Operating Procedure – Allwin21 AW 610 RTP

(Rapid Thermal Annealing)

Prepared by

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based on

Main manual provided by Allwin21 and discussion with Allwin21 service engineer David Chang, USA

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Pre check before entering in the lab for RTP Process

Step: 1. Check if any other tools in Fab Lab is ON or not. If any other tool (PECVD, Edge isolation tool) is/are ON, then enquire from facility people if you can use RTP as some gases are on sharing basis.

Step: 2. Check if cooling water is ON [Set pressure should be 25 -30 psi (~ 2 bar)].

Step: 3. Check if water supply to Pyrometer is ON [Set temperature should be 20 ^{0}C and stable].

Step: 4. Check if exhaust is ON (Ask facility people if not sure).

Step: 5. Check if CDA is available and ON (Ask facility people if not sure).

Step: 6. Check the process gases N_2 or Ar which you want to use is ON [[Set pressure should be 20 psi]. [Gases, which are available for RTP, are Nitrogen, Oxygen and Argon].

Step: 7. Wait for 10 minutes to stabilize all the flow and setups.

Front and back utilities and connection names:

Main SOP/H.K.S
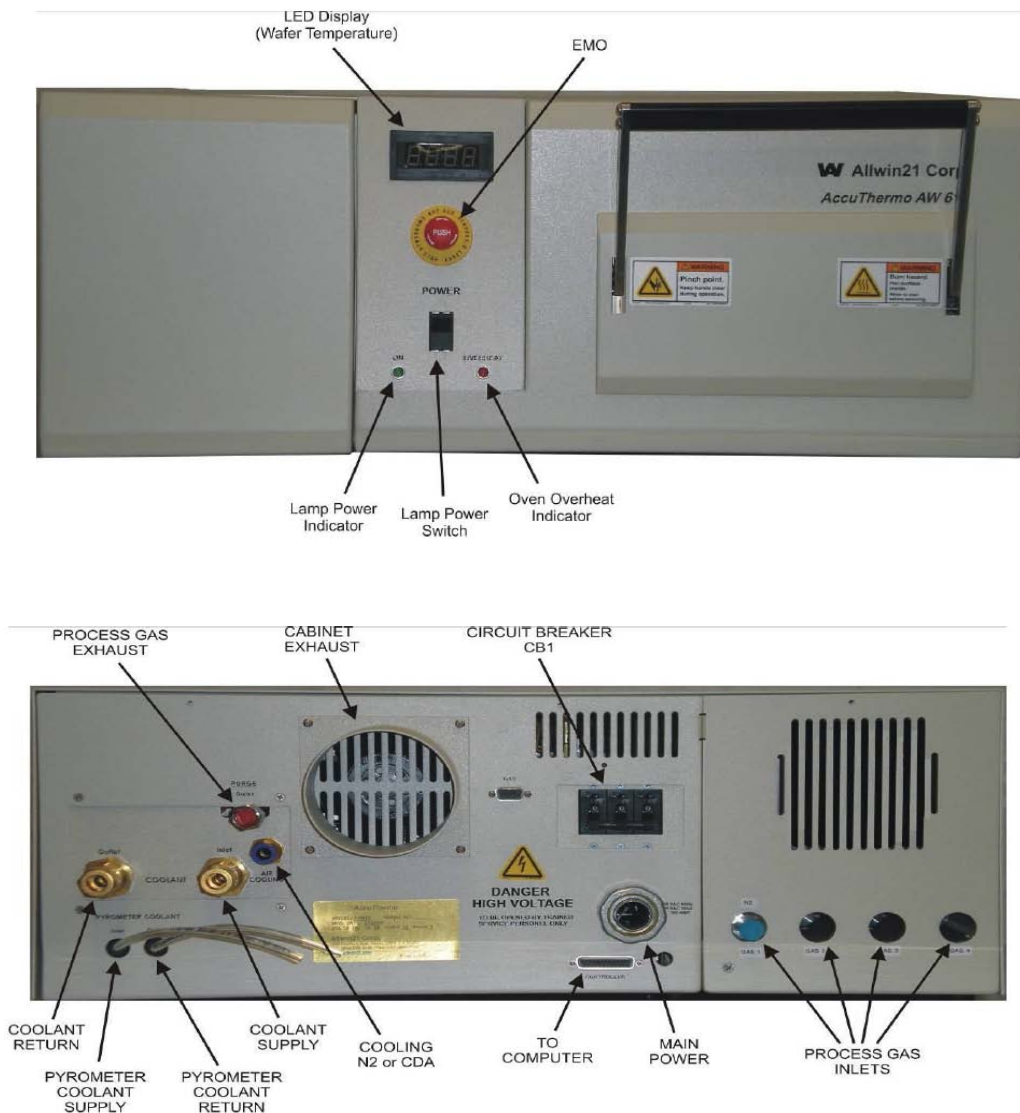
System Power UP

Step: 1. Ensure that you have followed step 1 – 7 as mentioned in "Pre check before entering in the lab for RTP Process".

Step: 2. Open the valve for CDA which is connected to regulators of MFC and Air cooling.

Step: 3. Crosscheck if CDA regulator for Pneumatics valve is set at 70 psi. [Consult Facility people] and the regulator is ON.

Step: 4. Crosscheck if CDA regulator for Air-cooling for system is set at 20 psi. [Consult Facility people] and the regulator is ON.

Step: 5. Ensure if the RTP system exhaust is Open [see fig below].

**Step: 6.** Switch ON the main supply for RTP system.

Step: 7. Switch ON the circuit breaker (CB1) available at backside of the system (see fig above).

Step: 8. Switch ON the lamp power switch available at the front panel of the system.

Step: 9. Check if LED display at front panel is showing Room Temperature (24-26 ^{0}C).

Step: 10. Switch ON the computer and LCD monitor for the system. [Sequence is important. Always start RTP system first and then computer].

Step: 11. You will see software control interface as below:
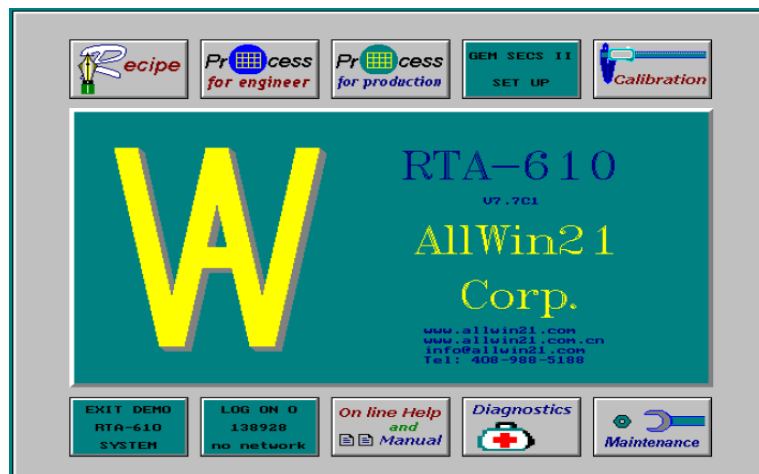
Step: 12. In case if you see command window then type **<u>rtapro</u>** and then press enter. This will lead you to interface as above.

Step: 13. Ensure that there is no wafer/sample left inside by someone in the process chamber of RTP except the test wafer, which is for balancing the thermocouple bead for free movement of thermocouple without interfering the walls of the chamber.

