

## **ANNEALSYS AS-One RTP Operating Procedures**

---

The AS-One is a high temperature Rapid Thermal Process (RTP) system. It is capable of anneals as high as 1500C with a ramp rate up to 200C and cooling rates up to 100C for 4" silicon substrates. The system is pyrometer controlled and calibrated to either a bare Si wafer or a specific susceptor type. The system uses turbo pumping to achieve pump down pressures as low as 10E-6 Torr. The system has MFC controlled gas channels for annealing in controlled ambient (Ar, O2, N2, 3%H2:N2 and vacuum). The process chamber is a cold wall, stainless steel chamber. The clam shell style design and the 4" wafer process chamber provides full access to the bedplate and easy loading and unloading of the substrates.



### **Training to Become a Qualified User**

---

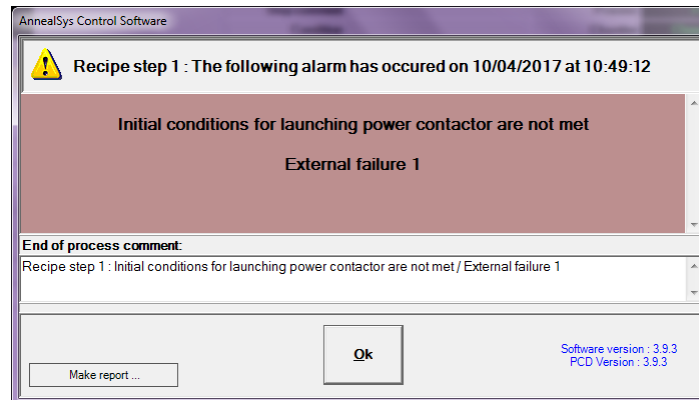
This tool requires a 1-hour training session for qualification.

### **Tool Start-Up (Simplify like Shutdown)**

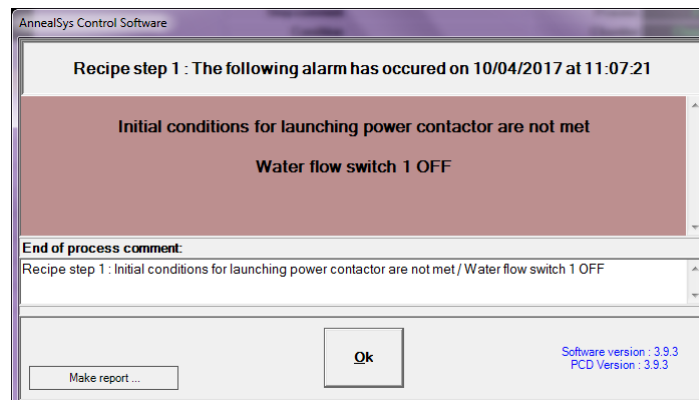
---

1. Review Badger for Shutdown, Problems and Comments. Verify there are no lab member reservations for the duration of your session.

2. Enable "AS-One RTP" on Badger. If the system is not enabled on Badger the following error will appear.



3. Turn on the power to the Chiller. The ON-OFF switch is located on the back panel at the upper right corner, when facing the front of the chiller.
4. Start the water flow in the chiller by pressing the START/RUN button located on the front of the chiller on the left side. If the chiller is not running, the following error will appear.



5. Open the AnnealSoft System software by clicking on the AS AnnealSoft icon.



6. Login using your dedicated Login ID and Password.
7. The software and system hardware requires initialization by running the **a\_Start Up Recipe**.
8. See the section Running a Recipe below on how to run a recipe.

