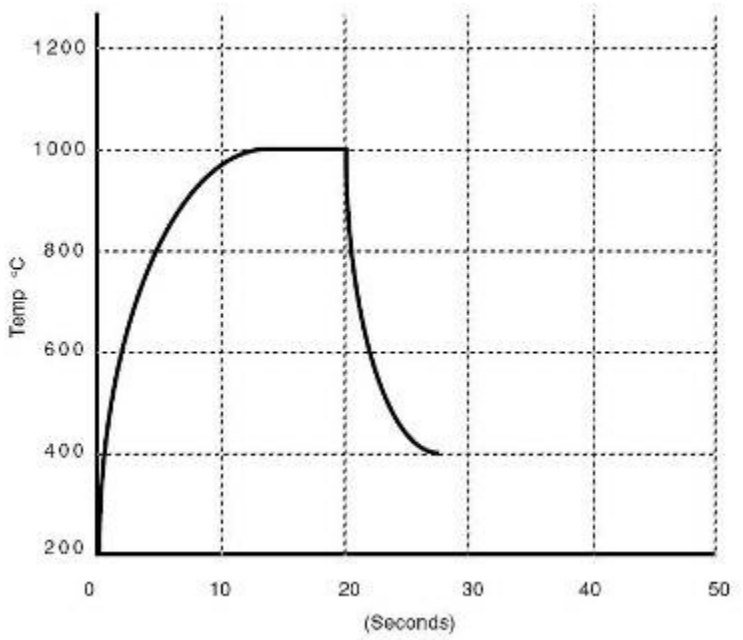


Figure 5-10: *Undershoot*

The following variables can be changed to compensate for an undershoot. Change only one variable at a time and run a few cycles. If the undershoot still occurs, change another variable.

- If the real-temperature is oscillating during the Ramp Up, there would be a good chance an undershoot would occur. Decrease the **GAIN** until the oscillation is eliminated (refer to the oscillation section above).
- If the real-temperature is sluggish during the Ramp Up and not reaching the model-temperature, increase the **GAIN** until the real-temperature follows the model-temperature.
- If the undershoot is caused by the intensity being too low during the transition, increase ***Steady-Intn-Factor*** for the RAMP step. The temperature at the end of the transition should be exactly the same as the setpoint for the Steady step.
- If the end of the transition reaches the setpoint temperature, but there is a dip at the beginning of the Steady step, the intensity is too low at the end of the transition. Increase ***Steady-Intn-Factor*** for the STEADY step.
- If the ***Steady-Intn-Factor*** for the Ramp and Steady steps are large, then the value in the **DELAY** field may be too large. Decrease the value in the **DELAY** field.

5.5 TROUBLESHOOTING THE PROCESS CONTROL

NOTE

For information on troubleshooting the process refer to the "*Troubleshooting*" chapter.

6. FILE ADMINISTRATION

Chapter 6: Chapter 6

The *Process for Engineer* screen includes 2 additional buttons for file administration:

	See the section for the *Process for Engineer* screen.
 ***(delete)***	See the section for the *Process for Engineer* screen.

6.1.1 FILE EXTENSIONS

The manual recommends using "RCP" for recipe extensions, but the software does not force you to do this. "RCP" makes it easier for a user to determine the type of file based on its extension. The software, however, separates the different types of files into their respective directories. So it really depends on which directory the file came from that determines the type of file it is, according to the software. However, you don't want to put a calibration file into the recipe directory. It will be listed in the "Recipe File" list box. But if you try to load it into the recipe editor, it will give unpredictable results.

Recommended extensions:

RCP	recipes
WFR	calibration files for a wafer
SPT	calibration files for a susceptor
001 - 999	process data files

6.1.2 SUGGESTED ID NAMES

The following are suggested names for the “DIR ID” and the “LOT ID”. There are many other categories that can be used. The only restriction is these names cannot exceed 8 characters in length.

DIR ID

Person’s Name
Date
Batch
Class Designation

LOT ID

Date
Lot ID
Batch ID

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7. TOPICS FOR DISCUSSION

Chapter 7: Chapter 7

7.1 REQUIREMENTS FOR GOOD PROCESSING

There are a few things to consider when setting up the RTA system and creating a recipe to get good results.

7.1.1 ADEQUATE AIR COOLING

Having adequate air cooling is necessary to cool the quartz tube, otherwise it becomes a secondary heating source and the heating may not be uniform. Measuring the **VOLUME** of air flow cooling the quartz isolation tube and lamps is necessary. Sufficient and consistent air flow can only be determined accurately with an air flow meter (see the ***Chamber Cooling Air*** section in the ***Installation*** chapter). If there are multiple systems on the same CDA line, then the tubing has to be large enough to adequately supply a sufficient and a constant amount of air to **ALL** systems at all times. (See the ***Adequate Tubing Size*** section of this chapter).

The tubing diameter needs to be large enough to supply an ample amount of CDA to adequately cool the quartz isolation tube and lamps at all times.

7.1.2 MEASURING TEMPERATURE

The temperature of a wafer is not 100% uniform over its entire surface and volume. This is due to contaminants, heat dissipation rates, density of the material, thickness of the material, etc. (See the ***Measuring Temperature*** section in this chapter) Also, during heating, the edge of the wafer is hotter than the middle. During cooling, the edge is cooler than the middle of the wafer. During a steady heating step, the middle will eventually become hotter than the edge. Therefore, the temperature of the wafer is never the same at any 2 points at the same time.

7.1.3 THE INTENSITY STEP

The intensity step is mainly used to get the temperature of the wafer above the MRT (Minimum Reliable Temperature) of the pyrometer. It can also be used to help get the temperature to start ramping when the wafer is cold (room temperature). If the intensity step is not adjusted properly, it can give bad results. The MRT of the pyrometer is usually around 400°C. If the process temperature is close to the MRT, then getting repeatable results will be difficult. If the intensity is too high, it is easy to get overshoots of the temperature. If the intensity step ends while the temperature is below the MRT, then there could be strong erratic oscillations of the intensity and temperature. It is best to have the temperature increase as slowly as possible, but not too slowly that it would affect the process results. Having the temperature increase slowly gives the temperature controller more time to reduce the intensity to make a smooth transition once the intensity step ends. It also takes time for the lamps and system to cool sufficiently so it doesn't continue heating. Remember, there is no temperature control during an intensity step.

7.2 TEMPERATURE

It can be said that the actual temperature is not the same as the measured temperature.

7.2.1 WHAT IS TEMPERATURE?

Temperature is a measure of the average energy of motion, or kinetic energy, of particles in matter. When particles of matter, whether in solids, liquids, gases, or elementary plasmas, move faster or have greater mass, they have more kinetic energy, and the material appears warmer than material with slower or less massive particles. In the context of thermodynamics, kinetic energy is also referred to as *thermal energy* and the transfer of thermal energy is commonly referred to as heat. Heat always flows from regions of higher temperature to regions of lower temperature. When matter is described as a collection of a large number of particles, it derives thermodynamic parameters as statistical averages of the microscopic parameters of the particles.

On the molecular level, temperature is the result of the motion of particles which make up a substance. Temperature increases as the energy of this motion increases.

Molecules, such as O_2, have more degrees of freedom than single atoms: they can have rotational and vibrational motions as well as translational motion. An increase in temperature will cause the average translational energy to increase. It will also cause the energy associated with vibrational and rotational modes to increase. Thus a diatomic gas, with extra degrees of freedom (rotation and vibration), will require a higher energy input to change the temperature by a certain amount, i.e. it will have a higher heat capacity than a monatomic gas.

The temperature of a system rises (kinetic energy increases) when it receives heat. Similarly, a loss of heat from the system tends to decrease its temperature.

When two systems are at the same temperature, no heat transfer occurs between them. When a temperature difference does exist, heat will tend to move from the *higher*-temperature system to the *lower*-temperature system, until they are at thermal equilibrium.

Temperature is the measure of the average kinetic energy of the molecules of a substance: the greater the kinetic energy the higher the temperature.

An increase in temperature is an increase of heat. Also, an increase in temperature means the kinetic energy of the molecules is increasing.

7.2.2 MEASURING TEMPERATURE

Measuring the temperature of a substance changes its kinetic energy at the point of contact. The point of contact transfers energy from the hotter material to the colder material. This means heat is removed from the hotter material to increase the temperature of the colder material.

If a thermocouple is positioned so it is touching a wafer, the thermocouple is exposed to the same heating source as the wafer. Therefore, the thermocouple is also being heated. Now, which one is hotter, the thermocouple or the wafer, or are they the same temperature?

At the point of contact, the kinetic energy is the same. The thermodynamics is at equilibrium at this point. However, the point of contact is a very small area, usually a few thousands of an inch square. The surrounding area is trying to become at equilibrium with the point of contact. It is

either removing energy from this point or transferring energy to this point. Over a large area, the energy at this point is different by the induced heating or cooling of the thermocouple.

A thermocouple by its nature is constantly removing heat from a system. It needs to generate electrical energy so external systems can measure the temperature.

Measuring the temperature also depends on the thermo conduction of the contact point. A bare thermocouple touching a bare wafer is different than a thermocouple that is embedded into a wafer with a ceramic paste. The embedded thermocouple does not touch the wafer directly. There is a layer of ceramic material between the thermocouple and the wafer material. Also, the ceramic material is shielding the thermocouple from being directly heated by the heating source.

Therefore, measuring the temperature with a thermocouple is an approximate value. There are many variables that affect the measuring of the temperature. If multiple thermocouples are used at different places on the surface of the wafer, they will all measure different temperatures for the same amount of heating. For instance: the edge will always heat faster and cool faster than the center of the wafer.

There are several variables that would affect the difference in front-side vs. back-side temperatures. Here are a few:

1) the thickness of the wafer
2) the surface coating
3) the material of the wafer
4) the crystalline structure
5) heat transfer rate

These factors and others have not been taken into account for the difference in temperature at different points, also known as the temperature uniformity of a wafer.

7.2.3 UNIFORMITY

Uniformity is the uneven temperature distribution within the surface of the wafer.

Temperature Distribution
The temperature of a wafer is not 100% uniform over its entire surface and volume. This is due to contaminants, heat dissipation rates, density of the material, thickness of the material, and other variables that are mentioned above.

During heating, the edge of the wafer is hotter than the middle. During cooling, the edge is cooler than the middle of the wafer. During a steady heating step, the middle will eventually become hotter than the edge. Therefore, the temperature of the wafer is never the same at any 2 points at the same time.

The difference in temperature can be reduced by ramping slowly. It can also be compensated somewhat by adjusting individual banks of lamps from within the recipe. For example, the outer edge lamps can be at a lower power during a ramp up, and the middle can be at a lower power during a controlled ramp down.

If a coupon (or small sample) is placed on a base wafer, the temperature at the coupon will be cooler than the rest of the wafer. This is because the total thickness of the wafer and coupon together is now thicker than the rest of the wafer. The thicker the material, the slower it is going to heat, and the more non-uniform it is going to be if heated fast. It will also remove energy from surrounding areas of the wafer, making the wafer even more non-uniform.

Sheet Resistance

The sheet resistivity measured on a wafer indirectly indicates the temperature uniformity. It also tests the results of uniformity for an actual process.

Check uniformity. Run a test wafer and measure the resistivity. Compare the values with those obtained on the wafer measured when the unit was first installed.

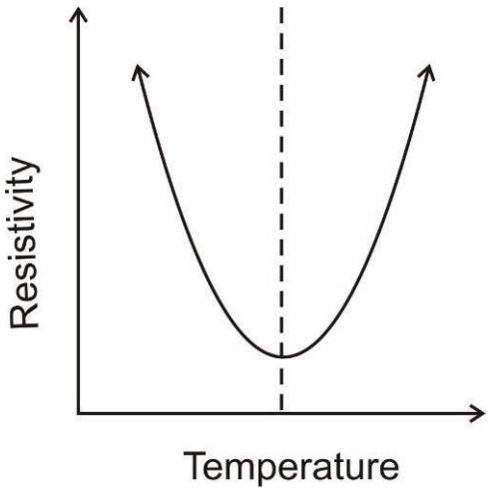

Figure 7-1: *Resistivity vs. Temperature*

With the implant conditions, ramp rate, steady step time and other parameters held fixed, the correct process temperature can be adjusted to give the desired resistivity. To determine the correct measured temperature to get the desired result, several runs with slightly different temperatures will need to be done. If the resistivity increases as the temperature decreases, then the correct temperature needs to be increased (see figure 7-1). However, if the resistivity increases as the temperature increases, then the correct temperature needs to be decreased.

7.3 GaAs, InP AND OTHER COMPOUND SEMICONDUCTOR PROCESSES

7.3.1 INTRODUCTION

GaAs, InP and other compound semiconductor material are used in the production of devices such as photovoltaic cells, optoelectronics devices like laser diodes and RF devices like high frequency amplifiers. These processes are used in the formation of GaAs Laser diode, LED, HgCdSb high efficiency solar devices, GaAs HBT, GaAs MESFET and pHEMT.

7.3.2 PROBLEMS

The GaAs, InP and other compound semiconductor processes create a region called the ohmic contact between the Metal layer and high doped GaAs layer or InP layer, or other compound semiconductor layer. The current-voltage (I-V) curve of the device needs to be linear and symmetric. Low-resistance and stable contacts are critical for performance and reliability. If the I-V characteristic is non-linear and asymmetric, the contact can instead be termed a blocking or Schottky contact.

To get a good ohmic contact, the metal has to flow into the substrate evenly and to a proper depth. The temperature range to flow the metal is very narrow (+/- 8°C or less) and low (400°C to 450°C). Thus, the temperature needs to be controlled precisely. If the temperature is too high, too much metal is flowed into the substrate and it will be too deep. This causes the contact to be Schottky. If too low, not enough metal is flowed. The wafer cannot be re-processed to have more metal flow to increase the depth, because it is now tempered and its properties have changed. In both cases, the wafer is useless and has to be discarded.

Engineers try to reduce this problem by creating a process recipe with multiple steady-state steps, figure 7-2. The first step would preheat the chamber and stabilize the temperature control before it ramps up to the alloy process steady-state step. The temperature at this preheat/stabilizer step is low enough that it has no effect on the physical properties of the wafer. When the temperature control ramps up to the alloy process step, the engineers cross their fingers and hope for a good outcome. If the temperature control is stable, then everything is fine. However, if it is not stable, the wafer is junk and has to be thrown away. The reason for this uncertainty in temperature control at the alloy process step is because the temperature control during the stabilizer step was not stable enough or the thermocouple did not have a good contact with the substrate/susceptor.