Step: 14. Click on the **Diagnostics** at the main software control interface. You will see software interface as below. Make sure that the thermocouple (TC) sensor is selected and temperature display at software interface for TC is same as LED display temperature at front panel of RTP system.
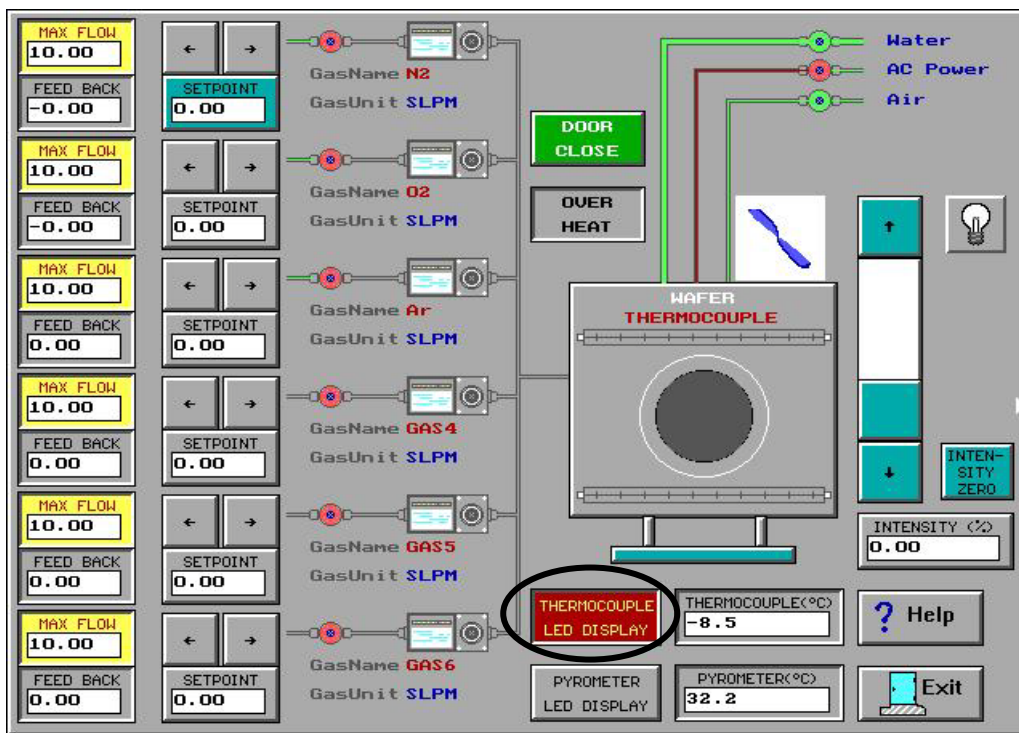
Step: 15. Once you are at **Diagnostics** software interface, check for the following to ensure the working of all sensors:

    a. Click on the water valve icon. The water flow should stop.

    b. Click on it again to make the water flow.

    c. Click on the air valve icon. The air flow should stop.

    d. Click on it again to make the air flow.

    e. Open and close the door of the chamber. The indicator "Door Close" should change from green to gray when door is opened.

Main SOP/H.K.S

f. Open the process gas valve [N_2 or Ar which ever is open or to be used] and set 3 to 5 SLPM of selected process gas flow in software interface to ensure tube purging. Observe that there is gas flow being displayed on the **Diagnostics** screen in flow feedback section. [The chamber door can be opened slightly (1 cm) during this test and again close it].

g. Check if thermocouple is connected properly inside the chamber (the two wires of thermocouple should not touch anywhere except at end point). If yes then place a dummy wafer inside on the quartz tray such that the tip of the cantilever thermocouple touching the backside of the wafer. Close the chamber door after this check.

h. Set the lamp **intensity** to 5 % in the **Diagnostic** screen and ensure that "Thermocouple Led display" is selected in the software interface and then click on the lamp icon. Observe the rise in the thermocouple (TC) section in the software interface. It should increase if so then TC is working fine. Also observe that the displaying temperature is same as Led display temperature at the front panel of the RTP system. [**Note that this test should be done quickly in short duration so that temperature should not rise above 200 ^{0}C. Also there should be a dummy wafer inside to ensure the heat sink**] Once test is done, then click again on the lamp icon to stop the lamp. Also set the lamp **intensity** to back to 0 % in the **Diagnostic** screen.

Note: For high temp process (> 700 ^{0}C) on Si wafer, you need to remove the thermocouple arrangement from the chamber and in that case you should select "Pyrometer LED display" in the software interface to test the temperature rise with intensity. Also note that Pyrometer is not sensitive below 500 ^{0}C temperature.

Step: 16. Click on Exit icon to go to main menu.

If all the steps from **Step 1- 15** is OK, then the system is ready for Process. If you find any abnormality, contact the System Owner/technical person.
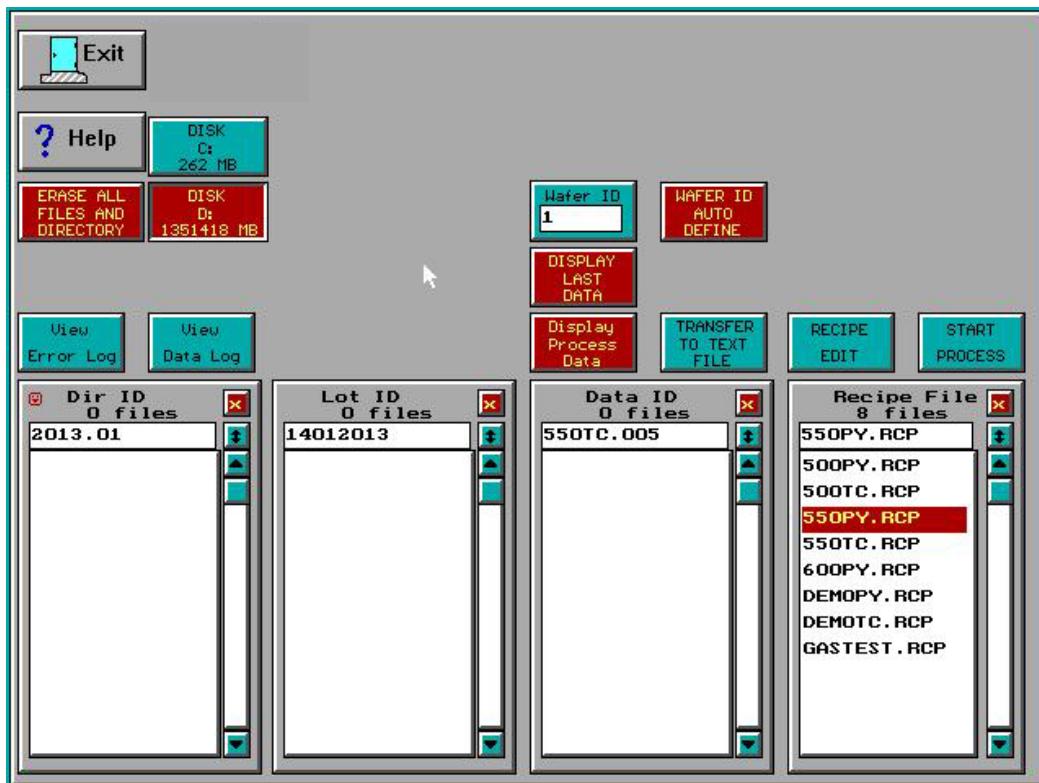
Process Recipe making/editing or running

Step: 1. If you are sure that the system is ready for process after following the "**System Power UP**" steps 1 -15, then follow as below.

Step: 2. Go to main menu which looks as below:

Step: 3. Click on "**Process for Engineer"** icon.

