User Manual
Jetfirst 200

Restrictions and Precautions

- **The following materials are forbidden in the RTP chamber:**
  - **Organic materials (Photoresists, PDMS, Kapton, …)**
  - **Metallic contaminants**
- **Gold and Copper are accepted under extensive training with CMi staff**
- **This tool is not MICRO-ELECTRONIC compatible**
- **The wafers and/or dies can be silicon, sapphire and glasses. For glasses, the temperature will be limited to the thermal strain point minus 50°C.**
- **At temperatures higher than 800°C under vacuum and higher than 1000°C at atmospheric pressure, the TC will be destroyed if in contact with the sample (expensive!)**
- **When possible, RCA cleaning is highly recommended.**

Plastic tweezers are not recommended as they might melt if in contact with the hot plate. <u>Recommended to use metallic tweezers.</u>

A <u>test run with a dummy sample is recommended</u> to make sure the tool is correctly set before running with your sample.

Table des matières

Ne pas oublier de mettre à jour la table des matières.

1. Introduction

1.1. Applications

The JetFirst 200 system is a bench top RTP (Rapid Thermal Process) tool.

The tool is dedicated to the following applications or processes:

- RTA: Annealing for silicon and compound semiconductor wafers (Nitrogen & Forming gas lines)
- RTO: Rapid Thermal Oxidation (Oxygen line)
- RTN: Rapid Thermal Nitridation (Ammonia line)
- RTD: Rapid Thermal Diffusion from spin-on dopant (Nitrogen line)
- Crystallization (Nitrogen line)
- Contact Alloying (Nitrogen & Forming gas lines)
- Solar applications for PV industry (Nitrogen line)

1.2. Equipment description

The system is compatible with wafers from 2'' up to 8'' as well as piece of wafers. The system is also equipped with a primary and turbo (secondary) pump for a better control of the environment before the thermal process and during the thermal process.

Equipment description

The equipment is composed of

- Process chamber in stainless steel
- A furnace part equipped with 24 tubular infrared lamps
- 4 gas lines (O_2, N_2, NH_3 and forming gas)
- A primary pump
- A turbo pump

The equipment is driven by a software interface (PIMS) but the following manual operations are requested:

- Sample loading / unloading
- Recipe selection and downloading
- PID selection and downloading
- Temperature sensor selection and setting up

Your recipes as well as the PID tables associated are stored in the directory of your laboratory as shown on the figure 2

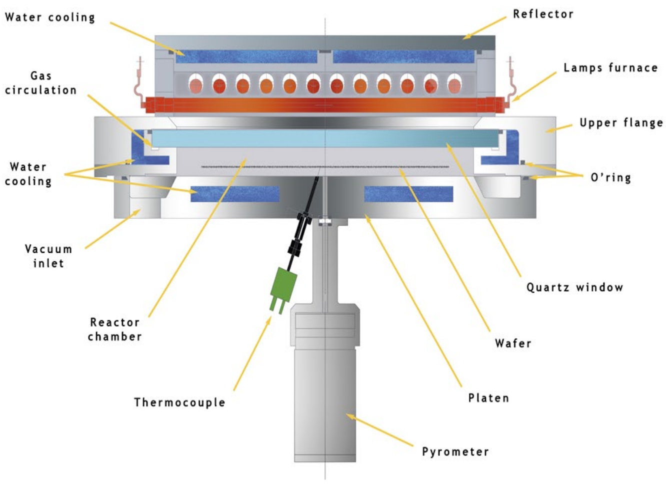


Figure 1
Cross section of the RTP chamber

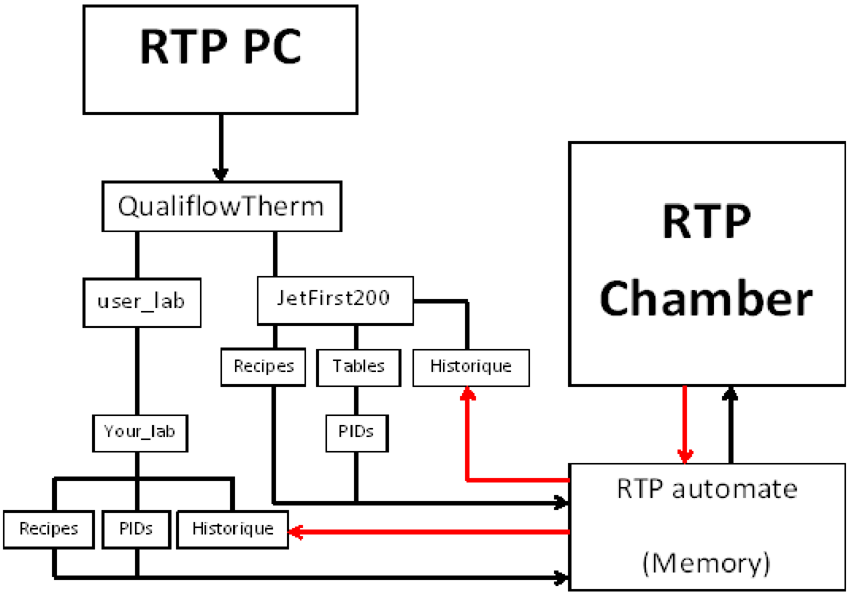


Figure 2

Schematic view of the RTP tool

1.3. Temperature control

The tool is equipped with 2 complementary systems to set, control and monitor the temperature: 3 thermocouples (one for the regulation TC1 and two for the monitoring TC2 and TC3) and one pyrometer (see figure I).