## Tool Shut-Down

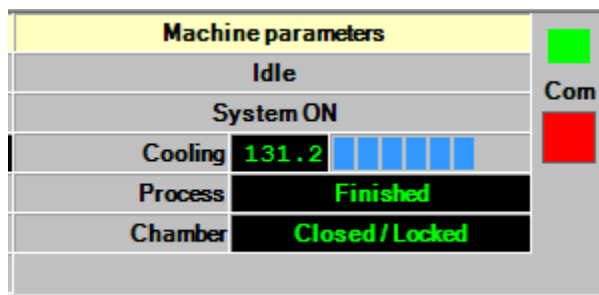
1. Prior to leaving the tool, you must download and run the **aa\_Shut Down Recipe**. This will place the tool in a safe state.

2. Once the **aa\_Shut Down Recipe** has completed
  1. Turn off the chiller, but pressing the RUN/START button and then toggling the power switch located on the back of the chiller.
  2. Shutdown the software by clicking on the **Shutdown** icon located at the lower right corner of the Process screen. This will log you out of the software and return the computer to the Windows desktop. Close the top of the laptop computer and move to a safe location.
3. Disable "As-One RTP" on Badger.
4. Report all 'Shutdown', 'Problems' or 'Comments' if problems were encountered during your session. Report any concerns to the CNM2 tool owner.

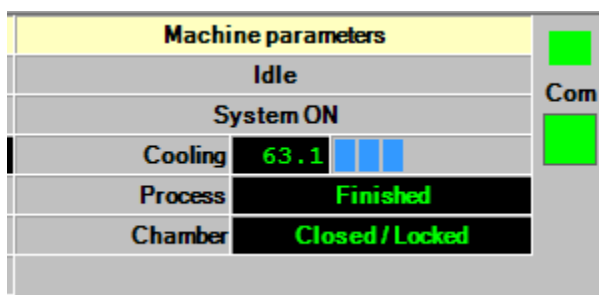
## Error Recovery

---

The **Com** light will turn red when there is a communication error between the computer and the RTP system.



If there is an error message displayed on the screen, clear the error by acknowledging the error. To reset the **Com** for the system, click on the red light. This should establish communications and the **Com** light should turn green.



## Running a Recipe

---

The primary screen for the operation of the system is the **Process** screen. From the **Process** screen you can vent the chamber to atmosphere, lock and unlock the process chamber, access recipes for editing, download recipes and run your process.

Temperature (°C)		Gas (sccm)	Setpoint	Readout	Pressures (Torr)		Recipe parameters		Machine parameters	
Control mode	POWER control	3%H2/N2	0.0	0.0	Full range	NA	Recipe time	0.0	Idle	Com
Setp (%)	0.0	N2	0.0	0.0	Strain	7.90E+2	Step time	0.0	System ON	
Power (%)	0.0	Ar	0.0	0.0			Step number	0	Cooling	Not cooling
TC1	Absent	O2	0.0	0.0			Step comment		Process	Finished
Pyro1	246.2						Condition		Chamber	Closed/Locked
TC2	Absent						Recipe name	a_Start Up Recipe		

Last downloaded recipe		Recipe to download	
Name	a_Start Up Recipe	Name	aa_Shut Down Recipe
Date of last download	05/04/2017	Creation date	10/05/2012 - 12:24:25
Hour of last download	10:58:49	Modification date	05/04/2017 - 10:56:05
User name	EdMyers	User name	EdMyers
PID table	SUSCEPTOR_PID	PID table	Si_PID
TC1 calibration table	TC1_K_Table	TC1 calibration table	TC1_K_Table
TC2 calibration table	TC2_K_Table	TC2 calibration table	TC2_K_Table
Pyrometer 1 calibration table	CAL_SI_1400C	Pyrometer 1 calibration table	CAL_SI_1400C
Post recipe action	None	Post recipe action	None

Download

Start process

Browse

Profile

Downloading was successful.

Machine	Chamber
Stop purge	Unlock chamber
Purge until ATM	

EdMyers/Engineer  
Software version: 3.9.3  
PCD Version: 3.9.3  
04/05/2017 - 11:14:32

1. Load your sample by clicking on the “Unlock Chamber” icon. Carefully raise the chamber lid and place your sample.

1. If you are using pieces, remove the carrier from the chamber and place your sample and any banking pieces on the carrier on the tabletop and not in the chamber.