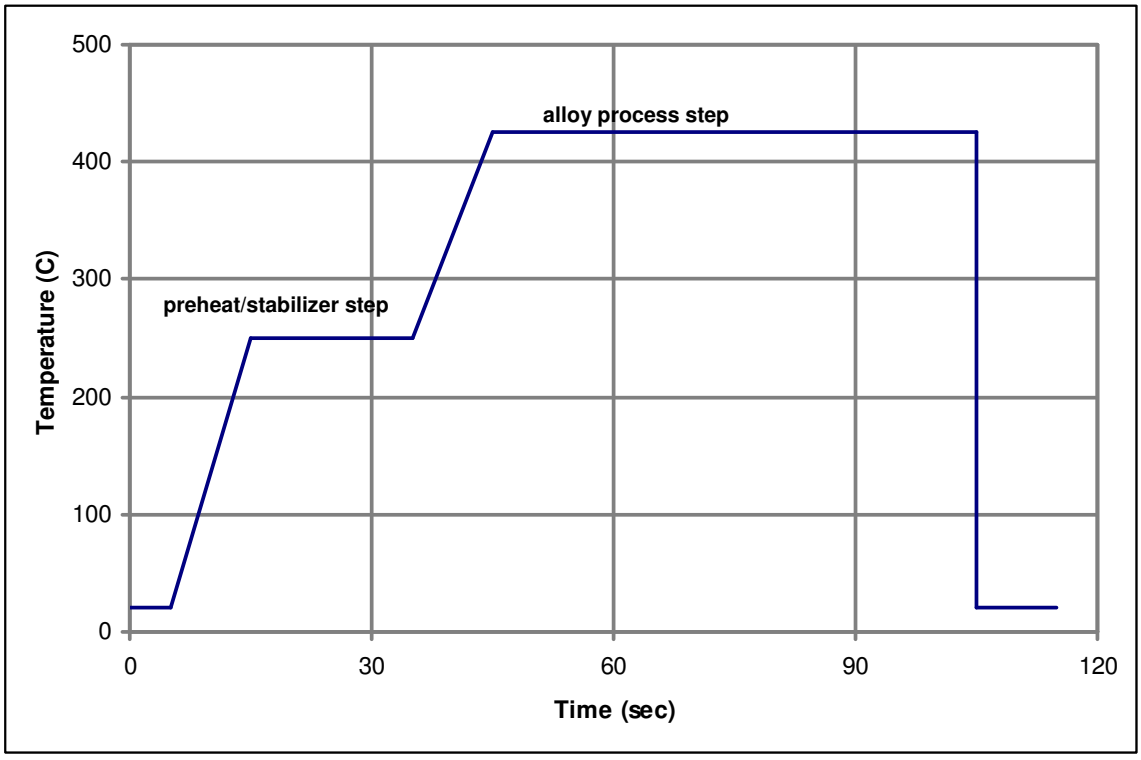

Figure 7-2: *Recipe with preheat step*

It is a problem getting good temperature control with a thermocouple that does not have a good and reliable contact with the substrate/susceptor. Too much contact force on the TC and the tip could bend and not make good contact. Too little contact force and the TC will separate away from the susceptor. Also, the TC tip could bounce on the surface of the susceptor. These cases will not give an accurate and true reading of the temperature of the susceptor. All these problems can give the process controller a difficult time controlling the temperature.

7.3.3 USING THE AW CONTROL SOFTWARE

A GaAs, InP and other compound semiconductor wafers are very expensive and, as explained earlier, it is difficult to get a good ohmic contact region. Thus, it is easy to ruin one of these wafers. Therefore, the yield can be very low if adequate precautions are not taken.

The AW control software has great temperature control and repeatability, even at low temperatures for the AW410/AW610. However, operators can upset the software by starting the process at different temperatures, thus making the temperature control not so repeatable and stable under these conditions. To avoid this, a multi-step recipe to process the wafer is used, figure 7-3. The first steady-state step preheats the chamber to a low temperature (for example, 150°C) to stabilize the temperature control. This is the preheat/stabilizer step. The process then ramps up to another low temperature (for example, 250°C) steady-state step and the control software checks the stability of the temperature control. This is the stability check step. The temperature is still low enough that it has no effect on the physical properties of the wafer. If the temperature control stability is within user defined limits, then the process control continues to process the wafer. However, if the stability is not within the limits, the process is aborted, thus saving the wafer. The wafer can then be re-processed and, thus, there is a higher yield.

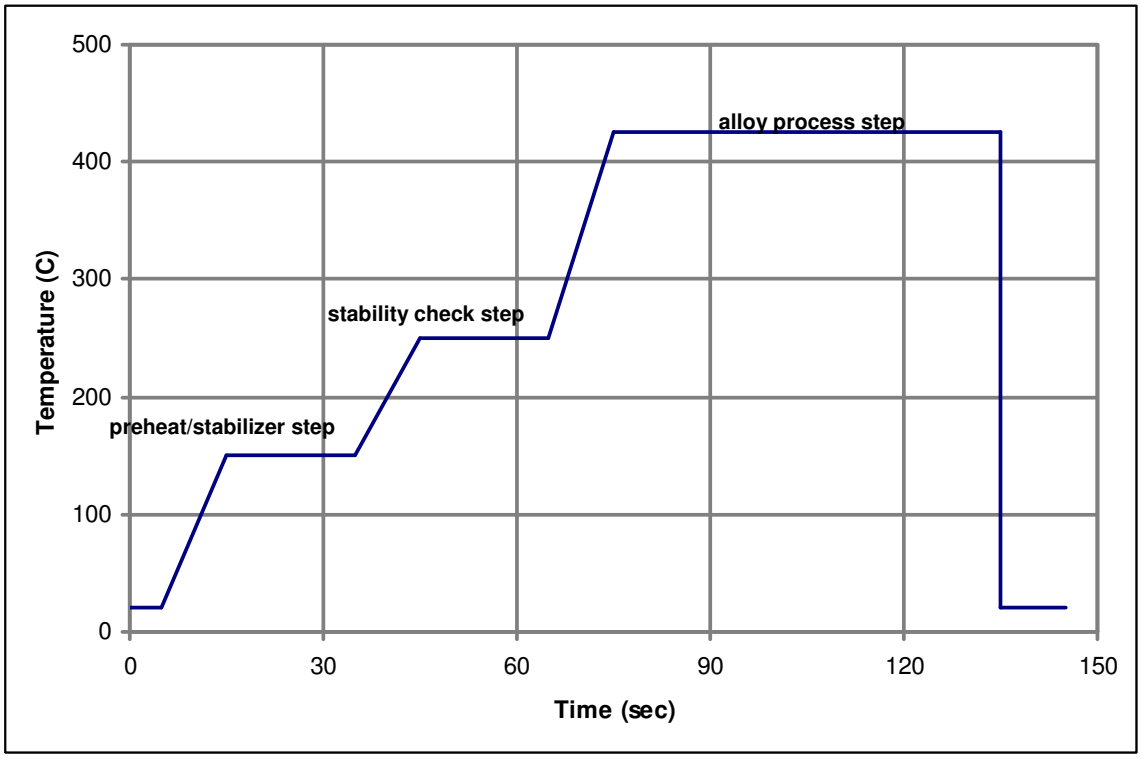

Figure 7-3: *Multi-step recipe to check stability*

These parameter limits are called PSum1 and PSum2. For this process, set PSum1 to zero (0) and refer to the PSum subsection of "Optimizing a Recipe" of this manual to set PSum2. PSum1 looks at the first steady-state step, which is the preheat/stabilizer step. The temperature control is usually not very stable during this step, until the end. Therefore, checking PSum against PSum1 needs to be disabled by defining it to be zero (0). PSum2 looks at the second steady-state step, which is the stability check step. Here, the temperature control needs to be stable and reliable before the software will allow the process to continue.

7.3.4 SUMMARY

The AW control software with a new controller can dramatically increase the yield of GaAs, InP and other compound semiconductor wafers. We have had reports from companies having nearly 100% of their wafers saved at the alloy process step.

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8. MAINTENANCE, BASIC

Chapter 8: Chapter 8

8.1 OVERVIEW

The maintenance information in this Operator's Manual is intended for operators and other personnel with limited access to the hardware. For a complete maintenance guide, refer to the Service Manual.

Please read the manual thoroughly before attempting to do maintenance. There are many helpful suggestions, and warnings. The Troubleshooting chapter has step-by-step guides to fix common and not so common problems.

☠ WARNING

Maintenance to the system should be done by a qualified service person.

CAUTION

Make sure both Water Cooling and Air Cooling are on before running a process or turning on the lamps. Cooling both the chamber and quartz window is very important to prevent breaking the quartz window and destroying the water seals. Both the Water Cooling and Air Cooling should be left on at least 5 minutes after the process ends. This is to make sure the chamber has cooled sufficiently.

During the maintenance operation, observe the following precautions:

- Do not use replacement parts not provided or recommended by Allwin21 Corporation.

☠ WARNING

Allwin21 Corporation is not liable for any damage or injury which may occur when unauthorized parts are used.

- Disconnect power to the system at the main disconnect box before performing any maintenance activity that requires the removal of access covers.

☠ WARNING

Follow proper lock-out/tag-out procedures.

8.2 PREVENTATIVE MAINTENANCE SCHEDULE

Preventive maintenance checks should be performed on a daily basis to ensure consistent operation of the AccuThermo RTP system.

Power down and switch off the power to the AccuThermo RTP system at the wall breaker and use proper lock-out/tag-out procedures whenever you remove the cover.

NOTE

The position of a part is relative to the machine. "Front" is in the direction of the front of the machine. "Left" is the left side when looking at the machine while standing in front of the machine.

8.2.1 DAILY MAINTENANCE

Water Level Check the water level for the Pyrometer Chiller and the chamber chiller (if it applies). Add distilled water if necessary.

Water Leaks Inspect for signs of water leaks.

Quartzware Check quartz isolation tube and wafer tray for contamination. Also inspect the oven unit for signs of water and particles. Clean the quartzware according to the instructions in the *Quartzware Cleaning* section of the ***Service Manual***.

Susceptor Check and clean the susceptor (optional) according to the susceptor "***Care and Cleaning***" section.

Facilities Check Verify that all facilities connected to the system are within the required limits. The check should include pressure checks, flow checks, or both. Refer to the ***Installation Manual*** for proper requirements.

Refer to the ***Service Manual*** for complete PM schedules.

8.3 QUARTZWARE

The AccuThermo RTP system uses two major pieces of quartzware. These are the quartz isolation tube and the quartz wafer support tray. AccuThermo RTP systems are normally shipped with the quartz isolation tube installed. The quartz wafer support tray is shipped in a separate packing container. It is recommended that the quartz isolation tube be removed, inspected for damage and cleaned prior to putting the system in service. Procedures for removing and installing this quartzware are detailed in the section below.

Semiconductor grade Quartz is a very stable material. It is not like regular glass, though it is of the same material. Quartz is made from pure silica, while regular glass has contaminates in it. This makes it very tolerable to extreme change in temperature.

8.3.1 PREVENTATIVE MAINTENANCE

The quartzware is an important part of this system. Maintaining it is very important. The quartzware needs to be inspected every day and kept clean. Dirty quartzware will contaminate processes and create non-uniform results. Later in this chapter details how to clean the quartzware. Refer to the PM schedule for scheduling quartzware cleaning.

To ensure uniform wafer heating, the quartz isolation tube, and the wafer tray must be kept clean. Thin films deposited on the quartzware may not be visible. If there is a loss of heating uniformity, clean the isolation tube, and wafer tray, even if no deposits are visible. The quartzware should also be cleaned prior to performing a temperature calibration.

It cannot be emphasized enough on the importance of maintaining clean quartzware.

- A dirty quartz isolation tube will reduce the amount of light from the lamps to heat the wafer. To get the wafer to the same temperature, the intensity has to be higher so there will be the same amount of energy reaching the wafer.
- A dirty pyrometer window will reduce the amount of IR radiation from the wafer from reaching to the pyrometer. With the pyrometer being the temperature sensor, it is a crucial part of the temperature control circuit. With a dirty pyrometer window, the wafer “looks” cooler to the pyrometer than it actually is. Therefore, the temperature control will increase the intensity to get the wafer hotter.

To reduce the effect of a dirty quartz window, the quartzware should be cleaned periodically. The frequency of vigorous cleaning depends on how dirty the processes are and how accurate the temperature needs to be. Dirty processes are usually caused by out-gassing of the wafers that are being processed.

8.4 SUSCEPTOR

Figure 8-1: *Susceptor Cover and Base*

8.4.1 INTRODUCTION

What is a Susceptor?

Allwin21 Corp. provides a susceptor (as an option) for processing wafers or substrate samples.

The susceptor consist of two pieces and is of high-purity graphite coated with inert Silicon Carbide (SiC) by chemical vapor deposition (CVD). Other material may be used for a susceptor, depending on the process engineer requirement.

The susceptor consists of a base and a cover (figure 8-1). The base has been hollowed out to make a flat pocket for the wafer or substrate samples.

Why use a susceptor?

Susceptors are ideal for use with wafers and substrates (such as GaAs wafers) that are transparent to the heating radiation of the lamps. It is a near-perfect black body for temperature uniformity across the wafer. It also eliminates built-in arsenic overpressure.

The protection and temperature tolerance of the SiC coating prevents both outgassing and particle shedding and ensures a long product lifespan.

The susceptor encases the wafer between two pieces of high purity graphite that are coated with SiC. The underside of the wafer sits in full contact with the inside of the flat susceptor pocket. It heats the wafer uniformly and from all directions. The precise temperature is obtained through either a pyrometer or a thermocouple in contact with the susceptor.

8.4.2 USING THE SUSCEPTOR

Handling of the susceptor

CAUTION

The susceptor assembly is very fragile. To prevent damage, use EXTREME CARE during handling. Do not scrape or touch the susceptor assembly against other objects.

CAUTION

The surface of the cover that faces the wafer should never touch other objects or surfaces. This is to prevent the surface from getting damaged or contaminated and to get repeatable results.

CAUTION

Touching the susceptor assembly without gloves contaminates the susceptor.