Step: 4. Now to create or modify recipe follow **steps 5 -32.** Creating a new recipe and editing an existing recipe are very similar. The differences between creating a new recipe and editing an existing recipe occur when the changes are saved. ***Creating a new recipe also involves changing the Recipe Name field.***

Step: 5. Use the slider to the right of the list to display. Click on the Recipe to select it. Click on the Recipe Edit button to display the Recipe Editor for any pre existing recipe to make new recipe. Check all the parameters are correct and as per wish for the process. For this, follow the following.

Step: 6. After selecting a pre-existing Recipe by click on the "Recipe edit" icon. You will be at a interface as below:

Main SOP/H.K.S

(Note in the above figure when Thermocouple sensor is selected, there is no INTN step at no. 2 in edit section. So whenever use thermocouple, don't use INTN step. It may be used when you wish fast ramp up but not advisable here. But INTN step is must if pyrometer is to be used as main sensor.)

Step: 7. Edit it. (If a new Recipe is to be created, also change the Recipe Name field before saving.)

Step: 8. For editing the recipe parameters follow the following.

Step: 9. The editor is divided into two main sections. The top section (header) is where the user inputs information pertinent to the overall recipe. The lower section (data entry area) is for the process recipe data entry.

Step: 10. The Recipe Name can be edited. This should be done if a new recipe is to be created. Follow the structure for recipe ID as (Temp)(Sensor-TC/PY) e.g. **500TC** or **550PY** (note that the name should not exceed 5 digits). Also leave the EXT field as RCP. This is the filename extension and the AW-900 software expects it to be RCP for a recipe.

Step: 11. Wafer type wafer button on header of edit pages as figure above toggles between "wafer" and "susceptor". Default value is "wafer". For small samples, it may be required to use a susceptor to hold the wafer inside. Also note that it is necessary to use a different type of chamber calibration data specific for the susceptor. **When use susceptor, follow Appendix – I before you move to next Step: 12.**

Step: 12. Sensor type thermocouple button on header of edit pages as figure above is for the temperature measurement sensor and can be toggled between the TC, pyrometer. Choose appropriate sensor, which you are going to use. (**For Pyrometer use, the temperature should be > 600 ^{0}C and for TC the temperature should be < 700 ^{0}C unless specified**. Also when use TC, make sure that thermocouple is connected in the chamber and working fine).

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.*

Step: 13. Use pyro offset button on header of edit pages as figure below, to use of the "system" "local" recipe value (Pyro Offset) for the pyrometer temperature measurement-correcting offset. To determine required offset value, use data from processing which is done earlier on process temperature on TC sensor based process for above 500 ^{0}C. Then

use offset value **x** if TC display temperature **>** Pyro display temperature and TC temp – PY temp = x and if if TC display temperature is **<** Pyro display temperature and PY temp –TC temp = x and use off set vale as (-) **x.**

Note: Never change the TC offset value. Its default value is 1.

Step: 14. Use emissivity button on header of edit pages as figure of screen as below, The pyrometer emissivity will use the "system" "local" recipe value (Emissivity). The value for the emissivity to be used with the pyrometer. A standard silicon wafer has an emissivity of 77.04.

Note: The software treats emissivity as a factor that offsets the pyrometer temperature reading. If the pyrometer temperature is not the same as the real processed temperature, then adjusting the emissivity offsets the pyrometer temperature reading (Don't change value without permission from technical person).

Step: 15. The five variables (Gain, Sensitivity, Delay, Psum1 Average and Psum2 Average) are for fine tuning the temperature control performance.

Step: 16. : 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.

Step: 17. : This is the value for the transient period from RAMP to STEADY. Normally and default value is 1.0.

Step: 18. : The value for the gain of the temperature PID control for the process steps RAMP and STEADY. Normally and default value is **1.5**.

Step: 19. : 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.

Step: 20. : 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.

Step: 21. : 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. Select Yes if at end, step of recipe is a delay step.

Step: 22. : This button resets all bank factors to the default value of 1.0. [Don't edit this section]

Step: 23. : 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 Head screen. Recommended is Local.

Step: 24. In data entry Area:
<u>**Note:**</u> A typical recipe steps using TC as main sensor consist of **Delay→Ramp→Steady→Delay**
A typical recipe steps using PY as main sensor consist of **Delay→Intn→Ramp→Steady→Delay**
See image at step 6 above for some idea.
Here in data entry section:

   a. Upto 40 steps can be defined.
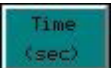
   b. : This is the Process Function, which describes the type of process function for that step. It can be RAMP, INTN, STEADY, DELAY, or FINISH.
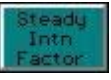
   c. : During the Steady step, the controller increases and decreases the lamp intensity so the specified temperature can be maintained. It then maintains that value until the specified time spent in the step has elapsed.

   d. : 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.
   Note: The process controller **cannot** do two consecutive RAMP steps.

e. `Intn`: The controller keeps the lamp power at a constant intensity during an Intensity step. *It is normally used to warm up the wafer sufficiently for the pyrometer sensor, since the pyrometer is not reliable below a temperature of 450ºC.* If an INTN step is followed by a RAMP or STEADY step and the set point temperature has been achieved during the INTN step, then the temperature will be maintained at that set point.

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

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

h. `Time (sec)`: This is the amount of time, in seconds, to act on the current step. **Note:** Extremely long, high temperature processes may damage the AccuThermo RTP system.

Step: 25. `Temp/ Intn (ºC/%)`: This is the target temperature or intensity the AccuThermo RTP system strives for.

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

    b. If the step function is RAMP, then this is the ending temperature of the ramp.

    c. If the step function is INTN, then this is the percentage of the lamp power intensity. [**It should not be set more than 15 %**]

    d. 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.

Step: 26. `Steady Intn Factor`: 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. (See the section for fine-tuning the system in main manual to understand how to use this parameter effectively).

Step: 27. `Gas 1 GAS1 SLPM` : `Gas 2 GAS2 SLPM` : `Gas 2 GAS2 SLPM` This is the value for the flow rate of N_2, O_2 and Ar for the system for process. Note that the value of total sum of set flow rate for process gas (either N_2/O_2/Ar or combination) in the edit section must be≤ **5 SLPM**, either use single or multiple gas. Be cautious when you use oxygen as it may explode at high temperature and high flow rate.

Step: 28. `Steady Intn`: This is a legacy parameter as is no longer used. It is now a global parameter and is in the System Setup screen as the Intn Tolerance field. It is normally less than 20%. [**Don't change anything in this section**].

Step: 29. Validate the Recipe by clicking on the "Recipe validate" icon. If the recipe is invalid, an error message will appear. Once the error has been corrected, validate the recipe again. The five variables (Gain, Sensitivity, Delay, Psum1 Average and Psum2 Average) are for fine-tuning the temperature control performance.

Step: 30. Save the Recipe by clicking on "save" icon.

Step: 31. Exit the Recipe Editor by clicking on the Exit 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.

    a. Click Yes (or press Y on the keyboard) to save the recipe.

    b. Click No (or press N on the keyboard) to discard all changes since the last save.

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

➢ **Some shortcut keys are listed here:**

Keyboard Editing Keys and Meanings

Key		Meaning
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).

Note: Other sections, which are not discussed here, like **"Bank Factor Reset"** button, **"Use System bank factor"** button, **"Recipe Head"** button, **"Bank Control"** button, **Never** test or edit these sections without permission.