**NOTE:** There is a lot of turbulence in the chamber during processing. It is critical to have pieces well secured during the process.

2. Once the sample has been placed in the chamber, carefully close the chamber lid.
2. In the right field of the **Process** Window (see below), select the desired recipe from the pulldown menu.

Recipe header information	
System	AS-ONE
Creation date	10/05/2012 - 12:24:25
Modification date	05/04/2017 - 10:57:29
User Name	EdMyers
Recipe name	a_Start Up Recipe
TC1 calibration table	TC1_K_Table
TC 2 calibration table	TC2_K_Table
Pyrometer 1 calibration table	CAL_SI_1400C
PID control parameter table	SUSCEPTOR_PID
Post recipe action	<input type="radio"/> Purge <input type="radio"/> Clean <input checked="" type="radio"/> None
<p>&lt; Commands &gt;</p> <p>New Browse Delete Print Save as Save</p>	

- Once the desired recipe is selected, click on the **Download** icon. This action is required to download the desired recipe to the control hardware. Once the download is complete, the selected recipe will appear on the left side of the **Process** window.

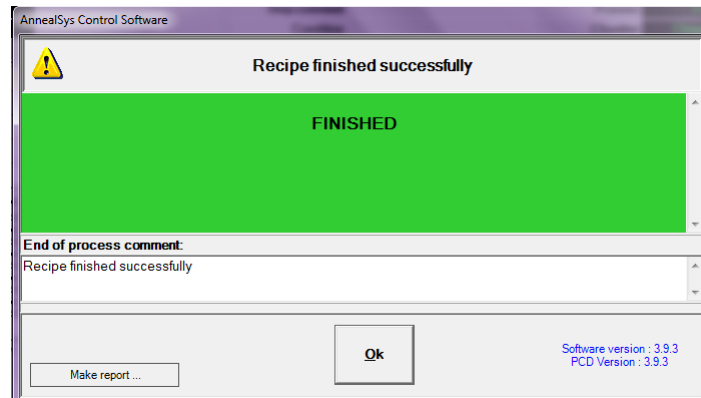
Recipe to download	
Name	a_Start Up Recipe
Creation date	10/05/2012 - 12:24:25
Modification date	05/04/2017 - 10:57:29
User name	EdMyers
PID table	SUSCEPTOR_PID
TC1 calibration table	TC1_K_Table
TC2 calibration table	TC2_K_Table
Pyrometer 1 calibration table	CAL_SI_1400C
Post recipe action	None

- Click on the **Start Process** icon located on the right side of the **Process** window.
- A **Historicals** window opens. The Historicals window provides fields for the name of the recipe and a recipe or sample comments that are saved with the process data.
  - The default naming convention for the Historical data uses a date time stamp and is shown in the figure below. It will be much easier to retrieve your data in the future if you change the Historical Name to a name with a more descriptive meaning. The Historical comment field should be used to provide information of the anneal which could include items such as a sample description and any recipe modifications from prior anneals.

Historical data	
Path	c:\annealsys\historicals\
Historical Name	his_20170405105244
Operator name	EdMyers
Logging mode	Engineer
Recipe name	aa_Start Up Recipe
PID parameter table name	SUSCEPTOR_PID
TC1 Table name	TC1_K_Table
TC2 table name	TC2_K_Table
Pyro 1 table name	CAL_SI_1400C
Historical comment	

- Press the **Start** icon to begin the process.
- The progress of the recipe is tracked in the **Real Time Process Data** window.

1. The Temperature, gas set points and readouts, chamber pressure and recipe parameters are displayed in table format along the top of the window.
  2. You can toggle between the Temperature, Gases or Pressure graphs by using the corresponding tabs located above the graph.
8. When the desired recipe is complete, the following notification window will appear.