Using the Susceptor

- CAREFULLY remove the susceptor assembly from the box and place it on a clean flat surface.
- Examine the silicon carbide coating of the susceptor: look for cracks and severe pitting.
- CAREFULLY place the susceptor on the pins of the quartz tray. The susceptor rests on the quartz tray to increase the heating and cooling rate.
- CAREFULLY remove the susceptor assembly from the quartz tray and place the susceptor on a clean flat surface.
- When removing the cover from the base, turn it over so the top of the cover is facing down. This is to prevent the surface that faces the wafer from getting contaminated.
- When placing the susceptor cover on the susceptor base, the top surface of the cover should be facing up and away from the wafer. The top surface needs to be specified and it shall always be facing up when on the susceptor base.

CAUTION

When heating the susceptor, make sure there is a wafer inside the susceptor. If the susceptor is heated without a wafer inside, the susceptor may crack and break. The wafer acts like a heatsink to help distribute the heat evenly throughout the susceptor

8.4.3 CARE AND CLEANING

NOTE

The susceptor may need to be replaced if it gets severely pitted or damaged.

- Examine the silicon carbide coating of the susceptor: look for cracks and severe pitting.
- Always place the susceptor on a clean flat surface.
- The susceptor is coated with a thin layer of SiC and may have to be cleaned periodically. There are different methods for cleaning depending on the contamination. To clean the susceptor, use cleanroom wipes and a cleaning solution as described in the table below. Use cleanroom wipes and DI water to rinse the susceptor after cleaning with the solution. Let the susceptor dry completely before running it in the oven.

NOTE

Never submerge the susceptor in liquid.

Contamination Type	Cleaning Solution
Metal	HCL
Organic	H4SO4/H2O2:H2O
Organic	Use a high temperature process like 800°C for 2 minutes to burn off the organic contamination

8.5 TEMPERATURE FEEDBACK DEVICES

The AccuThermo RTP system is equipped with two types of temperature monitoring devices: a thermocouple and an optical pyrometer (optional).

The optical pyrometer can be used throughout the recommended process temperature range of 400°C to 1200°C. The thermocouple is used for controlling processes at temperatures below 800°C. Above 800°C, the K-type thermocouple starts to react with silicon.

Refer to the ***Service Manual*** for an extensive discussion on the pyrometer and thermocouple.

8.6 THERMOCOUPLE

8.6.1 OVERVIEW

The AccuThermo RTP system only uses the K-type thermocouple. K-type thermocouples are made with nickel-chromium (NiCr) for one wire and nickel-aluminum (NiAl) for the other wire. The NiAl lead is attracted to a magnet. Therefore, use a small magnet to determine the proper polarity when connecting thermocouple wires to the door terminals. Wires with the same metal alloy should be connected together, otherwise the temperature will not be measured correctly.

When in use, the thermocouple is situated inside the quartz isolation tube and positioned so that it is in contact with the wafer being processed. The thermocouple is used typically to control process temperatures below about 800°C.

CAUTION

Thermocouple may fuse into the wafer and break at temperatures above 800°C. As a result, the thermocouple should be removed and the pyrometer should be used for temperature measurement when the oven is to be operated at temperatures higher than 700°C.

NOTE

Thermocouple life is shortened by operating with an oxygenated atmosphere. As a result, the thermocouple should be removed and the pyrometer used for temperature measurement.

The thermocouple assembly can be any of the following types:

- **Cantilever thermocouple assembly:** This type is a 10-mil type K bead thermocouple in direct contact with the backside of the wafer. The thermocouple is held against the wafer by two spring wires that also serve as the thermocouple leads. The wires pass through a removable T-shaped mounting piece made of quartz. Refer to figure 8-2.

- **TC wafer assembly:** This assembly is a type K chromel-alumel thermocouple, which is cemented to a wafer. The cement used is a sodium-free ceramic cement. Refer to figure 8-3. Typically, the TC wafer is used for the calibration of the pyrometer.

The Cantilever thermocouple is used in place of the TC wafer assembly for the measurement of oven temperature during wafer processing.

The TC wafer thermocouple is used during calibration of the pyrometer.

The two thermocouple wires for these two thermocouple assemblies run through a ceramic tube to K-type terminals on the inside of the oven door. The terminals run through a gas-tight seal in the door.

The door terminals and the terminals in connectors are marked either CH (NiCr) or AL (NiAl) according to their metal alloy composition. Also, the AL terminal is wider than the CH terminal.

Thermocouple voltages are fed to a temperature compensation circuit. The thermocouple compensation circuit contains an analog linearizing circuit with an output calibrated to 1 mv/°C. The signal is digitized and sent to the computer for use by the temperature control system. . (Refer to sections *Thermocouple Calibration* and *Thermocouple Circuit Testing*.)

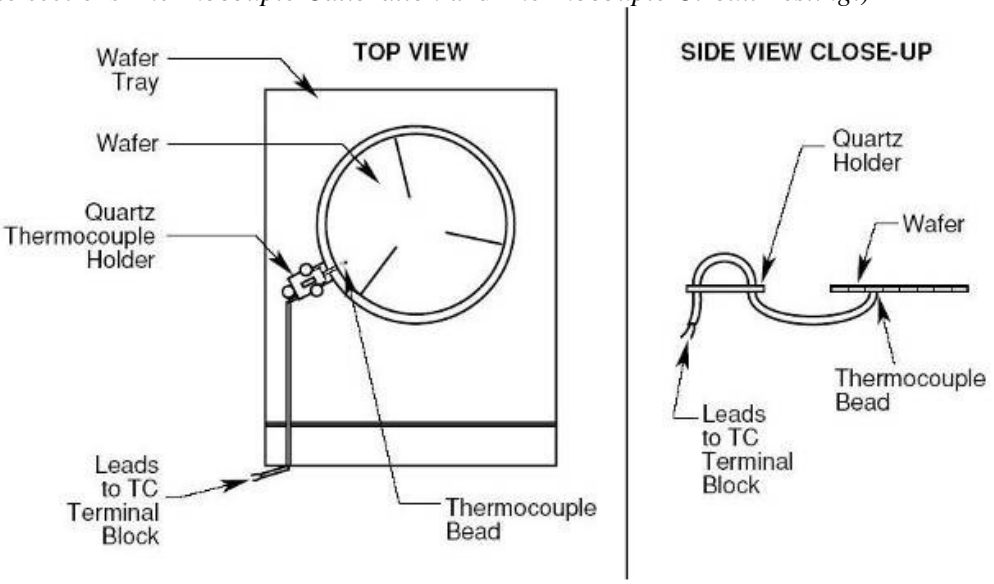


Figure 8-2: *Cantilever Thermocouple Assembly*

The Cantilever thermocouple assembly may be used in place of the pyrometer for the measurement of oven temperature. The Cantilever thermocouple assembly, shown in figure 8-2, uses a small thermocouple bead in contact with the backside of the wafer.

The TC wafer assembly (figure 8-3) has a thermocouple embedded in a wafer.

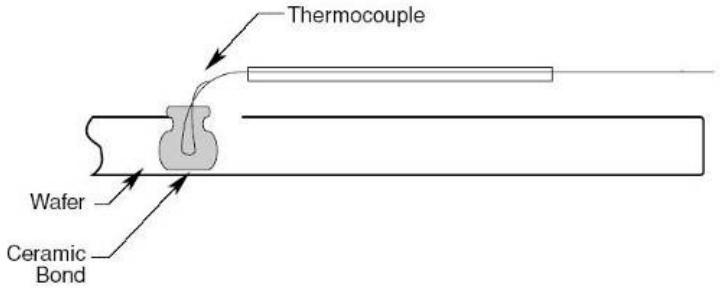


Figure 8-3: *Thermocouple Wafer Assembly*

8.6.2 INSTALLING THE THERMOCOUPLE

It has been noted that the Cantilever thermocouple may be used in place of the pyrometer, and it should be removed when the pyrometer is in use. When the thermocouple is installed, its operation should be checked before it is used for processing wafers.

The tools and supplies needed to install the thermocouple are:

- ☐ small screwdriver
- ☐ tweezers
- ☐ small permanent magnet of any type
- ☐ a pair of Latex gloves. Wear the gloves when you are handling oven quartz or thermocouple.

The procedure for installing and checking the thermocouple is as follows:

Step 1. Open the oven door.

Step 2. Using tweezers, remove the quartz lock-pin from the wafer tray.

Step 3. Place the thermocouple holder between the two fixed pins on the wafer tray, as shown in figure 8-4. The holder should be placed so the ends of the thermocouple leads emerge from the bottom of the holder. The holder should fit into the grooves in the pins.

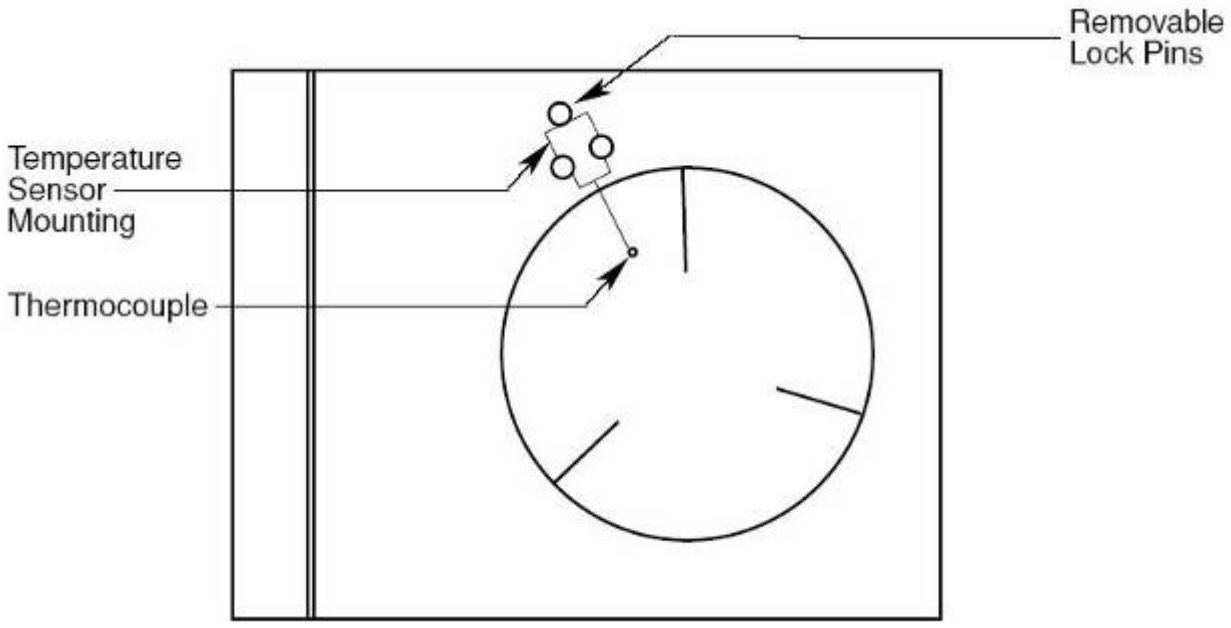


Figure 8-4: *Thermocouple Placement (showing Cantilever thermocouple)*

Step 4. Using tweezers, install the quartz lock-pin. This keeps the holder in place.

Step 5. Position the thermocouple holder so the ceramic tubing is as close as possible to the edge of the wafer tray.

Step 6. Attach the thermocouple leads to the type K terminals on the inside of the oven door. First, find which lead is attracted to a magnet. Attach this lead to the wider terminal, labeled "AL". Attach the other lead to the terminal labeled "CH". (If the leads are connected in reverse, the temperature feedback will go down when the wafer is heated.)

Step 7. Cut off surplus lead wire, leaving a little excess in case it will be necessary to reverse the leads.

Step 8. Install a test wafer on the tray. Be sure the backside of the wafer is down. Position the bead so it presses against the backside of the wafer.

Double Check

- Make sure the TC wires are connected properly (refer to *Thermocouple Circuit Testing*) and do not touch anything, except the quartz. The wires cannot touch the wafer. Only the bead end should touch the wafer. The wires cannot touch anything that is conductive or semi-conductive.
- Poor TC wire connection can give a jittery signal, because of the poor contact at the junction. Make sure the TC wire is secured tightly on the terminal. Do not twist wires together. This method does not create a good contact. The contacts from the bead to the analog circuit must be solid and secure at all times.
- Poor TC contact with the wafer. Make sure the bead of the TC has a good contact with the wafer. Momentary contact will look like the TC signal is jittery.

Step 9. Close the chamber door.

8.6.3 TESTING THE THERMOCOUPLE

When the thermocouple has been installed in the oven, check its operation as follows:

Step 1. Power-up the system, if it is off

Step 2. Go to the Diagnostics screen.

Step 3. If the system is set up for pyrometer operation, configure for thermocouple.

Step 4. Increase the lamp intensity to 5%.

Step 5. This step should take no more than 5 seconds to perform. Observe the temperature feedback. If the temperature indication goes down (i.e., if temperature is negative) as heat increases, the thermocouple leads have been connected in reverse. Change the lead connections at the oven door and repeat steps 2 to 4.

8.6.4 INSTALLING AND TESTING THE TC WAFER

Step 1. Install the thermocouple (TC) monitor wafer, making sure the polished side is down and the leads are connected using the correct polarity to the TC connectors, as described in the section *Installing the Thermocouple*.

Step 2. Check the functionality of the TC using the following procedure:

- Purge the chamber by running 10 SLPM of N2 for 30 seconds prior to running the tool in manual mode.
- Test the operation of the TC wafer as described in the section *Testing the Thermocouple*.

9. TROUBLESHOOTING, PROCESS

Chapter 9: Chapter 9

9.1 OVERVIEW

The troubleshooting information in this ***Operator's Manual*** is intended for operators, process engineers and other personnel with limited access to the hardware. For a complete troubleshooting guide, refer to the ***Service Manual***.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.1.1 TIPS FOR TROUBLESHOOTING

- Solve the real problem. Do not create one or more new problems to solve existing problem.
- Face the problem. Do not escape from the problem.
- Find the problem (if you find the problem, the problem is already 50% resolved)
- Find the root causes and reasons the problem exists.
- Follow the protocol and standards.
- Follow the documents.
- Double check, triple check.
- Ask if you are not sure.