Thermocouple regulation:

The regulation by thermocouple is done by direct contact measurement of the temperature on the wafer. The TC regulation is effective from the room temperature **up to 1000°C in atmosphere** and **up to 800°C under vacuum.** **Outside of these ranges of temperature or pressure, a regulation with pyrometer must be used and the thermocouple must be withdrawn from the process chamber!!**

The TC regulation is valuable for all types of substrates (Si, glass, quartz, susceptor, sapphire ….). The TC is in contact with the back side of silicon substrate or the susceptor. A clean back side is mandatory to ensure a good contact between the TC and the wafer and consequently a good reading of the temperature.

Pyrometer regulation:

The regulation by pyrometer is done by the conversion of the emitted radiation by the substrate in infrared into temperature. This conversion implies the creation of a conversion table (calibration table) which was done during the installation of the tool. The emissivity is dependent on the wafer itself and the layers that you have on it. A dedicated table could be necessary; in this case a test wafer with the same characteristics of the product wafer is needed.

The regulation with pyrometer is effective **from 500°C up to 1200°C in atmosphere** and **up to 1100°C under vacuum.** **Below 500°C, the thermocouple regulation must be used!**

The pyrometer regulation is not valuable for transparent substrates like glass, quartz, sapphire,… **All the transparent samples must be placed in a graphite/SiC susceptor**.

1.4. Software map

Figure 3. Software view

The different buttons/menus of the PIMS:

- *Logic I/O:* shows the white box with the real time read-out of the sensors
- *Parameters:* **FORBIDDEN**
- *PID Temperature controller:* where you can create/tune and apply the PID for your recipe
- *Configuration:* **FORBIDDEN**
- *Historicals:* where you can check previous logs and run of the tool
- *Maintenance:* **FORBIDDEN**
- *Processing:* where you can select a recipe and start a run
- *Recipes:* where you can create/tune your own recipe
- *Exit:* to exit the software

2. Create your recipe

2.1. Process description

A typical RTP recipe with a thermocouple regulation is composed of a minimum of 5 steps and a typical recipe with pyrometer regulation is composed of a minimum of 9 steps (see underlined text in table 1) up to 50 steps.

Step n°	Name	Action	Optional	Parameters
1	**Chamber conditioning**	**Primary pumping**	**No**	**-**
2	Vacuum setting	Secondary pumping	Yes	- Duration - Vacuum level
3	Gas filling	Chamber filling with the process gas	Yes	- Duration - Gas (O_2, N_2, NH_3 and forming gas)
4	Purge	N_2 filling up to atmospheric pressure	Yes	- Duration
5	<u>Ramp up</u>	Sample heating up to 200°C	Yes	-
6	<u>Steady state</u>	Pyrometer Pre activation	Yes	-
7	<u>Ramp up</u>	Sample heating up to 300°C	Yes	-
8	<u>Steady state</u>	Pyrometer activation	Yes	-
9	**Ramp up**	**Sample heating up to the set temperature**	**No**	**- Duration - Temperature (Ramp rate °C/s)**
10	**Steady state**	**Thermal treatment**	**No**	**- Duration**
11	**Ramp down**	**Cool down of the sample**	**No**	**- Duration - Temperature (Ramp rate °C/s)**
12	**Purge**	**Open N_2 purge valve**	**No**	-

Table 1

Description of the basic steps of a RTP recipe

The maximum duration of an annealing depends on the temperature as shown in the table below:

Process Temperature [°C]	500	600	700	800	900	1000	1100
Maximum process duration [min]	240	180	150	120	60	15	9
Maximum process duration [h]	4	3	2.5	2	1	0.25	0.15

Table 2

Maximum process duration vs. process temperature

2.2. Create a PID

To get the PID controller specific to your recipe, ask a CMi staff in charge of the tool to make it for you. If you need to tune multiple PIDs you can ask for a training specifically to make a PID.