Step: 32. After exiting the **"Recipe editor",** will be back at the "**Process for Engineer**" control interface as below.
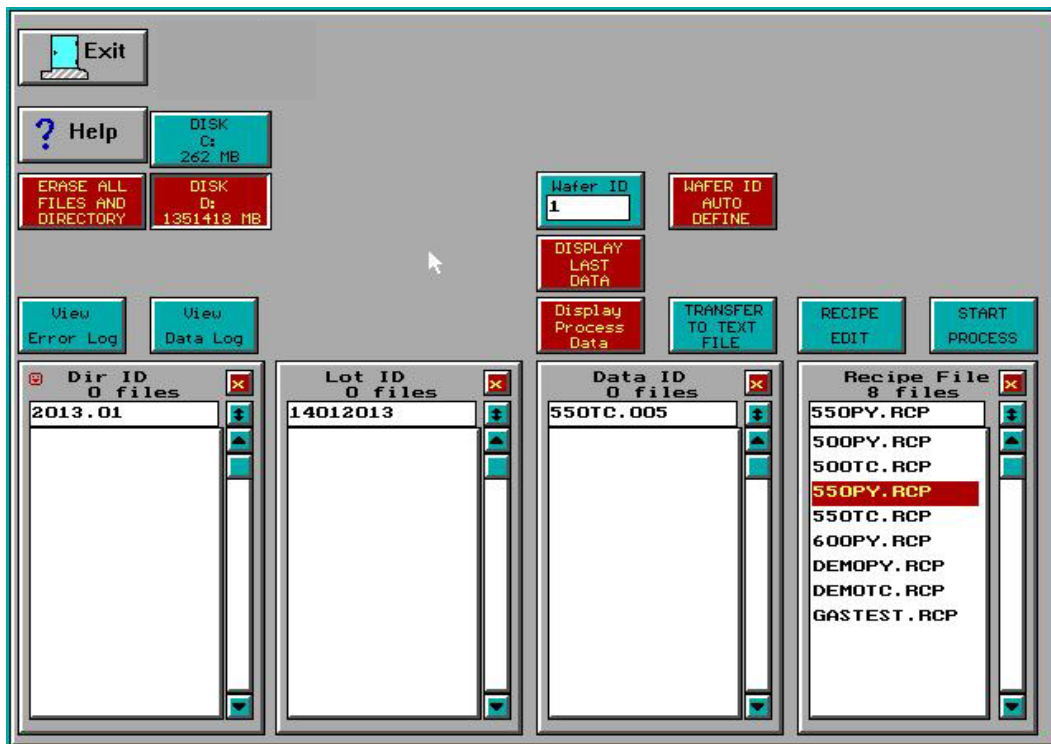
Step: 33. After editing recipe, select where the Process Data will be stored: The process data is stored on the hard drive after the process ends. The place on the hard drive it will be stored needs to be specified. Check, it should be **Disk D** (display in red colour).

Step: 34. Select a "**Dir ID**" e.g YYYY.MM and a "**Lot ID**" eg. DDMMYYYY from the list of Directory IDs and Lot IDs. The Data ID will be generated automatically as per Recipe ID after process.

Step: 35. Run the Recipe: To run the selected Recipe, click on the Start Process button. This will display the Process Monitor screen (see figure below). When this screen is displayed, the process will begin processing the wafer inside the heating chamber according to the selected Recipe. (Note: If you experience any problem/feel something wrong in temperature sensor, immediately press **ESC** button / use Emergency switch (EMO) at RTP front panel).
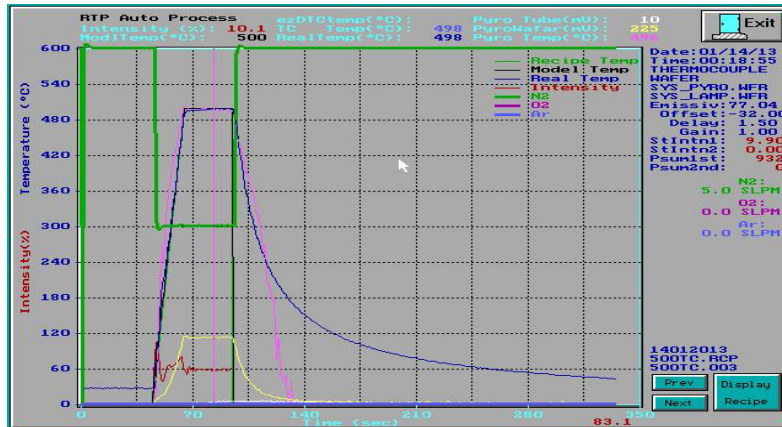
Step: 36. At the end of the process, "Process Over" will be printed over the Process Monitor screen and be blinking in different colours. Press any key to save the process data. This will also exit back to the Process for screen.

Step: 37. After the process is over, wait for some time until the LED display at RTP front panel shows < 50 ^{0}C.

Step: 38. <u>Stop process:</u> A process may be interrupted and stopped by pressing the **ESC key** on the keyboard. This will turn off the lamps. Use this if any sudden change in temperature in LED display/screen display you observe during process or interrupt is required.

Step: 39. To review the process data: To view the last run process data graphically, click on the Display Last Data button. This will display the process data on a screen very similar to the Process Monitor screen.

Step: 40. To view process data from previous runs, select the process data to be viewed from the "Data ID" column, and then click on the Display Process Data button.

Brief about different buttons in "Process for Engineer screen":

Wafer No.	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 Number	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.*	

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RTP_PROC Data Display	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 processing the wafer that is in the process chamber, using the recipe that is selected.

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.

Main SOP/H.K.S

System Power Down

Note: 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 heat up a wafer very rapidly until it melts. This can cause extensive damage to the AccuThermo RTP system.

Do Not Power-Down the AccuThermo RTP system unless it has been more than 10 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 for process gases in use.

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

Step: 3. Turn off the facilities breaker/safety switch (CB1) at the back of RTP system.

Step: 4. Turn off the facilities breaker switch main.

Step: 5. Turn off the CDA valve to regulators of MFC and Air cooling.

Step: 6. Turn off the quartz isolation tube cooling CDA/nitrogen [Ask facility person].

Step: 7. Turn off the pyrometer chiller water dedicated for RTP system. [Ask facility person].

Step: 8. Turn off the oven cooling chiller water dedicated for RTP system [Ask facility person].

Step: 9. Turn off the CPU and Computer monitor.

Appendix -I

Susceptor

About: The susceptor consists of two pieces and is high purity graphite/silica coated with inert Silicon Carbide (SiC) by CVD. We have 3" SiC coated graphite and 6" SiC coated Silica susceptor.

3" SiC coated graphite: To be used for max process temp upto 800 ^{0}C.

6" SiC coated silica susceptor: To be used for max process temp upto 1100 ^{0}C
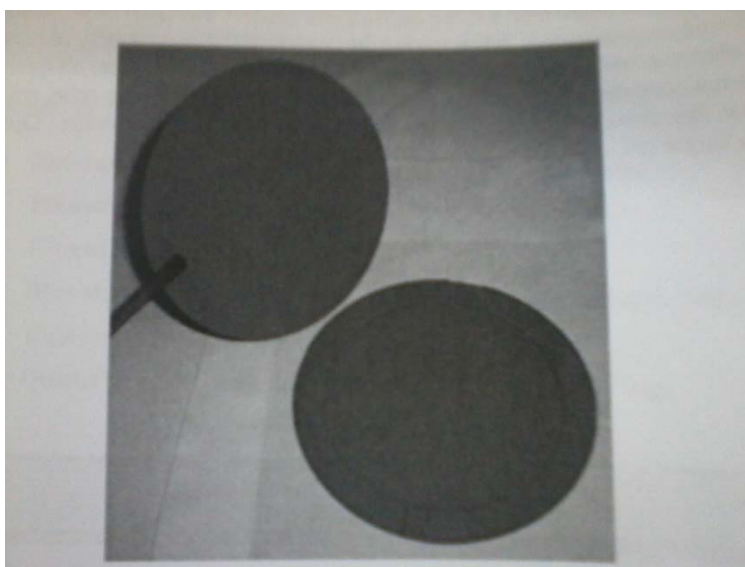
Fig: Susceptor cover and base

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

❖ *The susceptor encases the wafer between two pieces of high purity graphite that are coated wih SiC.*

❖ The precise temperature is obtained through either a pyrometer or a thermocouple in contact with the susceptor.