9.2 ALARM CODES

Alarm ID	Alarm Text	Comments
0000	Communication Down	Refer to the Troubleshooting chapter, section “No Communication Between the Oven Unit and the Computer”.
0001	Illegal Recipe Structure	Recipe was not developed on this machine.
0002	Upload Non-existent Recipe	N/A
0003	Air/N_2 Cooling Flow is too Low	Make sure the air flow is adequate. Check the machine specifications. Also see the section “Cooling CDA (Nitrogen)” in the Troubleshooting chapter.
0004	Cooling Water Flow is too Low	Refer to the Troubleshooting chapter, section “Cooling Water”.
0005	Gas Panel Power Failure	N/A
0006	Oven Temperature Interlock On	Refer to the Troubleshooting chapter, section “Overheat”.
0007	Wafer Over Temperature	This would happen if the software was using the thermocouple to monitor the temperature and the TC was disconnected or it broke. Then the temperature would rise above 1300 C. Just replace the TC and everything should be OK.
0008	Over Temperature, Bottom Plate	1) Make sure there is sufficient water flow. 2) Make sure the water is not blocked for the bottom plate. 3) Make sure the process time is not too long and the setpoint temperature is not too high.
0009	Over Temperature, Top Plate	1) Make sure there is sufficient water flow. 2) Make sure the water is not blocked for the top plate. 3) Make sure the process time is not too long and the setpoint temperature is not too high.
0010	Over Temperature, Triac Plate	1) Make sure there is sufficient water flow. 2) Make sure the water is not blocked for the triac plate. 3) Make sure the process time is not too long and the setpoint temperature is not too high.

Alarm ID	Alarm Text	Comments
0011	Water Leak	A water leak has been detected around the chamber.
0012	Oven Door Is Open When It Should Be Closed	1) Make sure the pneumatic pressure for the oven door is sufficient. 2) Make sure the oven door is not blocked. 3) Make sure the Oven door open/closed sensors are adjusted properly.
0013	Smoke Detector is On	N/A
0014	Gas 2 Leaking	N/A
0015	Gas 3 Leaking	N/A
0016	Gas 5b Leaking	N/A
0017	Gas 5b Interlock Is On	N/A
0018	Gas 5a Interlock Is On	N/A
0019	Gas 3 Interlock Is On	N/A
0020	Gas 2 Interlock Is On	N/A
0021	Gas 4 Interlock Is On	N/A
0022	Low Pyrometer Flow Level	The cooling water flow for the pyrometer is too low.
0023	Low Pyrometer Cooling Tank Water Level	N/A
0024	Incompatible Valve Opened/Closed	N/A
0025	(not used)	
0026	A to D (analog to digital) Time Out Error	The sensor took too long to change.
0027	ATP does not Exist	N/A
0028	ATP Time Out Error	N/A
0029	Gas 2 Flow Out Of Range	The gas flow for Gas #2 is either too high or too low from the setpoint. Refer to the Troubleshooting chapter, section “Gas Control”.
0030	Gas 4 Flow Out Of Range	The gas flow for Gas #4 is either too high or too low from the setpoint. Refer to the Troubleshooting chapter, section “Gas Control”.
0031	Gas 3 Flow Out Of Range	The gas flow for Gas #3 is either too high or too low from the setpoint. Refer to the Troubleshooting chapter, section “Gas Control”.

Alarm ID	Alarm Text	Comments
0032	Gas 5a Flow Out Of Range	The gas flow for Gas #5a is either too high or too low from the setpoint. Refer to the Troubleshooting chapter, section “Gas Control”.
0033	Gas 1 Flow Out Of Range	The gas flow for Gas #1 is either too high or too low from the setpoint. Refer to the Troubleshooting chapter, section “Gas Control”.
0034	Gas 5b Flow Out Of Range	The gas flow for Gas #5b is either too high or too low from the setpoint. Refer to the Troubleshooting chapter, section “Gas Control”.
0035	Purge Gas 3 Flow Out Of Range	The gas flow for Gas #3 purge is either too high or too low from the setpoint. Refer to the Troubleshooting chapter, section “Gas Control”.
0036	Purge Gas 2 Flow Out Of Range	The gas flow for Gas #2 purge is either too high or too low from the setpoint. Refer to the Troubleshooting chapter, section “Gas Control”.
0037	Gas 9 Flow Out Of Range	The gas flow for Gas #9 is either too high or too low from the setpoint. Refer to the Troubleshooting chapter, section “Gas Control”.
0038	Gas 10 Flow Out Of Range	The gas flow for Gas #10 is either too high or too low from the setpoint. Refer to the Troubleshooting chapter, section “Gas Control”.
0039	Illegal Gas Mixture	Adjust your gas specification so the gas mixture passes software validation.
0040	Purge Flow Too Low	Refer to the Troubleshooting chapter, section “Gas Flow Rate and Pressure Decreases”.
0041	Purge Sequence Error	N/A
0042	EMS Error	N/A
0043	Can’t Reach Temperature	Refer to the Troubleshooting chapter, section “Temperature”.
0044	Vacuum Pressure Is Outside Tolerance Window	N/A
0045	Bad Temperature Reading	The temperature sensor (pyrometer or thermocouple) might have a problem. Refer to the Troubleshooting chapter, section “Temperature”.

Alarm ID	Alarm Text	Comments
0046	Temperature Out Of Tolerance Window	1) The temperature is either too high or too low when it entered the steady step. The temperature must be under control during the ramp step. Refer to the Advanced Operation chapter, section “Optimizing the Temperature Profile”. 2) The temperature suddenly went down. The lamps were turned off. Refer to the Troubleshooting chapter, section “Interlocks Troubleshooting” or “Temperature”.
0047	(not used)	
0048	Lamp Check Error	1) Check all lamps to make sure they are all working. Refer to the Troubleshooting chapter, section “Lamps”. 2) Make sure there is sufficient voltage for the lamps.
0049	Lamp Calibration Error	1) Check all lamps to make sure they are all working. Refer to the Troubleshooting chapter, section “Lamps”. 2) Make sure there is sufficient voltage for the lamps.
0050	Door Check Error	The chamber door is open. Make sure the door is closed and locked. Refer to the Troubleshooting chapter, section “Interlocks Troubleshooting”.
0051	(not used)	
0052	Can’t Close Door	N/A
0053	Can’t Open Door	N/A
0054	Unspecified System Error	
0055	Send Not Ready	There is no cassette on the Send Cassette Station.
0056	Receive Not Ready	There is no cassette on the Receive Cassette Station.
0057	Receive Cassette Full Error	N/A
0058	Send Cassette Empty Error	N/A
0059	Wafer On Cool Position Error	There is a wafer on the cooling station when there should not be one.
0060	Wafer Not On Cool Position Error	There is no wafer on the cooling station when there should be one.

Alarm ID	Alarm Text	Comments
0061	Wafer In Oven Error	There is a wafer in the oven when there should not be one.
0062	Door Open Time-out Error	The oven door took too long to open. Make sure the door pneumatic pressure is sufficient.
0063	Door Closed Time-out Error	The oven door took too long to open. Make sure the door pneumatic pressure is sufficient.
0064	Door Can't Close Because Arm Is Extended In Oven	The oven door cannot close, because the robot arm is in the oven. Remove the robot arm.
0065	No Wafer On Aligner Error	There is no wafer on the aligner when there should be one.
0066	Wafer On Aligner Error	There is a wafer on the aligner when there should not be one.
0067	(not used)	
0068	(not used)	
0069	Door Can't Close Because Arm Is Extended In Oven	The oven door cannot close, because the robot arm is in the oven. Remove the robot arm.
0070	Robot Time-out Error	The robot took too long to move to the expected position. 1) Make sure there is nothing blocking the robot. 2) Make sure the robot cables are well seated in their connectors.
0071	CMD Not Accepted	N/A
0072	Send Command Communication Error	N/A
0073	Communication Buffer Flush Error	N/A
0074	Non-digit Error	N/A
0075	User Abort	The user aborted the process.
0076	Limit Switch Activated	N/A
0077	Extend/Retract Axis Motion Error	N/A
0078	Theta Motion Error	N/A
0079	Z Motion Error	N/A
0080	Extend/Retract Axis Error	N/A
0081	Theta Axis Error	N/A
0082	Z Axis Error	N/A
0083	Axis De-servo Error	N/A
0084	External Triggered Hard Stop	N/A

Alarm ID	Alarm Text	Comments
0085	Robot Teach parameters Not Accepted	N/A
0086	Wafer Not On Pan Error	The wafer is not on the robot end-effector.
0087	Wafer On Pan Error	The wafer is on the robot end-effector.
0088	Robot Not Ready	N/A
0089	Different Version Between S/W and Low Level Command	N/A
0090	Robot Params.	N/A
0091	Robot Cycle Time-out Error	N/A
0092	Robot High Level Command Cycle Error	N/A
0093	Wafer Exist In Station	N/A
0094	Arm Axis R Is In Unknown State	N/A
0095	Open Robot Param File Failed	N/A
0096	Robot Task Unknown State	N/A
0097	Wafer Not Aligned	N/A
0098	Aligner Not On or Not Installed	N/A
0099	Wafer Characterization Error	N/A
0100	Aligner Communication Error	N/A
0101	No Wafer To Align	There is no wafer on the aligner.

Alarm ID	Alarm Definition	Comments
0704	MFC Max Gas Flow is too low	With the MFC set to maximum flow, the gas flow is not within the tolerance. Refer to the Troubleshooting chapter, section “Gas Control”.
0719	Initial Temp of the step is too high!	The initial temperature of the steady step is too high. This could be caused by uncontrolled temperature during ramping. Refer to the Troubleshooting chapter, section “Temperature” and the Advanced Operation chapter, section “Optimizing the Temperature Profile”. Insufficient Cooling Air could cause the temperature control to not perform as before.
0721	Over Temperature or connecting problem!	The temperature inside the chamber is greater than 1250°C or the thermocouple is disconnected. Refer to the Maintenance & Diagnostics chapter, section “Testing the Thermocouple”.
0722	Temp sensor problem TC connect Reversed	The temperature is going down when the wafer is being heated. The thermocouple leads have been connected in reverse. Refer to the Maintenance & Diagnostics chapter, sections to Install and Test the Thermocouple.
0723	Psum out of limit. Sensor or lamp bad! Software Protecting	Use of the PSum has been implemented. It has been determined the average intensity is too high. This is caused by either a lamp not working or a dirty quartz tube or a bad pyrometer or thermocouple. Refer to: 1) the Advanced Operation chapter, section “PSum”, 2) the Troubleshooting chapter, section “Lamps”, 3) the Maintenance & Diagnostics chapter, section “Quartz Isolation Tube Removal and Installation”, 4) the Troubleshooting chapter, section “Temperature”.

Alarm ID	Alarm Definition	Comments
0725	Temperature Sensor Broken or Lamp Power Is Not On or Chamber Door is open	The control software is trying to increase the temperature of the wafer, but the temperature is not changing. Either the thermocouple is broken or the lamp power has not been turned on or the chamber door is open, which will prevent the lamps from coming on. Refer to the Troubleshooting chapter, sections “Temperature”, “Lamps” and section “Interlocks” in the Service Manual.
0726	No AW-RTP-900-008 card or card connection not good!	There is a bad connection between the computer and the control board in the AccuThermo RTP system. Refer to the Service Manual, section “Computer Problems”.
0727	Analog board problem Check DB25 cable or address switch setup	N/A
0728	Temperature out of limit at ramp	Adjust the control parameters for the recipe. Refer to the Advanced Operation chapter, section “Optimizing the Temperature Profile”.
0729	Temperature out of limit at steady	Adjust the control parameters for the recipe. Refer to the Advanced Operation chapter, section “Optimizing the Temperature Profile”.
0730	Intensity out of limit at steady!	Adjust the control parameters for the recipe. Refer to the Advanced Operation chapter, section “PSum” and chapter Maintenance & Diagnostics, section “Lamps”.
0731	ezDTC and Pyrometer Tolerance out of limit at steady!	Refer to the Advanced Operation chapter, section “Optimizing the Temperature Profile”.
0737	Gas Power Problem	N/A
0738	AC Power Problem	The control software cannot detect the Oven Unit. The oven unit main power may be off or a phase may not have power.
0739	Chamber Door Is Open or Water Flow Too Low	1) Make sure the Chamber Door is closed and locked. 2) Make sure the water flow is adequate. Check the machine specifications. 3) Refer to the Troubleshooting chapter, section “Interlocks Troubleshooting”.

Alarm ID	Alarm Definition	Comments
0740	Over Heat Sensor On. Cooling water problem	The overheat thermostat opened because the oven wall has exceeded 155°F. This is caused by insufficient water cooling. The water flow sensor may have stuck open or the water may have been shut off. After the oven has cooled sufficiently, inspect the oven and water lines thoroughly for leaks and damage. There is a reset button on the thermo-switch. Press this button in to reset the thermo-switch.
0745	Robot could not place wafer to the cassette	After the robot finished doing a "place wafer on cassette station" the robot detected the wafer was still on the end-effector. Make sure the robot is aligned properly with the cassette station.
0747	The Robot motor can not move to the zero position	N/A
0750	The Robot can not reach the setpoint position	N/A
0753		
0755	Wrong A/D factor	System Check
0759	Pyrometer A/D setup Error	The pyrometer A/D channel may be set wrong. Refer to the Administration chapter, section "System Setup".
0760	Thermocouple A/D setup Error	The thermocouple A/D channel may be set wrong. Refer to the Administration chapter, section "System Setup".
0761	Bank number out of range	This sounds like the setup file has been corrupted. It may be best to reload the software from the backup. Refer to the appendix "Backing Up and Restoring the Software".
0765	Wrong pyrometer calibration file	The pyrometer calibration file has been corrupted. The pyrometer needs to be re-calibrated. Refer to the Maintenance & Diagnostics chapter, section "Pyrometer Calibration".
0766	Wrong Lamp calibration file	The chamber calibration file has been corrupted. The chamber calibration file needs to be reloaded from the backup or the chamber needs to be re-calibrated. Refer to the Maintenance & Diagnostics chapter, section "Chamber Calibration".

Alarm ID	Alarm Definition	Comments
0768	The temperature of the Water 2 for pyrometer is	N/A
0789	Pyrometer Error or Disabled	Refer to: 1) the Troubleshooting chapter, section “Temperature”, 2) the Administration chapter, section “Factory Setup”, 3) the Maintenance & Diagnostics chapter, section “Pyrometer Calibration”.
0790	Thermocouple Error	Refer to: 1) the Troubleshooting chapter, section “Temperature”, 2) the Administration chapter, section “Factory Setup”, 3) the Maintenance & Diagnostics chapter, section “Thermocouple Calibration”.
0791	Pneumatic Valve Problem	Refer to the Troubleshooting chapter, section “Gas Control”.
0792	Front Panel Display Error	Refer to the Maintenance & Diagnostics chapter section “LED Temperature Display Calibration”.
0793	RS-232 (Front Panel) Error	The computer cannot communicate with the front monitor. Check the communication cable. Make sure the connectors are seated properly and firmly.
0794	There is a problem with the Robot RS-232.	The control computer cannot communicate with the robot controller. Check the communication cable. Make sure the connectors are seated properly and firmly.
0795	RS-232 (Aligner) Error	The control computer cannot communicate with the aligner. Check the communication cable. Make sure the connectors are seated properly and firmly.