2.3. Create a recipe (You have to be in Engineering mode – ENG / ENG)

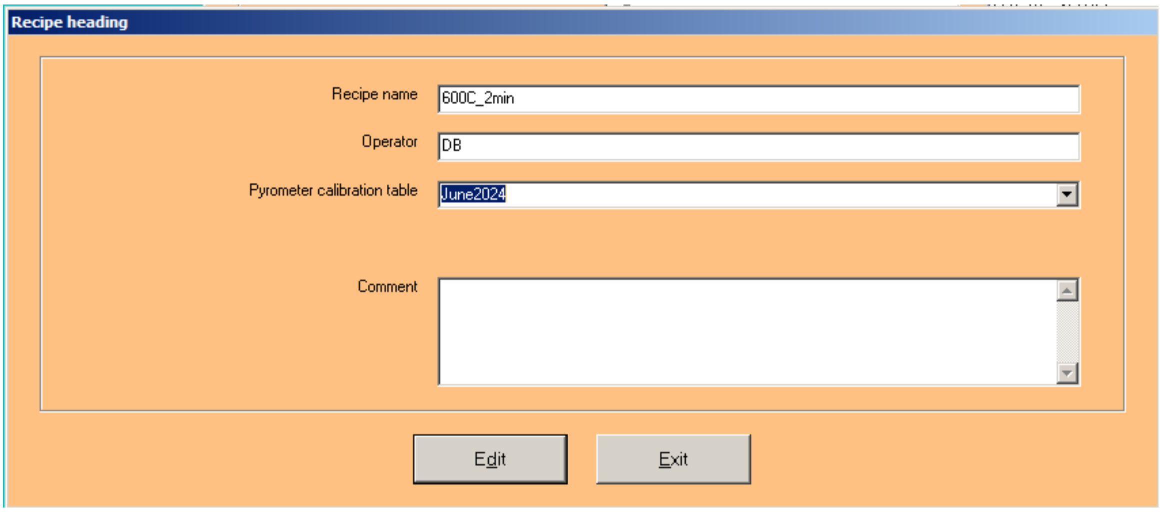
1. Open “***Recipes***” menu
2. Select a previous recipe in your folder or from CMi’s template and click “***Open***”
3. Give the recipe the name you want.
4. Set the pyrometer calibration table to the latest release and click “***Edit***”. N.B Even if you won’t use the pyrometer, you **must** set it
5. 1st step:
    a. **set** temperature to 25°C.
    b. **Check** the Primary vacuum box
    c. **set** the duration:
        i. **15s** if process with gas
        ii. **120s** if process with secondary vacuum

To go to the next step, press “***Next step***”

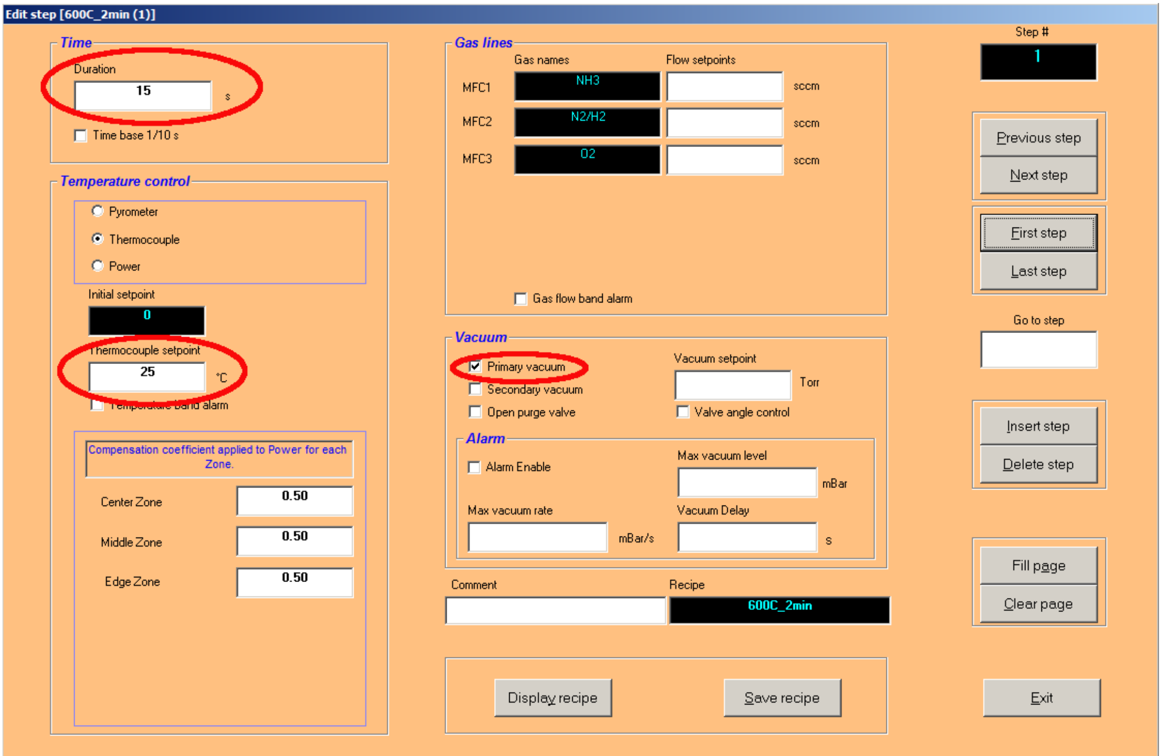
6. 2nd step:
    a. **keep** temperature constant.
    b. Multiple choices are available
        i. **Check** secondary vacuum with a duration >120s
        ii. **Set** the flow of filling gas (45-60s recommended for good filling)
        iii. **Check** the Purge box (45-60s recommended for good filling)
7. 3rd step:
    a. **remove** gas inflow for ramp stability.
    b. **Set** target temperature and duration.
    N.B: ramp up shouldn’t be faster than PID dynamic!
8. 4th step:
    a. **keep** temperature constant.
    b. **Set** annealing duration.
    c. **Set** gas flow if wanted
9. 5th step:
    a. **Set** temperature to 25°C
    b. For the duration:
        i. **Set** duration if controlled ramp down (slow cooling)
        ii. **Set** 10s else as the duration will ultimately be tool limited
10. 6th step:
    a. **Check** Purge box to clean chamber content
    b. **Set** duration for >20s
11. All steps:
    a. **Set** the temperature to the one you’re using (TC or pyrometer)
    b. **Set** compensation coefficient according to step temperature:
        i. **0.5** if T < 800°C
        ii. **0.7** if 800°C < T < 900°C
        iii. **0.9** if T > 900°C
12. Click “***Save recipe***” and save it in your folder