❖ <u>**Caution:**</u> 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.

❖ **Touching the susceptor assembly without gloves contaminates the susceptor.**

Using the Susceptor:

➢ 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.

➢ Place your samples inside the grooved area of the susceptor and cover it with susceptor cover properly. Now this is like as you process wafer directly on quartz tray.

➢ 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 be always facing up when on the susceptor base. Number mark is its identification and keep the number marked side always facing upward.

Care and Cleaning:

➢ The susceptor is coated with a thin layer of SiC and may have to be cleaned periodically.

➢ There are different methods to clean depending upon the contamination.

➢ To clean the susceptor, use cleanroom wipes and cleaning solution as described below.

➢ Use cleanroom wipes and DI water to rinse the susceptor after cleaning with the solution.

➢ Let the susceptor dry completely before running in the oven.

➢ **Never submerge the susceptor in liquid.**

➢ Use **HCL** for **metal** contamination removal.

➢ For Organic Contamination: $H_2SO_4/H_2O_2:H_2O$

Software interface changes when using susceptor: (Additional Steps):

Steps 1-10 as usual as mentioned in Process Recipe making/editing or running

Step: 11. (a). When using Thermocouple as sensor during process, then no changes required, directly follow the Step 12 after Step 11 as mentioned in main SOP.

Step: 11. (b). When using Pyrometer as sensor during process, then **Change the sensor type from Thermocouple to Pyrometer.**

The screen shot for such recipe editor interface will look something like below:

Important caution and note:

1. Maximum temperature **ramp up rate** allowed for **3" SiC coated graphite susceptor**: **15 ^{0}C/sec**

2. Maximum temperature **ramp up rate** allowed for **6" SiC coated silica susceptor**: **20 ^{0}C/sec**

3. Always ensure when setting the Pyrometer offset as mentioned in step 13 of main SOP in "Process Recipe making/editing or running" section that you have determined

the offset from earlier data, which has been generated using **susceptor and TC** sensor combination and **NOT with wafer and TC sensor** combination.

4. The susceptor should be placed as below shown figure **only on circular qurtz wafer tray**.
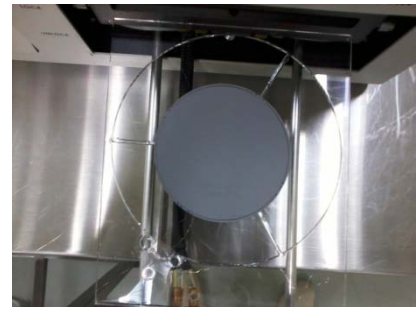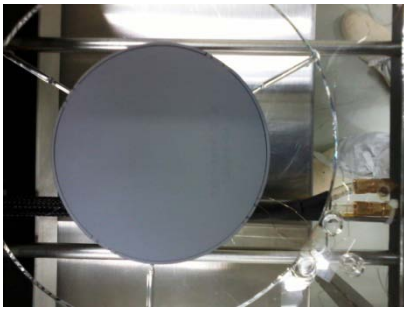
5. Ensure that you hold the susceptor properly, such that it does not get any scratch or fall down. Try NOT to use sharp tweezers.
6. Always use lint free cloth to place it on surface.
7. Put it back in its dedicated box after wrapping it in a lint free cloth.

Appendix –V

THERMOCOUPLE INSTALLATION AND TESTING

Important Note: It has been noted that the Cantilever thermocouple may be used in place of the pyrometer, and it should be removed for $> 750\ ^0\text{C}$ process temperature (otherwise specified) or 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 below. 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.

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.

Thermocouple Placement (showing Cantilever thermocouple):
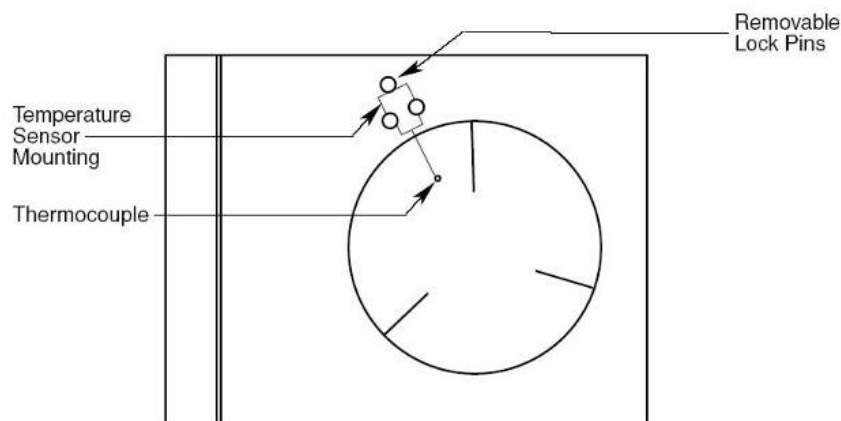
Step: 6. Attach the thermocouple leads to the type K terminals on the inside of the oven door. First, find which lead is attracted to a magnet. Attach this lead to the wider terminal, labelled "AL" which also be attracted to magnet. Attach the other lead to the terminal labelled "CH" or non attracted to magnet. (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. Make sure that the two wires of the thermocouple are not touching anywhere than on the tip/bead which is for touching the wafer for process.

Step: 9. Put a test wafer on the tray. Check if the backside of the wafer is down. Position the bead so it presses against the backside of the wafer. Make sure that the bead make good contact when wafer is placed on the tray.

Step: 10. Close the oven door.

Step: 11. Test the Thermocouple as follows:
1. Power-up the system, if it is off.
2. Go to the Diagnostics screen.
3. If the system is set up for pyrometer operation, configure for thermocouple.
4. Increase the lamp intensity to 5%.
5. 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.
6. This temperature test should be done quickly and carefully.

Appendix – VII

# QUARTZ WAFER SUPPORT TRAY REMOVAL AND INSTALLATION

Follow the following steps for Removal of Wafer tray for cleaning:

Step: 1. Open the oven door and pull it all the way out.

 Note: Make sure that the oven has cooled to a temperature below 50 ^{0}C before removing the wafer support tray or any other heated components.

Step: 2. If a thermocouple wafer or cantilever thermocouple is installed, carefully disconnect it from the TC input connectors on the door, and remove it from the wafer support tray. See Figure below.

Wafer Support Tray Removal and Installation:
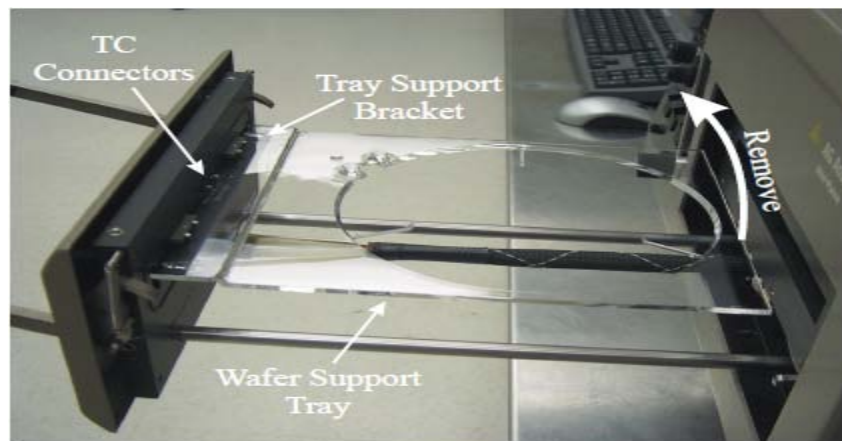
Step: 3. Using Latex gloves carefully lift up on the end of the tray closest to the oven. The tray can be easily lifted from the support bracket on the oven door.