9.3 FAQ

Frequently Asked Questions (FAQ)

9.3.1 PROCESSING

(Q)
When should the thermocouple be used and when should the pyrometer be used?

(A)
The thermocouple should be used if the process temperature is between room temperature and 800°C. The pyrometer should be used if the process temperature is between 500°C and 1200°C.

The thermocouple physically touches the back-side of the wafer. Above 800°C, the thermocouple will start to react with a pure silicon wafer, and the TC and wafer will break.

If the thermocouple cannot contact the wafer and the process temperature is below 500°C, contact Allwin21 Corp. for assistance.

The pyrometer is a non-contact temperature measuring device. It measures the amount of IR light radiation emitted by the wafer to determine the temperature of the wafer. The pyrometer starts to become reliable above 400°C. There should be an 100°C buffer zone between the lowest reliable temperature of the pyrometer and the process temperature. If the process temperature is too close to the minimum reliable temperature of the pyrometer, then there could be uncontrolled oscillation of the temperature.

1250°C is the maximum temperature for the AccuThermo RTA. If the measured temperature goes above this, the control software will abort the process. Therefore, there should be a buffer zone between the process temperature and the maximum temperature of the AccuThermo RTA. Otherwise, if an overshoot occurs, the control software may abort the process.

(Q)
After processing at 900°C for 30 seconds, can I ramp down to 50°C in 30 seconds?

(A)
A quick and simple answer is: NO.

It is impossible to control the cooling rate faster than the "natural" cooling rate of the wafer. The "natural" cooling rate is when the lamps are off and no longer heating the wafer. This is the fastest cooling rate you can achieve without additional means to increase the cooling rate.

For additional means to increase the cooling rate, refer to the section "*Wafer Cooling*" in the *Troubleshooting* chapter of this manual.

(Q)
What is the purpose for the intensity (INTN) step?

(A)
The reason for the intensity (INTN) step is to get the actual temperature of the wafer above the minimum reliable temperature of the pyrometer. There is no need to use this step if the TC has been selected as the temperature feedback sensor, but sometimes it does help, especially for fast ramps. Below the minimum reliable temperature of the pyrometer, which is usually 400°C, the pyrometer is noisy. This makes it very difficult for the control software to control the temperature. Above the minimum reliable temperature, the pyrometer gives a smooth signal, which can then be used to control the temperature and have repeatable results.

(Q)
I have a recipe that works fine for one wafer, but it has a difficult time following the recipe for another wafer.

(A)
Each type of wafer should have its own recipe. Heating depends on the thickness, surface area, size, material, coating and heat conduction of the wafer.

Sometimes when the RTA has been sitting idle for several hours, the first wafer may have difficulty making the transition from RAMP to STEADY. Warm up the chamber a little by processing a dummy wafer for a short time before processing the production wafer.

(Q)
During cool down, I have found that initially the temperature goes down very rapidly. It then becomes nearly flat and does not decrease much with time. Why does the wafer do this?

(A)
If it is desired to cool the wafer as fast as possible, then a Delay step should be used during the cool-down step. This step turns off the lamps and no longer heats the wafer. It allows the wafer to cool "naturally". This is the fastest cooling rate you can achieve without additional means. At first, the temperature will drop very fast. After several seconds, the rate of cooling will slow. It may take from 8 to 15 minutes for a substrate to cool below 100°C. This depends on the mass, volume and surface area of the substrate (wafer, susceptor). A large mass with small volume and small surface area will cool much slower than one with a large surface area. Large surface area can exchange its heat energy with the surrounding gas faster. So a susceptor will cool much slower than a wafer.

(Q)
How do I verify if the pyrometer is working well and is accurate? Is there any specific recipe to verify this?

(A)
Refer to the Pyrometer Calibration section of the Technical Manual. Do not assume the pyrometer needs to be calibrated.

(Q)
Is there a chart that I can use that tells me how long I can have a process run for a specific temperature?

(A)
The concept of the Rapid Thermal Processing machine is to rapidly raise the temperature and hold it at a high temperature for short periods of time. Now, because you are indicating you want to test processes for long periods of time, you are approaching experimental limitations that are out of scope of the RTP concept. What you are now facing are limitations not based on formulas, but limitations that are based on the design of the system's cooling efficiency and facilities cooling capabilities. Both of these combined are now the determining factor of what your machine can and cannot handle for extended periods of time. Creating a statistical chart of temperature versus time varies based on each system and facility.

We can recommend certain safety practices that will ensure the integrity and lifetime of your machine.

1) We highly recommend sufficient cooling time between each process run.
2) The water temperature should not go above 35°C. If your water temperature reaches above this, your chamber is close to overheating.
3) The differential water pressure between your inlet and outlet should never exceed 40 psi. Also, the maximum inlet pressure should not exceed 60 psi. Your fittings will fail and cause major leaks if these pressures are exceeded.
4) The cabinet exhaust air flow should be higher than your Cooling CDA flow by more than 10 CFM in order to prevent temperature build up within the cabinet.
5) The greater the air flow for the cooling CDA, the greater the cooling efficiency that can be achieved within your machine. However, extremely high PSI and particulates within the cooling lines can damage the quartzware.

(Q)
When the temperature reaches the 900°C, it suddenly decreases almost 20°C. Then it climbs back up to 900°C, and becomes steady. Can we decrease this offset with in 2°C or 1°C rather than 20°C?

(A)
The wafer temperature is following the Model Temperature very well during the Ramp Step. When it is making the transition from the ramp step to the steady step, the "intensity" (red line on the graph) drops a little. To prevent the intensity from dropping too much and making the temperature "undershoot", the "Steady Intn Factor" for the steady step has to be increased. Refer to section ***Temperature Profile Stages*** in the ***Advanced Operations*** chapter.

9.3.2 PROCESS GRAPH

(Q)
Explain the different temperature curves that are plotted?

(A)
The Recipe plot (green) shows the temperature profile for the recipe. The real temperature may not follow the recipe exactly until the first steady step.

The Model Temperature plot (black) is the calculated temperature for the temperature control to follow. The Model plot will follow the recipe precisely if the software setting "Keep Ramp Speed" is set to YES. It is desirable to "seed" the model temperature for the first ramp, so this setting should be set to NO. "Seeding" the Model Temperature starts the Ramp step at the current temperature of the wafer when the ramp step starts and then start ramping to the setpoint.

The TC Temperature plot (light blue) shows the temperature of the wafer that the thermocouple has measured.

The Pyrometer Temperature plot (pink) shows the temperature of the wafer that the pyrometer has measured.

The Real Temperature plot (dark blue) shows the temperature of the wafer from the temperature sensor type that was selected. This is either the thermocouple or the pyrometer. This line will plot over the selected sensor plot.

(Q)
What is the pink vertical line in the graph when I review the process data?

(A)
The Pink vertical line is an indicator line. It is only shown when the process data is reviewed. It may be moved either left or right by pressing the left or right arrow keys. Where ever it intersects a plot, the value of that plot is displayed at the top of the graph. The horizontal position of this line on the graph shows the time (lower right of the graph in red) from the start of the process. Refer to the "***Temperature Curves***" section in the ***Advanced Operations*** chapter.

(Q)
There is a pink color vertical line, which is the pyrometer temperature, at almost 90sec on the graph. It does not shows how the pyrometer temperature varies with time.

(A)
The pink vertical line is an indicator line. It is only shown when the process data is viewed. It may be moved either left or right by pressing the left or right arrow keys. Where ever it intersects a plot, the value of that plot is displayed at the top of the graph. Where this line is positioned on the graph shows the time (lower right of the graph in red) from the start of the process.

(Q)
It is hard to get the temperature to follow the recipe temperature profile. Why?

(A)
Refer to the Tutorial in the "***Advanced Operations***" chapter.

(Q)
During the ramp step, the temperature oscillates wildly. I am using a pyrometer as the temperature sensor. How can I keep the temperature from oscillating?

(A)
Refer to the "***Optimizing the Temperature Profile***" section in the chapter "***Advanced Operation***".

(Q)
The Real Temperature curve is not following the Recipe Temperature curve. Why and how can I correct this?

(A)
The control software is setup to follow the "Model Temperature" (black line). The Model Temperature is normally the same as the Recipe Temperature. There is one exception, the first ramp step. Before the first ramp step, the recipe says the temperature is 0°C. But the real temperature is anywhere from 20°C to over 200°C. This depends on the temperature of the system when the process starts. At the beginning of the first ramp step, the model temperature is "seeded" with the real temperature of the wafer. At this point, a line (within the software, but it is not shown) is drawn to the setpoint, where the steady step begins. This is the line the process will use to control the rate of the temperature.

If you want the real temperature to follow only the recipe, then go to the "System Setup" screen and make "Keep Ramp Speed" to YES.

If you are using the pyrometer as the temperature feedback sensor, then it is not advisable to follow the recipe curve for the first ramp. If the real temperature is greater than the recipe temperature then the lamps will turn off and the temperature will cool. If the real temperature drops below the minimum reliable temperature for the pyrometer, then the control software will have a hard time controlling the temperature, because the pyrometer would be very "noisy".

Our process engineers have found that most processes are sensitive to a very narrow temperature window. If the temperature is too low, then nothing will happen. If it is too high, then the sample is destroyed. The rate to get to a setpoint temperature isn't as important as how long it is maintained at the desired setpoint temperature. Also, the process results are much more repeatable if the first ramp step starts at the same temperature as the real temperature. It is also easier to control the temperature from this point.

9.3.3 MISC.

(Q)
How can I tell if my quartz tube is dirty? It looks clean.

(A)
It may be visually clean, but it may be dirty to the specific thermal radiation that is emitted from the lamps to heat the wafers. A dirty tube will also inhibit the thermal radiation the wafer is emitting for the pyrometer. A dirty tube will make the wafer appear cooler than it actually is when using the pyrometer. A dirty tube will make the intensity higher than it needs to be to make the wafer at the correct temperature. This will make the system less efficient. If production wafers are being processed, try using PSum. PSum will detect if the intensity is too high compared to previous runs.

9.4 COOLING

The heating chamber incorporates three cooling subsystems:

- A water cooling system for the oven walls and door.
- A nitrogen or air cooling system to reduce residual heating of the quartz isolation tube. This needs to be exhausted out the chassis exhaust, otherwise, the cabinet will get hot.
- A closed loop pyrometer cooling system, to maintain the pyrometer at a constant temperature.

The oven cooling system operates during any period when power is applied to the lamps and remains operational for 5 minutes after lamp power has been removed. The air system provides a continual flow through the system cabinet, around the quartz isolation tube. This eliminates residual heat from the chamber. The pyrometer cooling system operates continuously, whenever power is applied to the pyrometer chiller, to stabilize and maintain the temperature of the pyrometer.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.4.1 OVEN COOLING

Water cooling is used to keep the outer metal plates of the oven cool. The water is circulated through water passages and tubes in the oven walls and chamber door. This protects the oven from over heating. The quartz tube flange is "sandwiched" between 2 metal plates (refer to the Maintenance chapter). If these plates were not kept at a constant temperature, they could twist and bend and break the quartz tube.

9.4.2 QUARTZ ISOLATION TUBE COOLING

When the AccuThermo is in use, heat radiating from the lamps and the wafer raises the temperature of the quartz isolation tube. During a process, the quartz tube heats up, but not as much as if there was no air cooling. CDA or nitrogen is used to cool the quartz isolation tube and lamps. This provides a processing environment with an even temperature range for repeatable cycles. Stabilizing the quartz avoids non-uniformity issues and prevents drift in the temperature measurement when the pyrometer is used as the temperature sensor.

To remove residual heat, the cooling air should be left on for at least five minutes after the process has ended.

9.4.3 WAFER COOLING

When the lamps are turned off, the temperature of the wafer drops dramatically. After several seconds, the cool down rate becomes increasingly slower. This phenomenon is "temperature-and-radiation-dependent".

The difference in temperature between the wafer and the surrounding environment when the steady state ends is great, so the heat lose is fast. Recall studies of entropy in physics with heat/energy transfer. If 2 bodies with different heat levels are in close proximity, the 2 bodies will try to equalize their energy. The greater the difference, the faster the heat energy will equalize. As the difference becomes smaller, so does the rate of equalization. The quartz tube has a much greater mass than the wafer so it needs much more heat energy to increase its temperature, but air cooling keeps it relatively cool. The heat energy of the wafer will transfer to the quartz tube until they have equalized. Then they will cool at the same rate.

9.4.4 RATE OF COOLING

The cooling rate of the wafer in the AccuThermo is acceptable to most process engineers, because their processes are sensitive to a narrow temperature range. For a R&D system like the AccuThermo, leaving the wafer inside the oven for an extra 4-8 minutes is tolerable until the wafer has cooled below 100°C - 200°C. For a production machine, the robot will remove the wafer from the chamber at 400°C or higher and place it on a cooling station. (The wafer is still too hot to be placed in a plastic cassette.) In the meantime, the robot has placed another wafer inside the chamber.

Adequate Cooling Air

The *quartz isolation* ***tube cooling system*** is one of the most important subsystems in the AccuThermo RTP System. During the heating cycle, cooling nitrogen or air flows around the exterior of the quartz isolation tube and through the heating chamber, to maintain a consistent quartz temperature range. Adequate nitrogen or compressed air flow is essential to the proper operation of the system.

9.4.5 COVER GETS HOT

If the cover of the AccuThermo® RTP is getting hot to the touch, then there may not be sufficient cabinet air circulation.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.5 GAS CONTROL

9.5.1 GAS HANDLING SUBSYSTEM

The AccuThermo® incorporates a process gas subsystem that provides a contaminant and oxygen-free wafer environment. The process gas may be inert nitrogen, or it may be a gas that takes an active part in wafer processing. In this manual, the term "process gas" refers to either type, whichever is in use.