2.4. Recipe example – 600°C for 2min

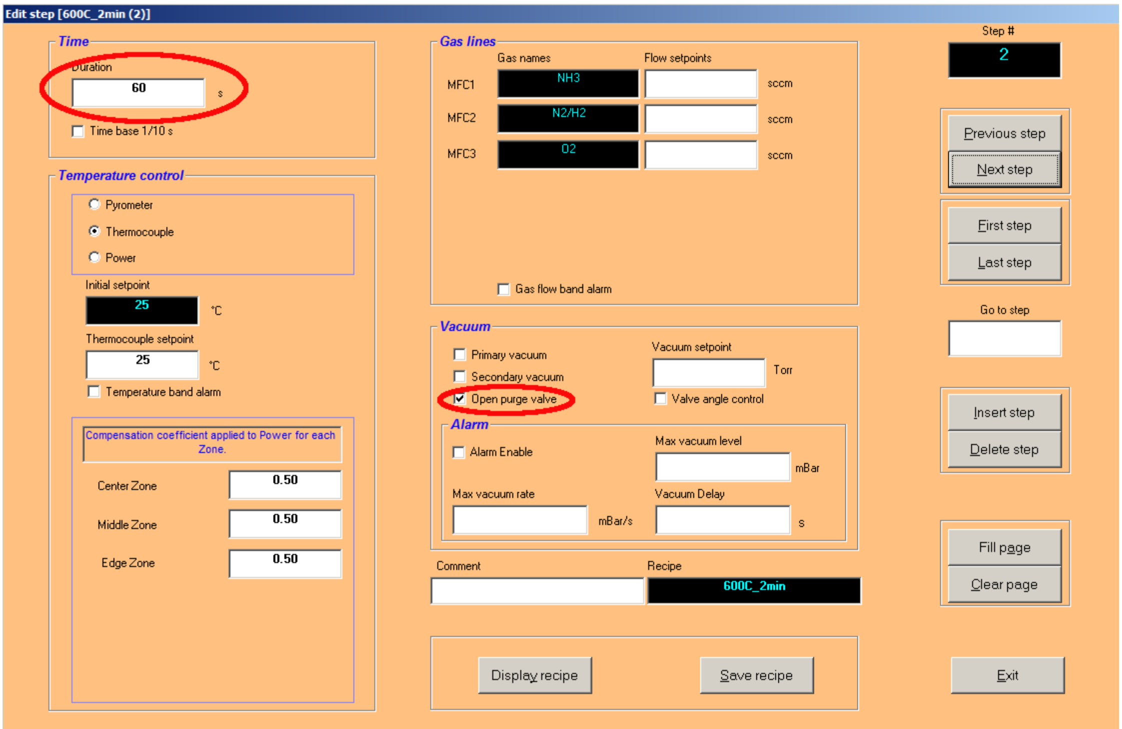
Recipe template:



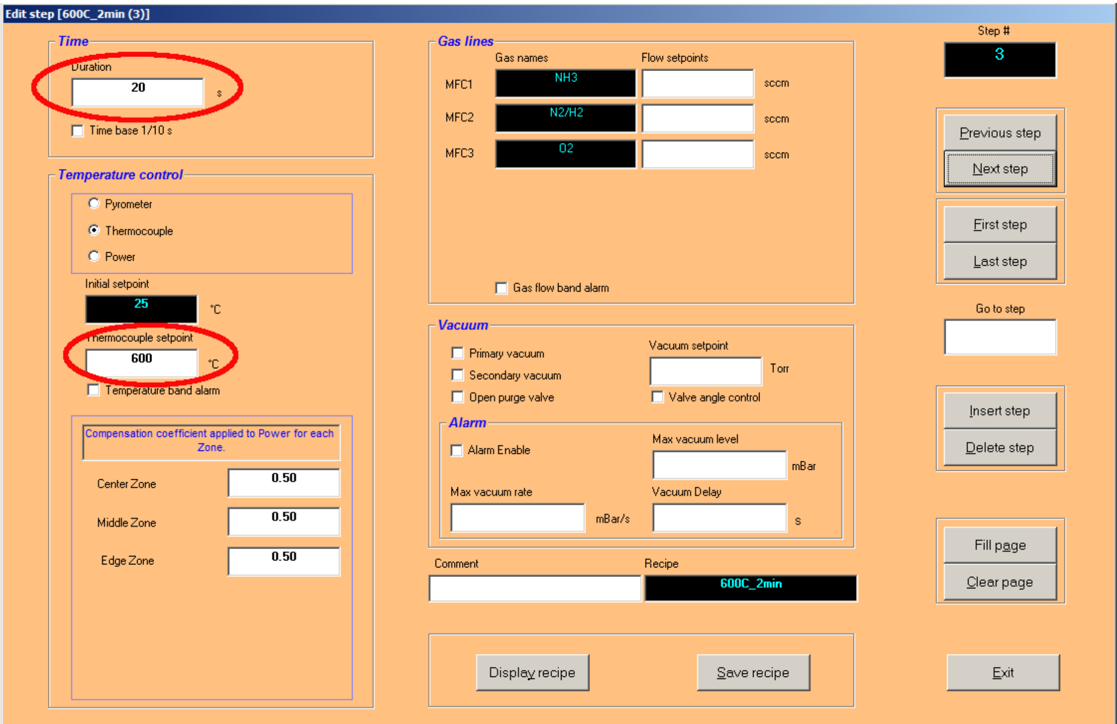
1st step:



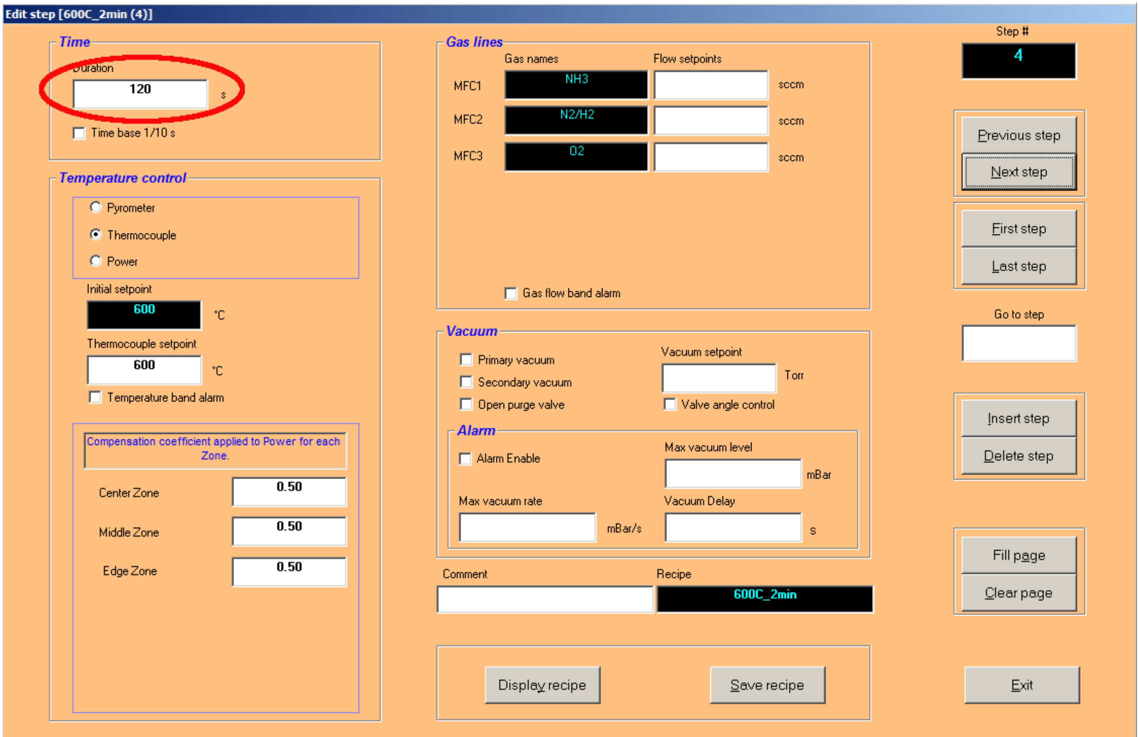
2[nd] step:



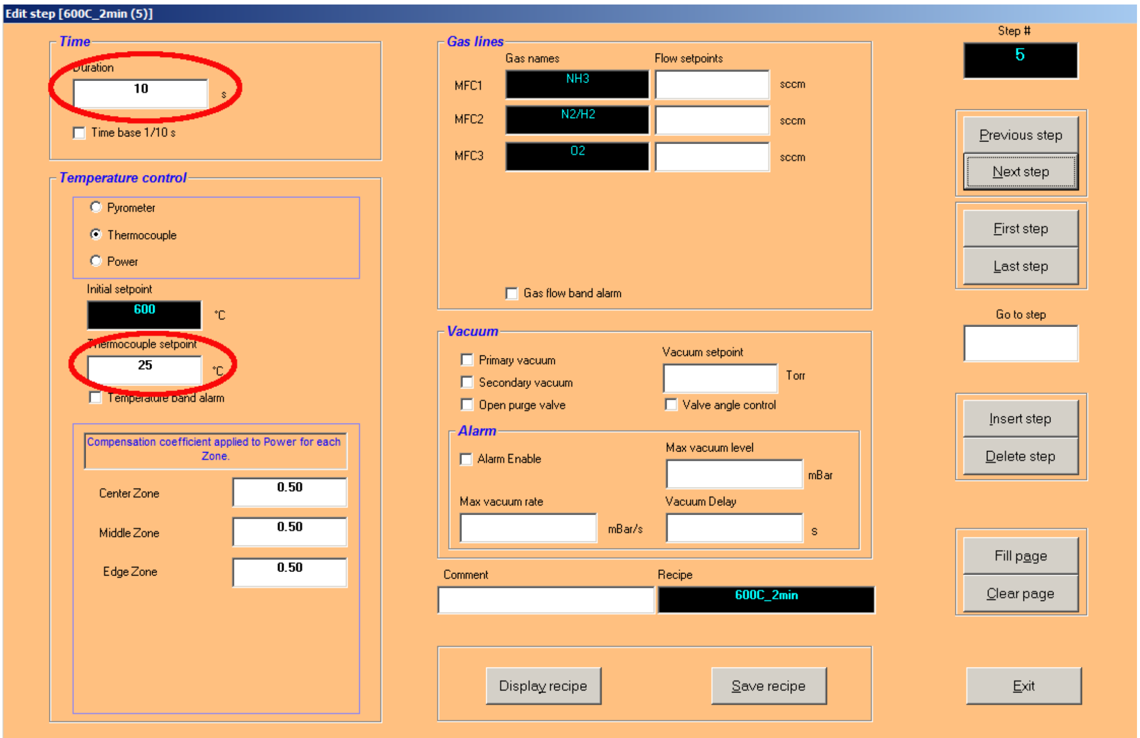
3rd step :