Step: 4. Inspect the tray for damage. Clean the tray, if required, following the instructions provided in Appendix - II.

Step: 5. Place the tray on a clean surface, preferably of quartz, or if a quartz surface is not available, place the tray on a surface covered with unused clean room wipes.

Step: 6. Perform any additional procedures that need to be done while the tray is removed from the system.

Follow the following steps for installation of Wafer tray after cleaning:

Step: 1. Reinstall the wafer tray with the wafer support pins up. Place the support edge of the tray on the flange support bracket while lifting the end of the tray closest to the oven. The tray will fit into the flange support bracket. Lower the end of the tray closest to the oven.

Step: 2. In order to achieve optimum process uniformity, it is very important that the wafer tray be level with respect to the AccuThermo RTP oven. Use the procedure below to ensure that the wafer support tray is properly levelled relative to the oven.

QUARTZ WAFER SUPPORT TRAY LEVELING:

Step: 3. Close the oven door to a point where the edge of the tray is flush with the oven flange. See Figures below.

Ruler
Oven Flange
Wafer Tray
Oven Door

With oven door most of the way open, measure from bottom of oven flange opening to top of tray.

≈3"
Ruler
Oven Flange
Oven Door
Wafer Tray

With oven door open approximately 3", measure from bottom of oven flange opening to top of tray.

Oven Flange Opening
Wafer Tray
Levelling Screws
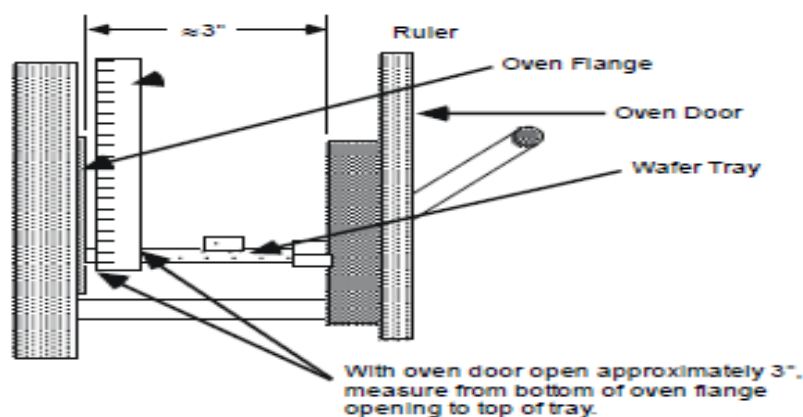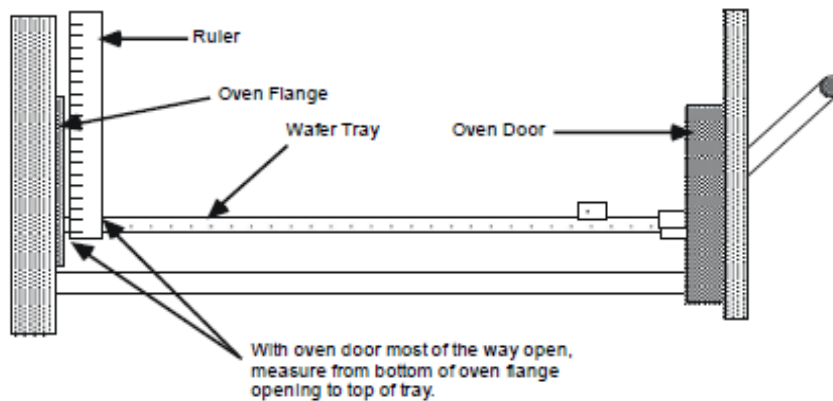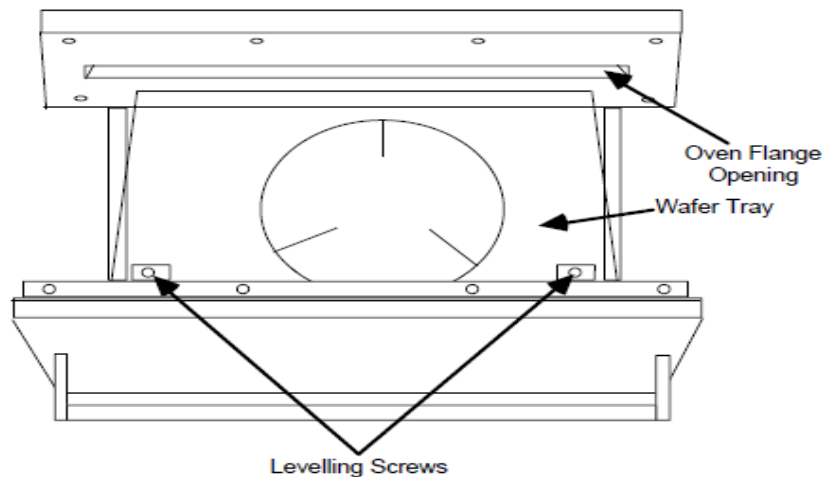
Step: 4. Using a ruler, measure the distance from the bottom of the oven flange to the top edge of the wafer tray. Measure the tray on both sides to verify that it is level from side to side.

Step: 5. If the tray is level from side-to-side, go to the next step. If the tray is not level side-to-side, then adjust the tray using the levelling screws. The level of the tray should be adjusted so that the end of the tray is centred with the opening in the oven flange. See Figure above for location of oven levelling screws. Once the tray has been levelled from side-to-side, note the distance from the bottom of the oven flange to the top edge of the wafer tray.

Step: 6. Close the oven door until it is open about 3 inches. See Figure above. Using a ruler, measure the distance from the bottom of the oven flange to the top edge of the wafer tray. This distance should be the same as the distance noted in step 4 or step 5 above. If it is the same, then the wafer tray is level. If it is not the same, then the tray will need to be leveled from front-to-back using the leveling screws. See Figure above for leveling screw locations.

Step: 7. Repeat steps 3 through 6, above, to verify that the wafer tray is level. The distance should be the same between the bottom of the oven flange and the top of the wafer tray on both sides of the tray with the door almost open and near the front of the tray with the door open only 3 inches.

Note: There may be some movement of the tray from left to right. This movement is normal and should not be a reason for concern.

Step: 8. Place a wafer on the tray. Slowly close the door of the heating chamber. Listen for any scraping sounds that may indicate that the quartz is not properly aligned. If you notice any scraping sounds or resistance to door movement, realign the tray and repeat this step.

Step: 9. Reinstall the top cover on the AccuThermo RTP system if it has been removed.