9. Return to the **Process** window by clicking on the **Process** icon.
10. Click on the **Unlock Chamber** icon and remove your sample.
11. After your final sample run, the **aa\_Shut Down Recipe** must be ran.

## Process Window

The **Process** window is divided in to four parts:

1. Main System Parameters: which displays the active status of the main system parameters and is located across the upper part of the screen.
2. Information Panel: located at the center part of the screen, displays the form related to the Primary Navigation Panel button selection.
  1. The left side of the pane shows the recipe which is downloaded in to the control hardware.
  2. The right side of the pane allows you to select the next recipe for you process. Once this recipe is downloaded, it will appear in the left pane.
3. Primary Navigation icons are located at the bottom of the window for opening:
  1. **Recipes** to create, modify, display or delete a recipe.
  2. **Process** to download a recipe and to run the process.
  3. **Historicals** to display historical process information and alarms list.
  4. **Configuration** for staff use only.
  5. **Manual Mode** for staff use only.
  6. **Diagnostics** for staff use only.
  7. **Shutdown** to exit from the control software and return to Windows.

4. The Information Panel located at the lower, right part of the window provides login information, software information and the date and time.

## Control and Monitoring Tables

---

An AS-One recipe is comprised of multiple inputs (tables) to control and monitor the process. The correct and current versions must be associated with each recipe to guarantee a repeatable and accurate process. For example, different tables are required for bare silicon, graphite susceptor or a silicon carbide susceptor.

1. Tables include:
  1. PID table: The PID control parameter table must be matched either to the backside of a Si wafer or to the correct susceptor in use.
    - **SILICON\_PID**: calibrated to the backside of Si
    - **GRAPHITE\_PID**: calibrated to the Graphite Susceptor
  2. TC1 calibration table: Calibrated to K-Type thermocouple (TC1\_K\_Table).
  3. TC2 calibration table: Calibrated to K-Type thermocouple (TC2\_K\_Table).
  4. Pyrometer 1 calibration table: Calibration for the pyrometer is dependent on the substrate or susceptor in use. Make sure to select the correct calibration table for your process.
    - **Silicon\_Pyro\_Table**: calibrated for the backside of silicon up to 1400C.
    - **Graphite\_Susceptor\_Table**: calibrated for the graphite susceptor up to 1500C.

If you have any questions regarding the correct tables, ask the tool owner prior to running the system.

## Writing a Recipe

---

A recipe is a multiple step sequence of individual process commands, operated under the Control and Monitoring Tables. The Control and Monitoring tables remain the same throughout the duration of the recipe.

1. From the Process window, select the **Recipes** icon.
  1. Create a New Recipe by clicking on the **New** icon. This results in all of the step fields being blank. You will need to input all information in to every field.
  2. Rename and modify an existing recipe by selecting the **Save as** icon. This approach will port over information from all the entered fields. Use the **Browse** icon to make sure you start with a recipe that contains the correct Control and Monitoring tables.

**WARNING:** The **Save** command will over write the existing recipe. Make sure you have renamed the recipe as not to compromise a fellow lab member's recipe.

2. Update the **Recipe Header Information** to have the correct TC1 and TC2 calibration table, Pyrometer 1 calibration table, PID control parameter table and the post recipe action.

3. The comment section is used to identify the owner of the recipe and the revision history.

Temperature (°C)	Gas (sccm)	Setpoint	Readout	Pressures (Torr)	Recipe parameters	Machine parameters
Control mode: POWER control	3%H2/N2	0.0	0.0	Full range: 0%	Recipe time: 0.0	Idle
Setp. (%): 0.0	N2	0.0	0.0	Strain: 7,94E+2	Step time: 0.0	System ON
Power (%): 0.0	Ar	0.0	0.0		Step number: 0	Cooling: Not cooling
TC1: Absent		0.0	0.0		Step comment:	Process: Finished
Pyro1: 246.1	O2	0.0	0.0		Condition:	Chamber: Closed/Locked
TC2: Absent					Recipe name: a_Start Up Recipe	