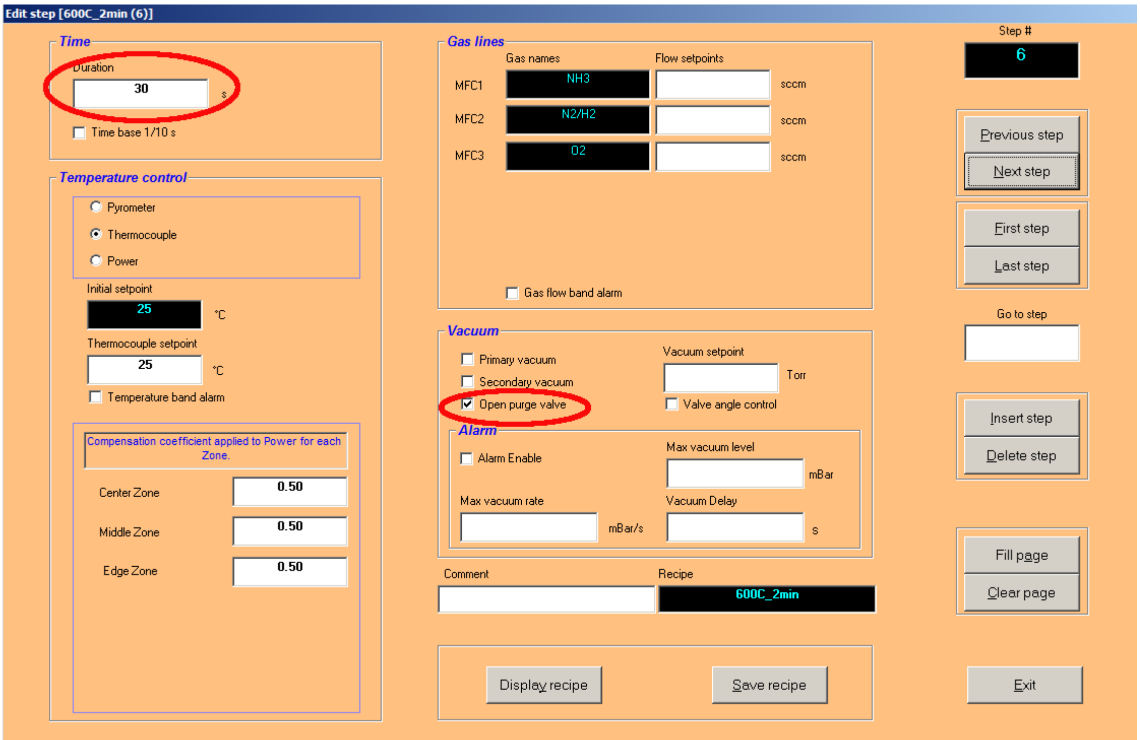
4th step :



5th step :



6th step :


Edit step [600C_2min (6)]
Time
Duration
30
s
Time base 1/10 s
Temperature control
Pyrometer
Thermocouple
Power
Initial setpoint
25
°C
Thermocouple setpoint
25
°C
Temperature band alarm
Compensation coefficient applied to Power for each Zone.
Center Zone
0.50
Middle Zone
0.50
Edge Zone
0.50
Gas lines
Gas names
Flow setpoints
MFC1
NH3
sccm
MFC2
N2/H2
sccm
MFC3
O2
sccm
Gas flow band alarm
Vacuum
Primary vacuum
Secondary vacuum
Open purge valve
Vacuum setpoint
Torr
Valve angle control
Alarm
Alarm Enable
Max vacuum level
mBar
Max vacuum rate
mBar/s
Vacuum Delay
s
Comment
Recipe
600C_2min
Display recipe
Save recipe
Step #
6
Previous step
Next step
First step
Last step
Go to step
Insert step
Delete step
Fill page
Clear page
Exit

3. Using the tool

3.1. Loading & Unloading

The system is compatible with wafers from 2'' up to 8'' as well as pieces of wafer or dies.

Whatever the sample you process, it should never be placed directly on the metallic floor of the RTP chamber!

For each size of wafer (4, 6 and 8'') and for dies, we have a set of picots in quartz (See figure 4). Each picot must be placed in their dedicated holes (depending of the size of the wafer) in the floor of the chamber (see figures 5 & 6).