Appendix - VIII

Some important points you should know

[1]. RTP control software main menu tree:
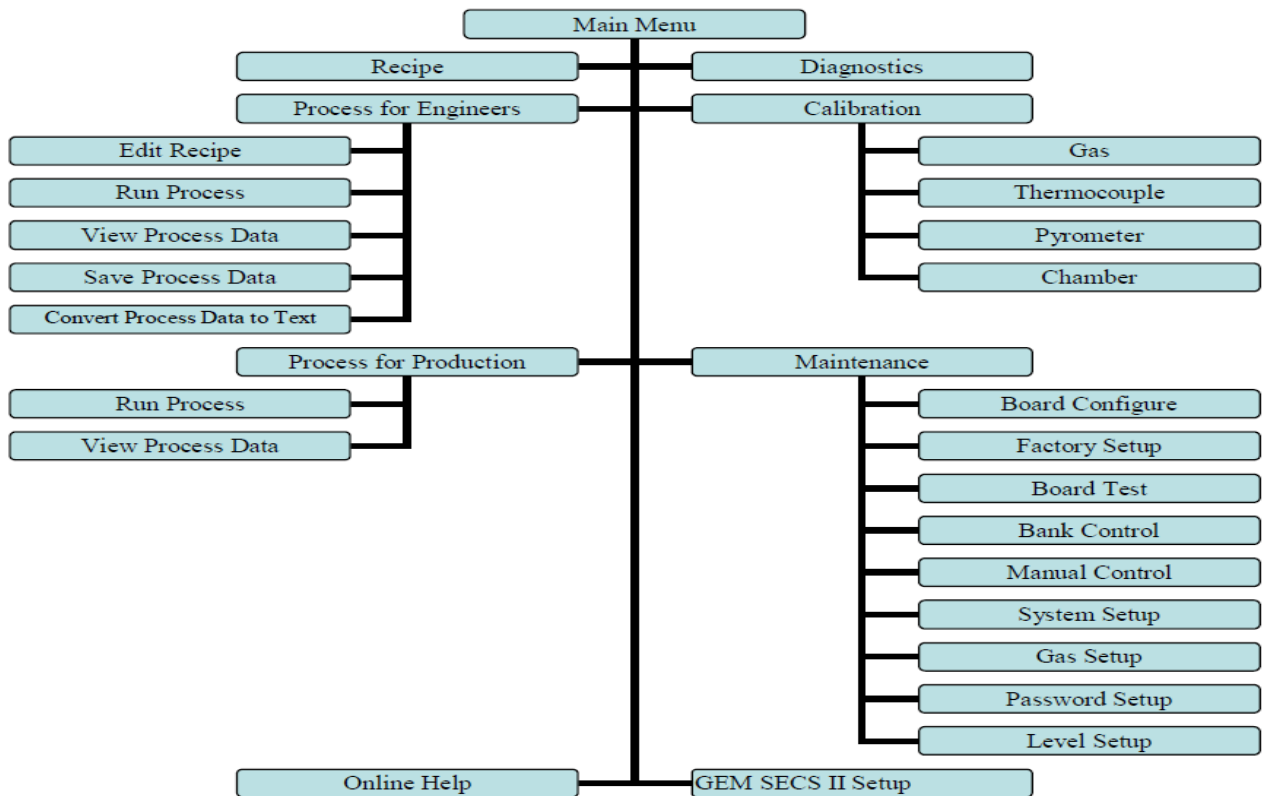
[2]. Temperature stages:

Stage: Description:

➤ **Delay:** The Delay Stage is used to purge the chamber of ambient air.

➤ **Intensity:** The Intensity Stage preheats the wafer to a temperature that is sufficient for the pyrometer to be usable. This is normally used if a pyrometer is to be used.

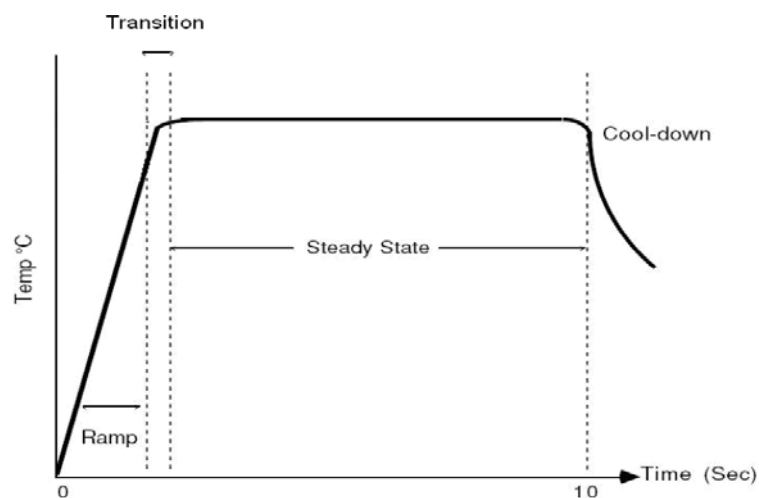➤ **Ramp:** The first Ramp of the recipe increases (Ramp Up) the temperature at a controlled rate to a desired set point. There can be subsequent Ramps in a recipe, either increasing or decreasing the temperature at a controlled rate to a desired set point. During a ramp, the intensity is adjusted to have the real-temperature follow the model-temperature.

➤ **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 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 set point.

➤ **Steady-State:** During Steady-State control, lamp intensity fluctuates to keep the temperature within the Steady-State range (±2°C). This is the Steady step programmed in the recipe.

➤ **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. At high temperatures, the wafer cools at a faster rate, initially, than it does at lower temperatures. The cool-down rate is therefore not uniform.

[3]. 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.

3.1 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.

3.2 If the measured temperature from the sensor is higher than the real temperature of the wafer, PSum will be smaller than the average PSum.

3.3 If the measured temperature is lower than the real temperature, PSum will be larger than the average PSum.

3.4 To get the same temperature control if the quartz isolation tube is dirty, PSum will be larger than the average PSum.

3.5   To get the same temperature control if some of the lamps have degraded or are bad, PSum will be larger than the average PSum.

3.6   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.

3.7   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.

3.8   It is believed that only 2 PSum's are needed.

3.9   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.

3.10 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.

3.11 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%.

3.12 The alarm can be disabled by making PSum1 Average and PSum2 Average less than 10.0.
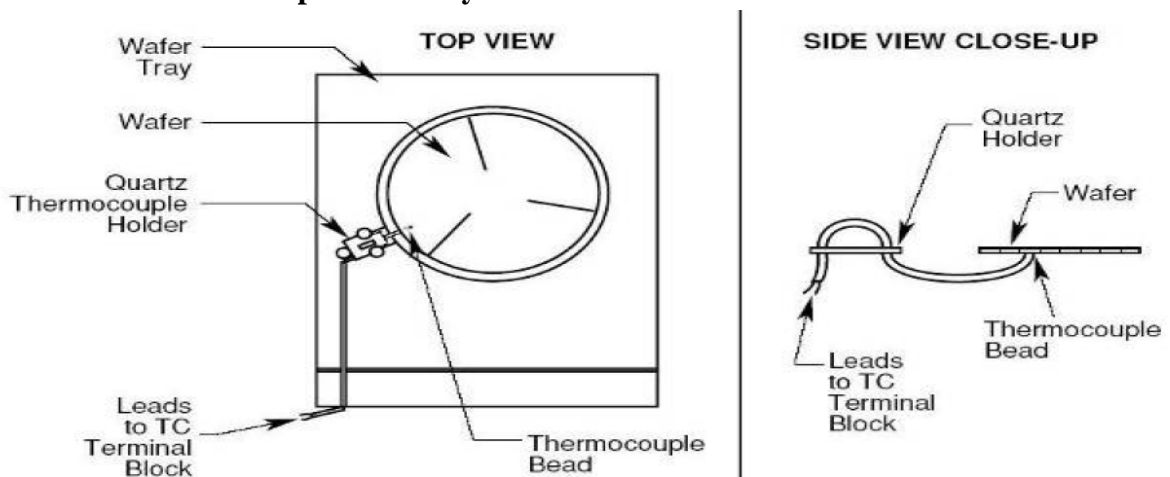

[4]. About Thermocouple:

4.1 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.