Recipe header information	
System	AS-ONE
Creation date	10/05/2012 - 12:24:25
Modification date	10/04/2017 - 10:34:47
User Name	EdMyers
Recipe name	Training_N2_Anneal
TC1 calibration table	TC1_K_Table
TC 2 calibration table	TC2_K_Table
Pyrometer 1 calibration table	Silicon_Pyro_Table
PID control parameter table	SILICON_PID
Post recipe action	<input type="radio"/> Purge <input type="radio"/> Clean <input type="radio"/> None
Rev1: 4/5/2017	

< Commands >

New Browse Delete Print Save as Save

Recipes Process Historicals Configuration Manual Mode Diagnostics Shut down EdMyers/Engineer Software version: 3.9.3 PCD Version: 3.9.3 04/10/2017 - 10:44:44

4. Select the **Steps** icon to display the individual recipe steps.

Recipe name	Training_N2_Anneal					
Step number	< Step 1 >	< Step 2 >	< Step 3 >	< Step 4 >	< Step 5 >	< Step 6 >
Step comment	Standby	Pumping	Flow Stabilization	Pre-heating	Stabilization	Ramp up
End of step condition	Duration	Duration	Duration	Temp.Pyro1	Duration	Ramping
Value	5 s	60 s	15 s	> 750 °C	10 s	20 °C/s
Temperature control	Power (%)	Power (%)	Power (%)	Power (%)	Pyro 1 (°C)	Pyro 1 (°C)
Setpoint - Alarm	0	0	0	15	750	1000
Vacuum	No pumping	Rough pump	Rough pump	Rough pump	Rough pump	Rough pump
Purge valve	OFF	OFF	OFF	OFF	OFF	OFF
Process gas valve 1	OFF	OFF	ON	ON	ON	ON
3%H2/N2 - Alarm	0	0	0	0	0	0
N2 - Alarm	0	0	1000	1000	1000	1000
Ar - Alarm	0	0	0	0	0	0
- Alarm						
O2 - Alarm	0	0	0	0	0	0

< Commands >

<< First Previous Next >> Last Copy Insert Delete Print Save

5. Each recipe step is comprised of the following components.

1. Step number: recipe step sequence number.
2. Step comment: a 20-character field displayed during processing used to define and track the progress of the recipe.
3. End of step condition: the condition at the end of the step that must be met prior to moving to the next step. The conditions are:
  - **Duration** in seconds.



- **Ramping** in °C/sec. Must conform to the ramp rate limits for each substrate.
  - **Temp.TC1** the TC1 Control Table but not relevant as the TCs are not installed.
  - **Temp.TC2** the TC2 Control Table but not relevant as the TCs are not installed.
  - **Temp.Pyro1** controls temperature using the **Pyrometer1 calibration table** called out on the **Recipe header information** screen.
  - **ATM** waits until the process chamber has reach atmospheric pressure.
  - **Autotuning DO NOT USE! This function is for the CNM2 staff only.**
4. Value: Defines the end of the step condition. For the Duration step condition the options are either seconds or temperature. For Ramping it is the ramp rate in °C/sec.
  5. Temperature control: The two option are Pyro1 (°C) or Power (%). Due to high temperature operation of the system the thermocouples have been removed from the chamber and are not available for temperature control.
  6. Setpoint Alarm: This is the set point for the step. It can be a Power % number or a temperature.
  7. Vacuum: The options are No Pumping, Roughing Pump and Turbo Pump.
    - Normally the Turbo pump is not running. It takes a number of minutes for the turbo pump to come up to speed.
    - When the turbo pump is running, no gas can be flowed due to the system interlocks.
  8. Purge valve: Purge is the high flow N2 used to quickly vent the chamber to atmosphere.
  9. 3%H2/N2 Alarm: The 3%H2/N2 process gas flow set point. The maximum value is 2000 sccm.
  10. N2 Alarm: The N2 process gas flow set point. The maximum value is 2000 sccm.
  11. Ar Alarm: The Ar process gas flow set point. The maximum value is 2000 sccm.
  12. -Alarm: This is an extra gas channel which is not in use.
  13. O2 Alarm: The O2 process gas flow set point. The maximum value is 2000 sccm.
6. Navigation between recipe steps is accomplished using the **First, Previous, Next** and **Last** icon buttons.
  7. **Copy, Insert** and **Delete** buttons are used to edit an entire recipe step.
  8. The **Save** button is used to save any changes made to the recipe.
  9. The **Profile** icon access the graphical representation of the recipe. There are options for viewing the temperature, pressure or gas flows.