Transparent samples compatible with high temperature treatments (quartz or sapphire) must be place in the SiC susceptor. The susceptor corresponds to a 6'' wafer; it can accept 4''wafers or smaller size. It can be used with or without cap. At last, the TC must be placed in its dedicated hole in the susceptor.

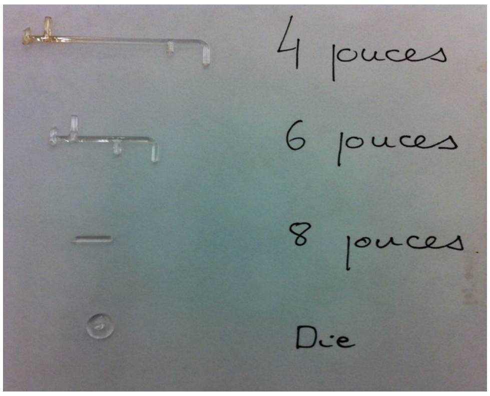


Figure 4
Set of accessories for 4, 6, 8'' and dies

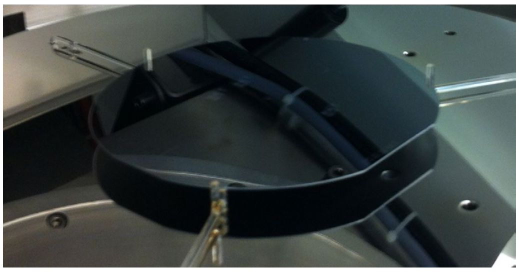


Figure 5
4 '' wafers in the RTP chamber on its 3 picots in quartz

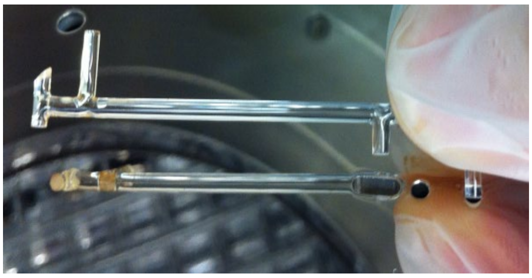


Figure 6
A picot above its emplacement in the floor of the RTP chamber

3.2. Thermocouple positioning/removal

To set the TC:

1. Unscrew nut (See Fig.9)
2. Move carefully up the connector until the TC touches the back of the substrate
3. The TC must touch (**no gap!**) but must not push up the substrate (**all picot should be in contact !**)
4. Screw back the nut whilst maintaining the TC in position.

As mentioned previously:

- **TC cannot support temperature above 1000°C at atmospheric pressure**
- **TC cannot support temperature above 800°C under vacuum**

If the TC must not be, you must unscrew the nut (see Figures 9 & 10) to move down the connector (between 5 to 9 mm) and hide it in the metallic floor of the chamber. The TC should not anymore be visible (see Figure 7).

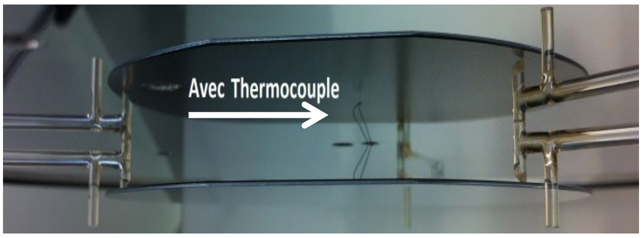


Figure 7
View of the TC in contact with the wafer placed on its 3 picots in quartz. TC should be touching its reflection

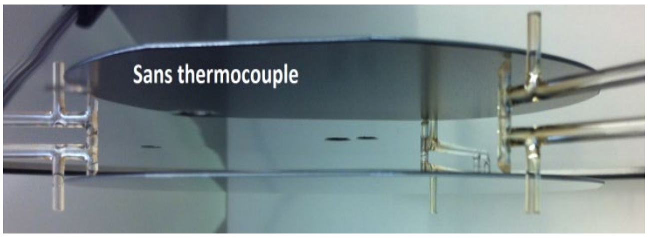


Figure 8
TC removed from chamber

Figure 9
Bottom part of the TC with the connector


Figure 10
Bottom part of the TC once the connector is moved down of few mm.
(NB: the nut must be screwed back in upper position before processing)

3.3. Start a run

1. Login on the PC zone 3
2. Turn On the tool (green button)
3. Open the chamber with the handle, load the wafer on the quartz picots:
   a- If the temperature control is done by the thermocouple, check that the TC is in contact with the wafer and close the chamber
   b- If the temperature control is done by the pyrometer, remove the TC from the chamber and close the chamber (see section 3.2)

After closing the lid, lower the handle to lock the chamber.

NB: A temperature higher than 800°C under vacuum and higher than 1000°C at atmospheric pressure destroy the TC if the TC is in contact with the sample!!!!

4. Click on "*PID temperature controller*" in menu bar (top left) to have access to PID interface.

5. To transfer the PID parameters from the RTP PC to the RTP automate, select with the "browse" function, your PID table in your library under the path "*QualiflowTherm/users_lab/Your_lab/…*" and press "open". The left column is filled with PID parameters on a yellow background.

3. Press "*Apply all "yellow" setpoints*" to transfer these numbers in the right column (tool memory) with black background.

4. Check that the 2 columns have the same values for each Temperature zone, if it's not the case, select the number in the left column and press "return".