Process gas enters the system at the rear chassis panel on the chamber cabinet to one of the process gas ports. The gas flow rate is then controlled by the MFC. Once the gas leaves the MFC, the flow is controlled by an optional pneumatic bellows valve. The gas then enters the gas manifold and is ported to the rear of the chamber. As the gas enters the chamber through the rear, it is distributed evenly left-to-right, top-to-bottom by a baffle. The gas then acts like a wall to displace the atmospheric gas and push it out of the chamber through the exhaust port. The exhaust port for the chamber is on the top-center of the front flange (this is visible when the chamber door is open). The gas exits the process chamber through this port and out a port on the rear of the chassis.

☠ WARNING

It is important to exhaust all process gases to a safe exhaust system, outside the processing area. Depending on the process gases being used and the type of wafers being processed, the exhaust may be toxic and hazardous. In this case the purge outlet should be connected to a facility scrubber.

During thermal processing, the door seals against the front flange. This creates a hermetically sealed processing environment.

Process gas is carried throughout the AccuThermo® by electro-polished stainless steel tubing.

In the AccuThermo® RTP system, gas flow is controlled by MFC's. The ranges for flow rate of the MFC's are varied. The software can be programmed for the maximum flow rate of the MFC and the type of gas that is connected to the MFC.

The processed gas exits the chassis through a port labeled "**Purge Outlet**" that is on the rear of the chassis.

9.5.2 GAS DID NOT SHUT OFF AFTER PROCESS ENDED.

- There is a button in the recipe editor that allows the gases to flow after the process ends. It is called "**Turn Off Gas After Process**". Toggle it so it displays "**YES**".

9.6 INTENSITY

9.6.1 INTENSITY VARIES AND SPIKES GREATLY WHEN STARTING A RAMP.

- If using the **pyrometer**, the starting temperature is not high enough for the pyrometer to sense the temperature reliably. Use an intensity step before the ramp step and make the intensity high enough and long enough so when the intensity step ends, the temperature of the wafer is high enough for the pyrometer to sense the correct temperature. (Refer to section "Temperature Curves".)
- If using the **thermocouple**, the GAIN is too large. Reduce the GAIN in the recipe.

9.6.2 INTENSITY WENT UP, BUT TEMPERATURE WENT DOWN

During a process run, the intensity on the graph went up to nearly 100%, but the temperature went down. The problem was the lamps were turned off. One of the lamp interlocks opened during the process run. Determine which interlock opened and why it opened.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.7 LAMP PROBLEMS

For further information on lamp operation, refer to the ***Service Manual***.

CAUTION

Make sure both Water Cooling and Air Cooling are on before running a process or turning on the lamps. It is very important to cool the chamber, lamp assembly and quartz window to prevent over-heating and destroying the seals.

Both the Water Cooling and Air Cooling should be left on at least 5 minutes after the process ends. This is to make sure the chamber has cooled sufficiently.

9.7.1 LAMPS DO NOT GO ON

The following is not a complete list of possible causes. Refer to the ***Service Manaul***.

- Check the EMO
- Check the Lamp Power switch.
- Check the water flow.

9.7.2 INTENSITY IS HIGHER THAN NORMAL

There are a few things that can make the intensity of the lamps higher than normal to achieve the same temperature. This can be determined by noticing the difference between one run and previous runs, but not very likely if it isn't more than 10%-20% more. The best method to determine if the intensity is too high is to periodically review the process runs or use the PSUM parameters. The following are possible causes.

- **The quartzware is dirty.** This would cause the intensity to be higher, because not as much heat energy can reach the wafer. To reduce the effect of a dirty quartz tube, it should be cleaned periodically.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.8 LED DISPLAY

The LED display on the front of the AccuThermo® RTP system shows the current temperature of the wafer inside the chamber in real-time. It shows the temperature only if the "**Lamp Power**" switch is turned on.

The LED display indicates the temperature from either the pyrometer or the thermocouple. There are 2 methods to select either the TC or pyrometer:

- Go to the Diagnostics screen and select either the thermocouple or the pyrometer. Clicking on the button labeled "**Thermocouple LED Display**" will show the TC temperature on the LED Display. Clicking on the button labeled "**Pyrometer LED Display**" will show the pyrometer temperature on the LED Display.
- Run a process that requires the desired temperature sensor. In a recipe, either the thermocouple or pyrometer can be selected as the S**ensor Type**. Whichever is selected will be displayed on the LED Display during a process, and shown as the "Real Temperature" on the *Process Monitor* screen.

What shows on the LED Display should match what is being displayed on the computer monitor.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.9 OVERHEAT

Whenever the chamber overheats, the Overheat Light (Red) will be on. This indicates the chamber walls have overheated or there is a wafer over temperature condition. The Overheat Light is located on the front control panel.

☠ WARNING

Let the chamber cool down. The cooling water and air must stay on while the chamber is cooling down.

If the cooling water was off when the overheat occurred, leave it off. If the cooling water was on, leave it on.

Go to the ***Diagnostics*** screen. This will keep the cooling air and water on. Do not leave this screen until the chamber has cooled down to room temperature.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.10 PROCESS

For further information to troubleshoot a process refer to the section ***Optimizing the Temperature Profile*** in the "***Advanced Operations***" chapter.

For further information about using the thermocouple refer to the *"**Thermocouple**"* section in the *"**Maintenance**"* chapter.

For an understanding on how and why the AccuThermo RTA performs the way it does, refer to the different sections in the ***Maintenance & Diagnostics*** chapter in the ***Service Manual***.

9.10.1 PROCESS RESULTS INDICATE DIFFERENT TEMPERATURE

Thermocouple

If the After-Process tests show the wafer temperature was different than the process run indicated while using the thermocouple, then the thermocouple bead was not touching the wafer.

The leads of the thermocouple act as springs, pushing the thermocouple bead against the backside of the wafer.

However, if the leads are heated to a high temperature, then they will droop and fall away from the wafer.

- Make sure the TC bead touches the wafer.
- Use shorter TC leads that cantilever out from the T-shaped quartz holder. Long leads that cantilever out will droop away from the wafer more easily.
- Use the pyrometer if the process temperature is above 750°C.
- A TC lead is touching the wafer. Only the bead should touch the wafer.

Pyrometer

If the process results indicate a lack in correspondence between actual temperature and the process run indicated while using the pyrometer, then either

- the quartzware is dirty or
- the pyrometer chiller is not set at 20°C. The pyrometer was calibrated at the factory when the chiller temperature was set at 20°C. The pyrometer electronics is sensitive to temperature variances, so make sure the pyrometer chiller is set to 20°C. Also, the pyrometer water temperature needs to be kept at least 3°C above the dew point. If condensation accumulates inside the pyrometer, the sensitive electronics can be destroyed.
- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

A dirty chamber window would restrict light entering the chamber. It would also heat up the window. The intensity would be higher with a dirty window to get the wafer to the same temperature. Since the pyrometer is sensitive to the IR spectrum of light, a dirty pyrometer window would read a cooler temperature for the wafer than the actual temperature. This would compound the pyrometer reading of the wafer, making the temperature lower than it actually is.

The quartzware needs to be cleaned periodically. The preventative maintenance schedule requires the quartzware to be cleaned at least once a month or more.

If the wafers are processed using the same recipe, then consider using the **Psum** alarm parameter in the recipe. This will alert you to a dirty window. Refer to section ***Process Control Alarms*** for a discussion on how to use Psum. Run several wafers with clean quartzware to determine the proper Psum values. A set of qualifying recipes may have to be developed to test the condition of the system periodically.

9.10.2 PROCESS TEMPERATURE IS DIFFERENT THAN BEFORE TO GET SAME RESULT

If the process temperature is different than before to get the same result as previously, then the quartz isolation tube is dirty. This would happen if the process is using a pyrometer to determine the temperature of the substrate.

9.10.3 PYROMETER

The pyrometer is used as a non-contact temperature measuring device. It is used for process temperatures between 550°C and 1200°C. The pyrometer will not indicate a reliable temperature below 400°C. Consult the ***Service*** manual for the ***Minimum Reliable Temperature*** for the pyrometer.

The pyrometer is sensitive to the IR spectrum of light (heat). The pyrometer has to "look" through the quartz isolation tube to measure the thermal radiation of the wafer. If there is anything inhibiting the IR radiation from reaching the pyrometer, the pyrometer will not read the thermal radiation of the wafer properly.

A dirty quartz isolation tube (chamber) would restrict light entering and leaving the tube. The intensity would be higher with a dirty quartz tube to heat the wafer to the same temperature. Since the pyrometer is sensitive to the IR spectrum of light, a dirty pyrometer window in the quartz tube would inhibit proper reading of the wafer.

The quartzware needs to be cleaned periodically. The preventative maintenance schedule requires the quartzware to be removed and cleaned at least once a month or more. If the process is "dirty" and out-gases, the quartzware may have to be cleaned more frequently.

If the wafers are processed using the same recipe, then consider using the **PSum** alarm parameter in the recipe. This will alert you to dirty quartzware. Refer to section "Process Control Alarms" for a discussion on how to use PSum. Run several wafers with clean quartzware to determine the proper PSum values.

Consider developing a set of qualification recipes that will test the condition of the quartzware and the rest of the system.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.11 PYROMETER CHILLER

9.11.1 CHILLER WILL NOT START

- Check the AC power source. Make sure the circuit breakers are ON and the voltage is correct.
- Inspect the water level inside the chiller.

9.11.2 LOSS OF COOLING CAPACITY

- Check the front and rear ventilation panels to make sure that they are not obstructed.
- If the unit was just turned OFF after a refrigeration cycle, leave the power off for five minutes. Then turn the unit back ON and check for proper operation.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.12 SAMPLES SLIDE OFF BASE WAFER

Samples sliding is usually caused by:

- The base wafer is convex (not flat with the center higher than the edge).
- The base wafer is tilted at an angle (not level). Level the tray and oven.
- If there is any vibration, the samples could slide.
- Samples could also slide if there is too much gas flow. The pressure differential range for the MFCs is 15 – 40 psid. Set the gas input pressure to 20 psi, reduce the flow rate and increase the purge time.
- There is gas trapped between the sample and the base wafer. When the sample is heated rapidly, the gas expands and lifts up the sample. Then the sample slides around like a hockey puck. Either increase the temperature slowly for the first several seconds or make the surface of the base wafer rough.
- Another method to keep the sample on the base wafer is to etch out an area in the middle of the base wafer.

9.13 TEMPERATURE

The solution depends on the type of temperature sensor that is being used: ***Thermocouple*** or ***Pyrometer***. Refer to the appropriate sensor section in the ***Troubleshooting*** chapter and the ***Maintenance & Diagnostics*** chapter of the ***Service Manual*** for further information on these sensors. Also, refer to the ***Temperature*** section in the ***Topics for Discussion*** chapter.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.13.1 TEMPERATURE DOES NOT FOLLOW RECIPE

The control software is setup to follow the "Model Temperature" (black line). The Model Temperature is normally the same as the Recipe Temperature. However, there is one exception, the first ramp step. The step function preceding the first ramp step can either be DELAY or INTN (intensity). If the preceding step function is a DELAY step, then the recipe says the temperature is 0°C. If it is an INTN step function, then the intensity value is plotted as the temperature for the recipe temperature. But the real temperature is anywhere from ~20°C (room temperature) to over 400°C. This depends on the temperature of the system when the ramp step starts. At the beginning of the first ramp step, the model temperature is "seeded" with the real temperature of the wafer. At this point, a line (within the software, but it is not shown) is drawn to the end-point of the RAMP step. This is the line the process control will use to control the rate of the temperature.

There is a button in the *System Setup* screen called **Keep Ramp Speed.** If it is **NO**, then the temperature control will follow the model (black line) as described above. If it is **YES**, then the temperature control will follow the ramp at the same ramp rate the recipe defined. That is, the temperature control will not start controlling the temperature until the real temperature intersects the defined recipe (green line). This will keep the ramp rate as defined in the recipe.

If the pyrometer is used as the temperature feedback sensor, then it is not advisable to follow the recipe curve. If the real temperature is greater than the recipe temperature then the lamps will turn off and the temperature will cool. If the real temperature drops below the minimum reliable temperature for the pyrometer, then the control software will have a hard time controlling the temperature.

It has been found that most processes are sensitive to a very narrow temperature window. If the temperature is too low, then nothing will happen. If it is too high, then the sample is destroyed. The rate to get to a setpoint temperature isn't as important as how long it is maintained at the desired setpoint temperature. Also, the process results are much more repeatable if the first ramp step starts at the same temperature as the real temperature. It is also easier to control the temperature from this point.

9.13.2 HARD TO GET TEMPERATURE TO FOLLOW RECIPE PROFILE.

Refer to the ***Optimizing the Temperature Profile*** in the "***Advanced Operations***" chapter.

9.13.3 TEMPERATURE VARIES AND SPIKES GREATLY WHEN STARTING A RAMP.

- If using the pyrometer, the starting temperature is not high enough for the pyrometer to sense the temperature reliably. Use an intensity step (INTN) before the ramp step and make the intensity high enough and long enough so when the intensity step ends, the temperature of the wafer is high enough for the pyrometer to sense the temperature of the wafer correctly and reliably. (Refer to section "***Temperature Curves***".)
- The GAIN is too large. Reduce the GAIN in the recipe.

9.13.4 DURING RAMP STEP, TEMPERATURE OSCILLATES WILDLY.

Refer to the "***Optimizing the Temperature Profile***" section in the chapter "***Advanced Operation***".

9.14 THERMOCOUPLE

For further information on diagnosing problems with the thermocouple refer to the ***Service*** manual.

To test the condition of the thermocouple, increase the lamp intensity to 5%. (Refer to the ***Diagnostics*** Screen.) The temperature should increase.

If the TC temperature:

increases	The TC is good.
decreases	The TC leads are reversed on the door terminal posts. The lead that is attracted to a magnet should be attached to the wider (left) terminal. Refer to the ***Maintenance*** chapter, section ***Thermocouple***, subsection ***Installing the Thermocouple*.**
does not change **is very high (>1300°C)** **is very low (< 5°C)** **spikes up and down**	➢ Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.
changes very little	A TC lead is being grounded.
rises too fast	The TC is not making good contact with the wafer and is being heated directly.

9.14.1 THERMOCOUPLE (TC) KEEPS BREAKING

Causes

- **Oxygenated Atmosphere:** The thermocouple life is shortened considerably in an oxygenated atmosphere. Check for a chamber leak and fix it. Contact an equipment engineer for assistance and refer to the ***Service Manual***.
- **The Process Temperature is above 800°C.** Consider using the pyrometer or reduce the process temperature. Refer to the ***Maintenance*** chapter, section "***Thermocouple***".