# Historicals Data

The Historicals application contains the stored process data information for all previous processing runs. The data is accessed by selecting the correct file (this is way a descriptive file name and comments are helpful).

Temperature (°C)		Gas (sccm)	Setpoint	Readout	Pressures (Ton)		Recipe parameters		Machine parameters	
Control mode	POWER control	3%:H2/N2	0.0	0.0	Full range	7%	Recipe time	0.0	Idle	
Setp. (%)	0.0	N2	0.0	0.0	Strain	7.90E+2	Step time	0.0	System ON	
Power (%)	0.0	Ar	0.0	0.0			Step number	0	Cooling	Not cooling
TC1	Absent		0.0	0.0			Step comment		Process	Finished
Pyro1	246.7	O2	0.0	0.0			Condition		Chamber	Closed/Locked
TC2	Absent						Recipe name	a_Start Up Recipe		

Temperature (°C)		Gas (sccm)	Setpoint	Readout	Pressures (Ton)		Currents (A)		Recipe parameters	
Control mode	POWER control	3%:H2/N2	0.0	0.0	Full range	3.48E-12	Current 1	03.32	Recipe time	226.7
Setpoint	0%	N2	0.0	0.0	Strain	9.38E+0	Current 2	03.27	Step number	0
Power (%)	0.0	Ar	0.0	0.0					Step comment	
TC1	0.0		0.0	0.0					Condition	
Pyro1	391.7	O2	0.0	0.0						

Ox 1000C\_T4B

Recipes	Process	Historicals	Configuration	Manual Mode	Diagnostics	Shut down	EdMyers/Engineer Software version : 3.9.3 PCD Version : 3.9.3 04/05/2017 - 11:38:04
---------	---------	-------------	---------------	-------------	-------------	-----------	--

1. Clicking on the Zoom icon allow you magnify a portion of the data graph by left-clicking on the mouse and drawing a box.
2. Clicking on the Cursor icon allows you to find the actual and measured parameter values by left-clicking the mouse at the desired feature in the data graph.

## Appendix

---

### 1. AS-One 100 High temperature Configuration and Specifications

#### 1. Tool Specifications

Maximum Substrate Size	100 mm diameter
Recommended Temperature Range	Ambient to 1500 °C
High Temp Pyrometer Control Range	400 °C to 1500 °C
Thermal Couple Control Range <sup>1</sup>	Ambient to 1000 °C <sup>1</sup>
Maximum Temperature Range <sup>2</sup>	1500 °C <sup>2</sup>
Maximum Ramp Rate for Silicon	200 °C
Maximum Ramp Rate for a Susceptor <sup>3</sup>	20 °C <sup>3</sup>

#### NOTES:

- <sup>1</sup> The Thermal couple reacts with silicon at temperatures >725 °C.
- <sup>2</sup> Temperatures of 1500 °C is achievable with a 100mm diameter purified graphite susceptor without a lid.
- <sup>3</sup> Silicon carbide coated susceptors are limited to temperatures less than 1250 °C.

#### 2. Maximum step duration verse temperature

Temperature (°C)	Maximum Duration
1500 °C	30 sec
1400 °C	150 sec
1200 °C	15 min
<950 °C	3 hours