4.2 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.

4.3 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.

Note: Thermocouple may fuse into the wafer 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.

4.4 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. See Figure below.

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. See Figure below. Typically, the TC wafer is used for the calibration of the pyrometer.

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

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

4.7 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.

Cantilever Thermocouple Assembly:

The TC wafer assembly has a thermocouple embedded in a wafer.(Thermocouple Wafer Assembly):
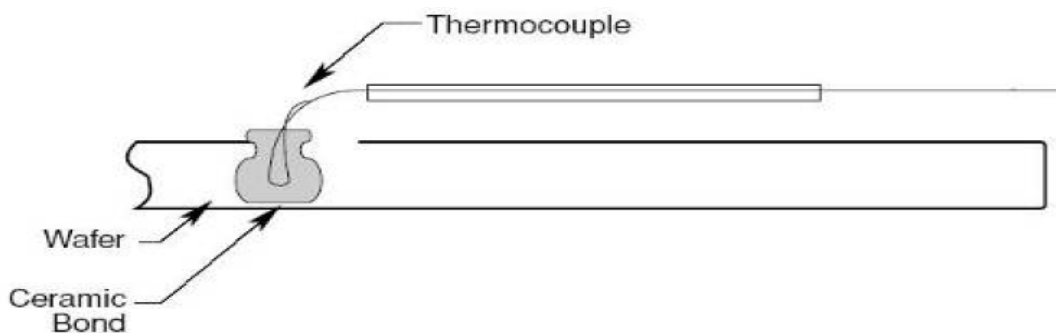
[5]. About Optical Pyrometer (ERP):

5.1 The **Extended Range Pyrometer (ERP)** is an optical pyrometer attached to the bottom plate of the oven. Radiation from the wafer reaches the pyrometer through the bottom of the transparent quartz isolation tube and through a small aperture in the oven floor. The pyrometer converts detected infrared light energy to a voltage.

5.2 Optical pyrometer readings are emissivity-dependent. This means that these readings are affected by changes in wafer backside surface colour and roughness, deposited backside layers, or variations in substrate materials.

5.3 The ERP measures wafer temperature by detecting infrared light radiation emitted from the wafer within a specified wavelength range. The resulting signal is adjusted to compensate for the effects of non-wafer radiation sources.

5.4 Undesired radiation emitted from non-wafer sources must be compensated for or filtered out in order to accurately measure wafer temperature inside an AccuThermo RTP system heating chamber lamps and light energy emitted from the isolation tube .

5.5 During extended heating cycles, the temperature of the thermopile and AccuThermo RTP system quartz isolation tube gradually increases.

5.6 Thermopile heating causes increased output signal voltage without a corresponding increase in received infrared radiation.

5.7 Isolation tube heating creates an additional source of infrared emission adding to and increasing the infrared energy being received by the pyrometer.

5.8 These phenomena both work to distort the wafer temperature measurements of the optical pyrometer.

5.9 To eliminate the effects of thermopile heating, the ERP incorporates a water-cooling system that maintains a steady pyrometer thermopile temperature.

5.10 To minimize the effects of quartz isolation tube heating, the quartz isolation tube is cooled with compressed nitrogen or clean dry air (CDA). This maintains the temperature of the tube within a specified range but does not entirely prevent the temperature measurement distorting effects of isolation tube heating.

5.11 Additional cancellation of the effects of isolation tube heating is enabled by the dual range infrared detection capability designed into the extended range pyrometer.

5.12 Specifically, the ERP incorporates both a Wafer-Sensing Pyrometer (referred to as the Wafer Pyrometer) and a Tube-Sensing Pyrometer (referred to as the Tube Pyrometer).

5.13 Each of these pyrometers incorporates a different proprietary infrared band pass filter.

5.14 Wafer Pyrometer: The wafer-sensing pyrometer measures wafer temperature by "looking" at the wafer through the quartz isolation tube. During wafer processing, the heating of the isolation tube causes the wafer temperature measurements to "drift". To minimize this problem, a proprietary "pyrometer window" has been installed into the bottom of the quartz isolation tube. Mounted below a small aperture in the bottom plate of the AccuThermo RTP system heating chamber, the Wafer Pyrometer measures wafer temperature through this opening.

5.15 Tube Pyrometer: The tube-sensing pyrometer measures wafer temperature, including a maximized level of isolation tube heating induced "drift" by looking at the wafer through the thickest part of the quartz isolation tube.

Extended Range Pyrometer:
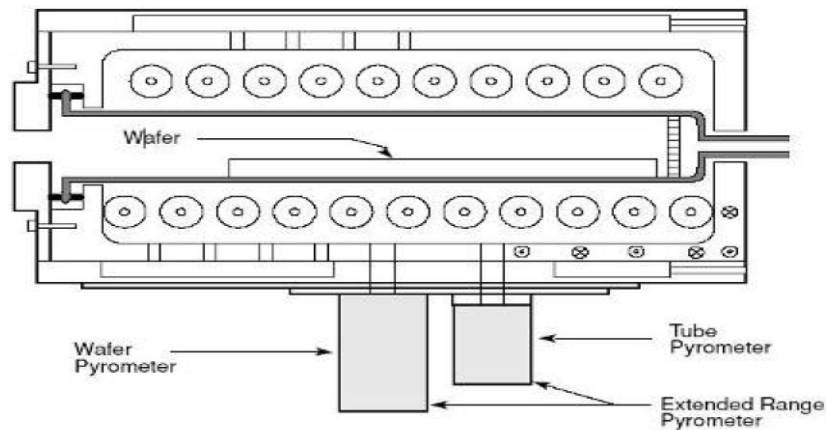
5.16 To cancel the effect of additional radiation from the quartz tube and other sources, measurements taken from the Tube Pyrometer are combined with measurements from the Wafer Pyrometer. This enables the system to correct for the effects of isolation tube heating.

5.17 Specifically, the software subtracts a fraction of the Tube Pyrometer output signal from the output signal of the Wafer Pyrometer. The difference of the two signals provides a precise indication of wafer temperature. The resulting signal is mapped by the software for the full range of processing temperatures (from **400°C to 1200°C**).

5.18 To further insure accuracy, the pyrometer calibration is performed using calibrated thermocouple wafers in the heating chamber.

[6]. Some Queries and Answers:

➢ **Sometimes you may not get high ramp up rate, in such case what to do?**
   Ans: Some times it may happen that you may not be able to get high ramp up rate due to thin wafer, because the wafer you are running if thin, it is suggested to lower your "steady intn factor" for ramp step and decrease the gain for overall recipe (for example, steady

intn factor for ramp = .80 and gain = .7). Try this and see how it goes. If it does not succeed at first time, try to lower one or both values again.

- ➢ **Can I have control for lowering my cooling rate?**
  Ans: If you want to cool off slower for your wafer process then you can add another "ramp" step after your 400C steady step. In the ramp step you can specify the cooling rate. For example, after 400C steady step, you can add ramp step with 1. Time = 30 second, 2. Temp= 100C. This way the software will control your ramp down rate and in this case it is 10 C/s (300 C/30 S = 10 C/s).

Appendix IX

Weekly tool cleaning Procedure for RTP tool

1. Use Lint free cloth and IPA only for cleaning purpose.
2. Wipe thoroughly the top side of the instrument and attached Monitor and Keyboard by lint free cloth wet with IPA.
3. Always use hand gloves for cleaning/using the instrument.
4. You can use Nitrogen gun with slow flow rate for cleaning the restricted region by blowing the dust particles out with nitrogen gas (GN2) flow.
5. After cleaning, keep all the accessories and tools at proper place and keep the system region neat and clean.