9.14.2 TEMPERATURE READING IS TOO LOW OR JITTERY

Poor and jittery signals from the thermocouple are caused by poor contacts and shorts.

- Make sure the TC wires are connected properly (refer to ***Installing the Thermocouple***) and the wires do not touch the chamber door or chamber front flange. The wires cannot touch the wafer. Only the bead end should touch the wafer. The wires cannot touch anything that is conductive or semi-conductive.
- Poor TC wire connection can give a jittery signal, because of the poor contact at the junction. Make sure the TC wire is secured tightly on the terminal. Do not twist wires together. This method does not create a good contact. The contacts from the bead to the circuit on the control board must be solid and secure at all times.
- Poor TC contact with the wafer. Make sure the bead of the TC has a good contact with the wafer. Momentary contact will look like the TC signal is jittery.
- If the TC wires come out between the chamber front flange and the door, make sure they do not cross. Closing the door can pitch the wires and create jittery readings.
- A bad pyrometer could make the TC reading jittery. Do the following test:

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

9.15 UNIFORMITY

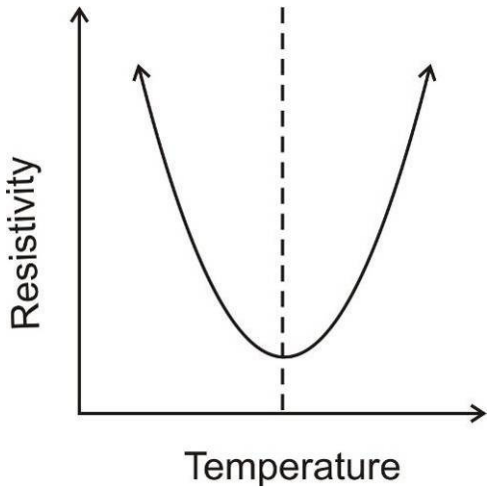
(Refer to the *Uniformity* section in the ***Topics for Discussion*** chapter.)

9.15.1 DEFINITION

Uniformity: uneven temperature distribution across the surface of the wafer.

The sheet resistivity measured on a wafer indirectly indicates the temperature uniformity. It also tests the results of uniformity as an actual process.

Check uniformity. Run a test wafer and measure the resistivity. Compare the values with those obtained on the wafer measured when the system was first installed.



With the implant conditions, ramp rate, steady step time and other parameters held fixed, the correct process temperature can be adjusted to give the desired resistivity. To determine the correct temperature, several runs with slightly different temperatures will need to be done. If the resistivity increases as the temperature decreases, then the correct temperature needs to be increased. However, if the resistivity decreases as the temperature decreases, then the correct temperature needs to be decreased.

9.15.2 PROBLEM

The uniformity is not acceptable or is not as good as before. The uniformity is normally measured by processing an implanted wafer and checking for resistivity.

Using a multi-point TC wafer is not reliable, nor are temperature sensitive “crayons”. The problem with using an array of TC sensors embedded in a wafer is that it tells a snapshot in time of what is going on. One area may lag compared to another area, so it may look cooler. To check if the TC wafer is performing correctly, run a process 4 times with the multi-point TC wafer inside the chamber. After each run, rotate the wafer 90°, for a total of 360°. The hot and cool areas should not move when the TC wafer is rotated. If it does, this shows the multi-point TC wafer is unreliable in determining if there is a problem with uniformity.

9.15.3 CAUSES

There are several factors that can affect uniformity.

- The quartzware may be dirty. Clean the quartzware according to the ***Service Manual***.
- Level the quartz tray according to the ***Service Manual***.
- There could be insufficient air cooling. The CDA/N_2 cooling flow rate could be insufficient. Refer to the ***Installation Manual***.
- There could be insufficient water cooling. This could cause a chamber plate to get too hot. The water cooling flow rate could be insufficient. Refer to the ***Installation Manual***.
- The process gas may have a problem.
    - Low process gas flow – The process gas source may be getting low.
    - Process gas pressure may be too high – If the process gas pressure is too high, the MFC may not be able to control it properly.
    - Contaminated process gas.
- The heat absorption over the entire surface of the wafer may not be uniform.
- The heat conduction throughout the wafer may not be uniform.

- Contact an equipment engineer for assistance. Refer to the ***Service Manual*** for more possible causes and remedies.

Consider using the PSum parameter in the recipe if the same type of production wafers are being processed using the same recipe. Refer to section "***Process Control Alarms***" for a discussion on how to use PSum. Run several wafers with clean quartzware to determine the proper PSum values.

Remember, energy dissipates relative to the square of the distance. At 1150°C, the lamps are putting out a lot of energy and a little deviation in the lamps will make a lot of difference. At 500°C, the lamps are putting out little energy, so a little difference in the lamps will not make much of a difference in uniformity.

9.16 "NO AW-RTP-900-008 CARD OR CARD CONNECTION NOT GOOD!"

- If this error message appears on the computer monitor screen, then refer to alarm 726.

10. SYSTEM SOFTWARE

Chapter 10: Chapter 10

10.1 OVERVIEW

Allwin21 AccuThermo® RTP systems use DOS 7.10 as the operating system for the control software. (Refer to a DOS manual for a full explanation of these and other DOS commands.) It has a size limit of 100 GB per drive. However, some of our functions in the control software were created using DOS 6.22 which has a size limit of 2 GB per drive. Therefore, drive C: is partitioned to 2000 MB, while drive D: uses the rest of the drive space.

Drive C: is considered the primary hard drive, and it is assigned the drive letter C:. This drive contains the operating system, utilities, and the control software. It can also contain some process data.

Drive D: is considered the secondary hard drive, and is normally assigned the drive letter D:. This drive is used as a second source to store process data.

When a USB drive is inserted into a USB port on the computer, it may be assigned the drive letter D:. Then, the secondary hard drive might be assigned the drive letter E:.

However, some computer BIOS may assign the USB drive the drive letter E:.

The procedures that backup information from the hard drive to a USB drive expect the USB drive to be 2 GB or less in size.

NOTE

While the USB drive is plugged into the computer, do not run any processes. The process may not be recorded.

10.1.1 FILENAMES

- Filenames have no more than eight characters.
- Contain only the letters A – Z, the numbers 0 – 9, the underscore (_), and the dash (-).
- Cannot contain spaces, commas, backslashes, or periods.

10.1.2 PATH

In DOS, you list the path where a file is stored by separating the directory names with the backslash (\).

For example:

```
\doc\info
```

The first backslash represents the root directory. The second backslash separates the INFO directory from its parent directory, DOC.

10.1.3 WILDCARDS (*, ?)

If you want to perform the same task for a group of files, you don't have to use the same command repeatedly for each filename in the group. You can use wildcards to specify groups of files. A wildcard acts as a substitute for a name or extension.

There are two wildcards:

- The asterisk (*) represents a whole word or group of characters.
- The question mark (?) represents a single character.

For example, list all of the files and directories in the current directory that start with the letter 'c':

```
dir c*.*
```

10.2 SOFTWARE STARTUP

10.2.1 OVERVIEW

The control software is already installed on the hard disk of the control computer. All you need to do is power-up the system and make sure the computer, and monitor are on. Once powered up, the *Main Menu* will appear on the monitor. See Figure 4-2.

It is always advisable to make a backup copy of the control software. It may be needed in the event that the system is damaged, and problems develop on the computer which necessitates reloading the control software.

Refer to the sections "***Back Up the Control Software***" and "***Restoring the Control Software***" of this manual for information on how to make a backup copy of the system.

10.2.2 REBOOT THE COMPUTER

The user will be asked to rebooting the computer for two reasons:

1) Whenever a USB drive is connected to a USB port on the computer, the computer needs to be rebooted before it will be detected. This is because DOS is not a "plug-n-play" operating system. The USB driver only detects a USB drive when the computer is booting.
2) The control software was just updated with a new version. Rebooting the computer will alow the new version to load.

There are two ways to reboot the computer, soft reboot and hard reboot.

SOFT REBOOT
To abort and reset the control software at any time, simultaneously press and hold down the [**CTRL**, **ALT** and **DEL**] keys on the computer keyboard. This will reboot the computer and reload DOS — This procedure could not be used if there is no response from the keyboard.

HARD REBOOT
Turn power to the computer off, wait 10 seconds, and then turn the power back on.

If the computer locks up and doing a soft reboot doesn't do anything, then do a hard reboot.

10.2.3 EXITING CONTROL SOFTWARE

This procedure describes how to exit the software that controls the operation of the system. It is a function that is only available to operators that log in at a sufficient access level.

Press 'Q' (or 'q') on the keyboard from the *Main Menu* to exit the control software and go to DOS.

10.3 DETERMINE USB DRIVE LETTER

The USB drive is normally assigned the drive letter D: when it is installed in a USB port. However, this is not always the case. This procedure explains how to determine the drive letter for the USB drive that has been inserted into a USB port.

DOS is not a plug-n-play operating system. This means the USB drive will only be detected at boot time. The USB drive will only be found at the time the computer boots. Therefore, after the USB drive is inserted into a USB port, the computer needs to be rebooted. The USB drive will probably be assigned one of the following drive letters: D: or E:

Step 1. Insert a USB drive that is 2 GB or smaller into a USB port.

Step 2. Reboot the computer.

Step 3. When the computer has booted and is idle at the *Main Menu*, exit the control software. (Refer to the section "***Exiting Control Software***".)

Step 4. Use the DOS command **DIR** to determine which drive the USB is assigned.

DIR X:

where X is the drive letter. If the drive letter is correct, then the root directory of the USB drive will be listed. However, if the message "**Invalid Drive Specification**" or "**Drive not Ready**" appears then try another drive letter. Start with the letter D and go until Z.

If the assigned drive letter for the USB drive is D:, then the secondary hard drive that was assigned drive letter D: when the USB drive was not installed is now probably assigned drive letter E:. This hard drive is used as a secondary drive for storing process data.

NOTE

While the USB drive is plugged into the computer, do not run any processes. The process may not be recorded.

10.4 BACKING UP AND RESTORING FILES

10.4.1 BACK UP THE CONTROL SOFTWARE

Drive C: contains the control software and generated files (i.e. recipes, calibration data, and process data that are on drive C:). This procedure will backup all control software files that reside on drive C:.

Step 1. Connect the USB drive to the USB port on the system computer.

Step 2. Reboot the computer.

Step 3. When the computer has booted and is idle at the *Main Menu*, exit the control software. (Refer to the section "***Exiting the Software***".)

Step 4. Determine the proper drive letter for the USB drive (see "***Determine USB Drive Letter*** ").

Step 5. Change the drive to drive "C:" by typing the following DOS command:

```
c:
```

Step 6. Change to the control software directory of drive "C:" by typing the following DOS command:

```
cd  \RTAPRO
```

Step 7. Change the drive to the USB drive. For example, if it is drive "D:", then type the following DOS command:

```
d:
```

Step 8. Create a directory for the backup files (if it has not been created). For example, if the directory name is "backupAW", then type the following DOS command:

```
mkdir  \backupAW
```

Step 9. Type the following DOS command:

```
xcopy  c:\RTAPRO\*.*  X:\backupAW\*.*  /s
```

where **X:** is the USB drive letter. This will backup all files to your USB drive. These files can be archived on a server.

Step 10. Remove the USB drive when the computer has stopped copying files and reboot the computer.

END OF PROCEDURE

10.4.2 BACK UP PROCESS DATA ON DRIVE D:

Drive C: and drive D: contain the process data that the machine has generated. The process data on drive C: will be backed up when backing up the Control Software.

Drive D: is normally considered the secondary hard drive, and is normally assigned the drive letter D:. When a USB drive is inserted into a USB port on the computer, the USB drive is normally assigned the drive letter D: and the secondary hard drive may be assigned the drive letter E:.

The following procedure will backup all process data on the secondary hard drive to a USB drive. These files can be archived on a server. They can also be viewed on your office computer that is running the AccuThermo® RTP control software in demo mode.

Step 1. Insert the USB drive into a USB port on the system computer.

Step 2. Reboot the computer.

Step 3. When the computer has booted and is idle at the *Main Menu*, exit the control software. (Refer to the section "***Exiting Control Software***".)

Step 4. Determine the proper drive letter for the USB drive (see "***Determine USB Drive Letter*** ").

Step 5. Determine the drive letter for the secondary hard drive, by typing the following DOS command:

```
dir e:\
```

It should list a directory called "**RTA_DATA**". Try other drive letters if RTA_DATA was not found (D: through Z:). The drive letter should be different than the USB drive letter.

Step 6. Change drive to the USB drive. For example, if it is drive "d:", then type the following DOS command:

```
d:
```

Step 7. Create a directory for the backup process data (if it has not been created). For example, if the directory name is "data", then type the following DOS command:

```
mkdir  \data
```

Step 8. Type the following DOS command:

```
xcopy  X:\rta_data\*.*  Y:\data\*.*  /s
```

where **X:** is the drive letter of the secondary hard drive and Y: is the USB drive letter. This will copy all process data for the AW610V control software onto the USB drive.

Step 9. Remove the USB drive when the computer has stopped copying files and reboot the computer.

END OF PROCEDURE

10.4.3 RESTORING THE CONTROL SOFTWARE

The following procedure will restore the control software to the hard drive and will revert all setup information to the last backup state. If any recipes or calibration files have been changed since the last backup, they will also revert to the last backup state.

Step 1. Connect the USB drive to the USB port on the system computer. Use the USB drive that has the control software backup files.

Step 2. Reboot the computer.

Step 3. When the computer has booted and is idle at the *Main Menu*, exit the control software. (Refer to the section "***Exiting the Software***".)

Step 4. Determine the proper drive letter for the USB drive (see "***Determine USB Drive Letter*** ").

Step 5. Change to drive "C:" by typing the following DOS command:

```
c:
```

Step 6. Create the control software directory (if it has not been created) to restore the software to drive C:. The directory name is "**RTAPRO**". Type the following DOS command:

```
mkdir  \RTAPRO
```

Step 7. Change the drive to the USB drive. For example, if the USB drive is drive letter "D:", then type the following DOS command:

```
d:
```

Step 8. Type the following DOS command:

```
xcopy  X:\backupAW\*.*  c:\RTAPRO\*.*  /s
```

where **X:** is the USB drive letter and **backupAW** is a previous back up session to be restored. This will restore all of the control software files to the primary hard drive, drive C:.

END OF PROCEDURE

10.5 UPDATING THE CONTROL SOFTWARE

The version code of the control software is made up of 2 parts: the major and the minor. These parts are separated by a decimal point. The minor part of the version code (the right side) follows the decimal point. It is made up of 3 characters. Each character position has a specific meaning as described in the following table.

Character Position	Meaning	Format	Example
1	year	hexadecimal	6=2006 A=2010
2	month	hexadecimal	1=January 2=February 3=March 4=April 5=May 6=June 7=July 8=August. 9 = September A=October B=November C=December
3	release number	hexadecimal	1 - F

Whenever an updated version of the control software has been received, the extension of the filenames will be coded the same as the version of the control software.

For example: If the filename is **`RTAPRO.7B2`**, then the minor version of the control software is 7B2.
7 = 2007
B = November
2 = variant #2

This software was released in November, 2007. It is the second variant for the month.

If a notification has been sent that there is an update of the control software, do the following procedure:

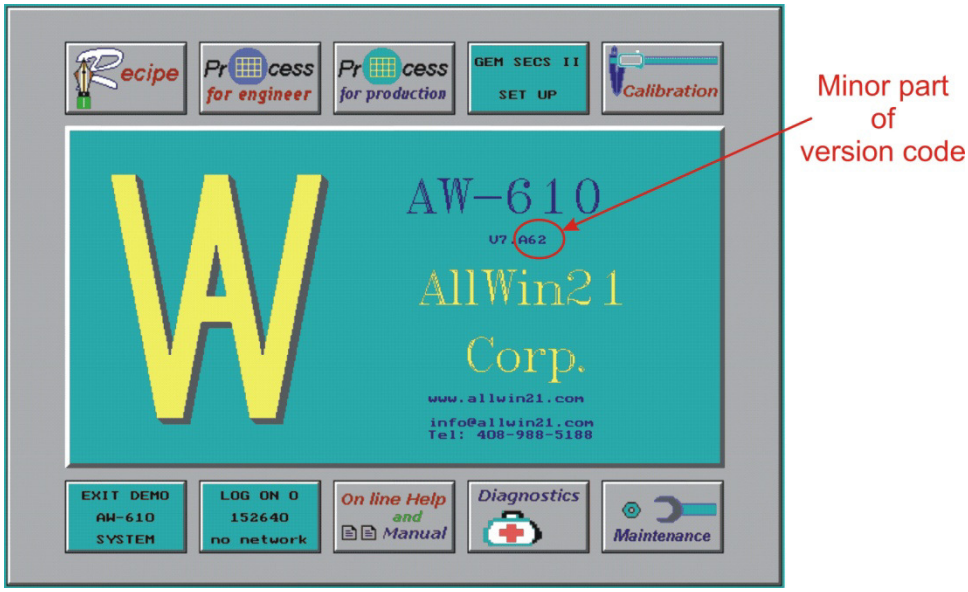
Step 1. Download the files onto your computer.

Step 2. Copy the files onto the **root** directory of a USB drive that is 2 GB or smaller. The USB drive that came with the system is best.

Step 3. Take these files to the machine.

Step 4. Connect the USB drive to the USB port on the system computer.

Step 5. Reboot the computer.



Step 6. Once the computer is showing the *Main Menu*, **note** the 3 character minor part of the current version code.

Step 7. Exit the control software. (Refer to the section "***Exiting the Software***".)

Step 8. Rename the extension (EXE) of the existing application control software with a new extension that is the minor part of the current version code, as noted above. Use the following command. For example, if the minor part of the current version number is **123**, then type the following command line.

```
COPY   RTAPRO.EXE   RTAPRO.123
```

A copy of the application file (RTAPRO.EXE) will be made with the filename RTAPRO.123, where 123 is the current version code.

Step 9. Determine the proper drive letter for the USB drive (see "***Determine USB Drive Letter*** ").

Step 10. Copy the files from the USB drive (drive D:) into the control software directory. For example, if the USB drive letter is D:, then type the following command:

```
COPY   D:RTAPRO.*   C:RTAPRO.*
```

A copy of the application file with the new version code as the file extension will be made in the control software directory.

Step 11. Change the extension of the new application file to EXE. Use the following command substituting 321 for the minor part of the new version, as described above.

```
COPY   RTAPRO.321   RTAPRO.EXE
```

A copy of the application file with the new version code will be made with the filename RTAPRO.EXE.

Step 12. If the computer asks you to overwrite a file, type “a” for “All” and press ENTER to replace the old files.

Step 13. You have just updated your control software. Now reboot the computer to have it take effect.

END OF PROCEDURE

10.6 KEYBOARD SHORTCUTS

Main Menu

key	screen
F1	Help
F2	
F3	Recipe Edit Selection
F4	Process for Engineer
F5	Process for Production
F6	
F7	
F8	Calibration Menu
F9	Diagnostics
F10	Maintenance Menu

Maintenance Menu

key	screen
F1	Factory Setup
F2	Board Configuration
F3	Test Boards
F4	Lamp Zone Control
F5	Manual Control
F6	System Setup
F7	
F8	
F9	Level Setup
F10	Password Setup

10.7 RUNNING THE CONTROL SOFTWARE ON A DESKTOP COMPUTER

Sometimes, it may be desirable to run the application control software on a desk top computer to view process data, or create recipes. The screens can be copied and pasted into documents for reports or to create company procedures for the system.

If the desktop computer is running Microsoft Windows XP or later, Linux, or Mac OSX, the control software cannot run directly under these operating systems (OS). It needs to have a utility called DOSBox to run as a shell between the OS and the control software.

DOSBox is an open source DOS emulator, which means it is a free utility that can be downloaded from the internet.

www.dosbox.com

Follow the directions at the web site to download and install DOSBox.

Once DOSBox is installed, a directory on the hard drive needs to be created for DOSBox to mount to. Mounting can be setup automatically when DOSBox starts. From this directory, the control software can be installed. It is best to treat the mounted directory as the root directory and copy the control software as if you are restoring it (see "***Restoring the Control Software***").

To start the control software, you need to be in the control software directory. Now, type the following DOS command to run the control software in demo mode.

```
RTAPRO  -d
```

The application control software will run like it is on the system.

Read the DOSBox information on how to do a screen copy and other things.

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APPENDIX

A: SELECTION OF THE PURITY OF GASES

Gases are available in a range of purity grades. These purity grades are identified by names such as "Research Grade", "Ultra High Purity", "Zero", "Prepurified", etc., which give an indication of relative purity such that "Ultra High Purity" is purer than "Prepurified". These terms, however, are not absolute. "Research Grade" Argon is not the same purity as "Research Grade" Methane or even "Research Grade" Nitrogen. The same purity name may be used for the same gas by different manufacturers, each offering the product with different specifications. The grade name therefore does not tell the user what the actual purity level is – it varies from product to product and manufacturer to manufacturer.

The important measures of purity are the overall percentage purity of the gas and the identity and levels of the impurities present.

A simple system used to signify the percentage purity is a digitized grade system. In this system the first digit signifies the number of 9's in the percentage purity. The second digit indicates the next number that differs from a 9. Thus:

Helium 4.5

There are four 9's in the purity and the next digit is a 5 –

99995 as a purity percentage is 99.995%

Similarly Argon 6.0 is 99.9999% (Six 9's and the next digit is a 0)

Often of more importance in a particular application is knowing what impurities are present and at what level. If Nitrogen is used as a zero gas for a ppm Oxygen analyzer, it is important to know the Oxygen level of each grade of Nitrogen when selecting which to use.

Summary Purity Table

Percentage Purity	Grade	Total Impurities
99.99%	4.0	100 ppm
99.995%	4.5	50 ppm
99.999%	5.0	10 ppm
99.9995%	5.5	5 ppm
99.9999%	6.0	1 ppm

B: SOFTWARE CRITIQUE

Contact Name			
Company Name			
Address			
Telephone		Email	

Equipment Model		Equipment Serial #	
Equipment Designation Name (name you refer to machine)			

Date	
Software Version	
How do you like this software?	☐ very good ☐ good ☐ adequate ☐ barely adequate ☐ bad
Suggestions for added features	
Comments	

Email to: info@allwin21.c

C: PROBLEM REPORTING

Email the following problem report to: info@allwin21.com

Describe the problem in the subject line in 8 words or less.

PROBLEM REPORT

Contact Name			
Company Name			
Address			
Telephone		Email	

Equipment Model		Equipment Serial #	
Equipment Designation Name (name you refer to machine)			

Date	
Software Version	
Problem	

Electrical	voltage		# of phases	
	wire size		circuit breaker size	
	line frequency			
Chamber Cooling Water	flow rate		inlet temperature	
	inlet pressure		diff. press.	
Cooling Air	flow rate		tubing diameter and length	
	pressure			
Pyrometer Cooling Water	temperature			
Process Gas	pressure		tubing diameter and length	
Process Exhaust	negative pressure			
Pneumatic Air	pressure			

Please give as much detail and information as possible to replicate the problem at our facility.

When you comment on an issue that involves the software (example: error 0007), tell us:

- How did the error occur?
- Is it repeatable?

Take a picture of the ENTIRE screen and send it to us. There are much more information on other areas of the screen that may help us determine the problem.

D: HOW TO ORDER / RETURN EQUIPMENT

The information contained in this appendix includes the following:

- How to order equipment and parts
- How to return parts
- How to exchange parts
- What to do when the system is down
- Service Agreements

D.1 HOW TO ORDER EQUIPMENT AND PARTS

To order parts from Allwin21 Corporation, call:

Allwin21 Corporation
Customer Service
Phone: 1-408-778-7788

To obtain a quote and information concerning part availability, please have the following information ready:

- System model number (example: AccuThermo AW610)
- Serial number of the system
- Part number of the required part
- Purpose of order (spares, failed part, etc.)
- "Ship To:" address
- "Bill To:" address
- Purchase order number

D.2 HOW TO RETURN PARTS

🏷 NOTE

An RMA (Return Material Authorization) number must be obtained from AllWin21 prior to shipping any parts back to AllWin21.

A Return Material Authorization (RMA) Number is required in order to return or exchange system parts. To obtain an RMA number, call:

Allwin21 Corporation
Customer Service
Phone: 1-408-778-7788

Return any failed parts to the following address:

Allwin21 Corporation
220 Cochrane Circle
Morgan Hill, CA 95037
Attn: RMA # _____

Ensure that the RMA (Return Material Authorization) number is included with any returned part(s). Include the following information with the part:

- System model number (example: AW610)
- Part number of failed part
- Detailed failure information
- Serial number of system and of the failed parts (if applicable)
- "Ship To:" address
- "Bill To:" address
- Purchase order number
- RMA (Return Material Authorization) number

As the customer, it is your responsibility to return the part(s) in a proper packing container. Failure to return the part properly could result in further damage to the part.

NOTE

The RMA (Return Material Authorization) number must be visible on the outside of the package when returning a failed part. Allwin21 Corporation will not accept returned parts without an RMA number. This could result in the sender being billed for the full purchase price.

D.3 HOW TO EXCHANGE PARTS

After troubleshooting to isolate a failed part, replace the part with a site spare if one is available. If the system is down due to an isolated failed part and no site spare is available, call:

Allwin21 Corporation
Customer Service
Phone: 1-408-778-7788

Contact Allwin21 Field Service to properly identify the failed part. Allwin21 will issue an RMA (Return Material Authorization) number to you which must be included when the failed part is returned. The failed part MUST be returned to Allwin21 within ten (10) days in the proper packing container or the full purchase price will be billed. Replacement parts under warranty are shipped out in the timeliest manner possible.

All returned parts must be shipped in the same packing material as the replacement part. Failure to return the part in the proper packing container could result in further damage to the part.

D.4 WHAT TO DO WHEN SYSTEM IS DOWN

If the system is down and you cannot isolate or fix the problem within a reasonable period of time, call Allwin21 Corporation Customer Service for telephone assistance or a service visit. Telephone numbers are staffed by trained Allwin21 Corporation technicians, who can provide on-the-spot help with difficult problems and advice on repairs.

Allwin21 Corporation
Customer Service
Phone: 1-408-778-7788

D.5 TIPS FOR TROUBLESHOOTING

- Solve the real problem. Do not create one or more new problems to solve existing problem.
- Face the problem. Do not escape from the problem.
- Find the problem (if you find the problem, the problem is already 50% resolved)
- Find the root causes and reasons the problem exists.
- Follow the protocol and standards.
- Follow the documents.
- Double check, triple check.
- Ask if you are not sure.

D.6 RULES FOR EQUIPMENT MAINTENANCE

- Treat all the connectors like eggs. Never "drop" the connector on the ground or on any other hard surface.
- Pull out a PCB board at least 30 seconds after turning off the machine.

  dU=dI/dt,
  Even at a very low leakage current, the voltage will be very high when the PCB is removed too soon. Many boards are damaged due to this phenomenon.
- Turn on the machine at least 10 seconds after turning it off. This is because the inductance circuit is still at a high voltage after the machine was turned off. Many machines get problems after being shut down and then turned on too quickly.
- Always check facility condition before turning on the machine.

D.7 EQUIPMENT TROUBLESHOOTING EXPERIENCES

- >80% of equipment down time is caused by connectors. There are many kinds of reasons for bad connections:
  a. loose connectors
  b. corroded or oxidized pins of the connectors
  c. broken wires in the cable
- >90% of RF problems are caused by the RF cable and connectors.
- >75% of machine down time is caused by wafer transport.
- >95% wafer breakage problems is caused by wafer transport.
- Do not think there is a big issue in the problem first; always think and start from small issue first.

E: MAINTENANCE PLANS

E.1 EXTENDED MAINTENANCE PLANS

AllWin21 commitment to customer support carries on past the warranty period. By offering a choice of extended maintenance plans, we can satisfy most of your service requirements. Contact Allwin21 Field Service or Sales Administration for more details.

E.2 SERVICE TRAINING

AccuThermo system uptime may be increased dramatically by having trained in-house personnel and spare parts kits. Operator and Service training (a one day course) are available at Allwin21 for a fee. These courses cover the following types of information:

- System overview
- Operation
- Software use
- Recipe construction
- Temperature control and optimization
- Preventive maintenance
- Electronics operation and troubleshooting
- Temperature monitoring using the thermocouple and pyrometer

Students are usually Applications Specialists, Equipment Engineers, System Operators and Maintenance Technicians. Emphasis is on hands-on work, as the classes are small and allow personalized instruction.

F: MANUAL REVISION HISTORY

Date	Rev.	Description
Dec. 2011	G	Initial Release of the Operation Manual (split from the Technical Manual)
Nov. 2016	H	Remove single-phase; update pictures

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