5. Close the window with "*Exit*"

6. Press on "*Processing*" and go to your directory from the menu "*Recipe*" to download and press "yes". Once the recipe is selected, press on "*Download*". Wait for the message "Download was successful" and then press "Ok".

7. To start the recipe, press a first time "*start processing*"

8. Press a second time "*start processing*"

9. The process window opens to monitor the run. You can manually abort the run by pressing "*STOP*"

9. Once the run is done, save the process data in your directory and wait for the cooling down procedure (around 6 min).

NB: the chamber is locked until the cooling finishes

10. Once the cooling down procedure is done, the chamber is unlocked and you can open the chamber with the handle, take your sample and load a new one/ or close the chamber and logout.

4. Run monitoring

4.1. Process window

Once the process started the process window opens automatically.

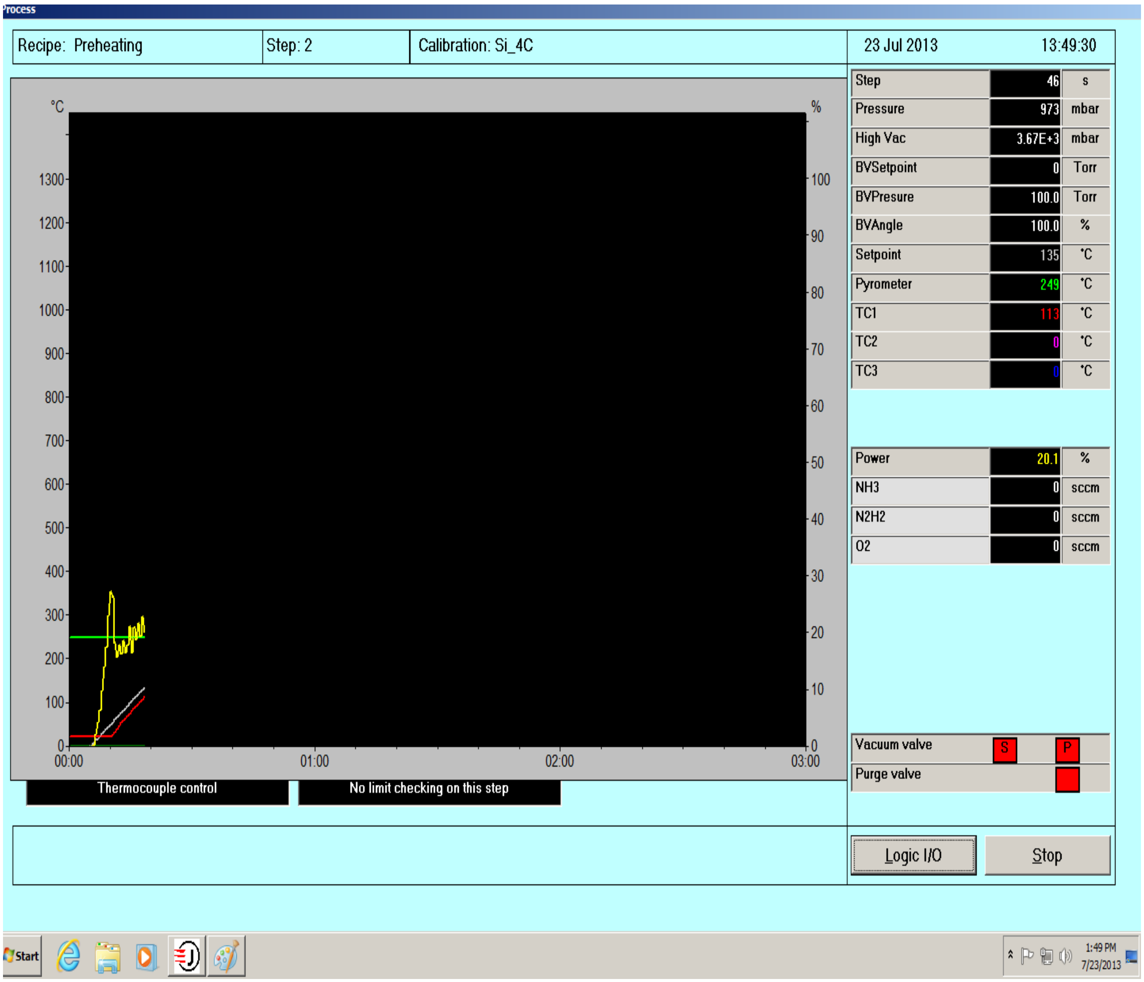


Figure 11

Process window

It shows :

- Current step
- Time remaining before the end of the current step
- Pressure in chamber
- Setpoint / Targeted temperature
- Measured temperature by TC and pyrometer
- Relative input power in the lamps
- Gases flow
- States of valves

To assess if the run is going well, you must check the oscillations in power. The smaller the amplitude the more stable is the temperature. If the amplitudes of oscillations are too big press "***Stop***" to abort run.

Oscillations may be due to:

- **Most common**: Incorrect contact between TC and substrate -> reposition it
- Compensation coefficients are bigger than expected for your temperature range

4.2. Access historicals

You can access the process data of a previous run by:

1. Clicking "***Historicals***" once
2. Clicking "***Historicals***" again
3. Select the run you want to check in your directory

This will open the process data in the same fashion as the process window.

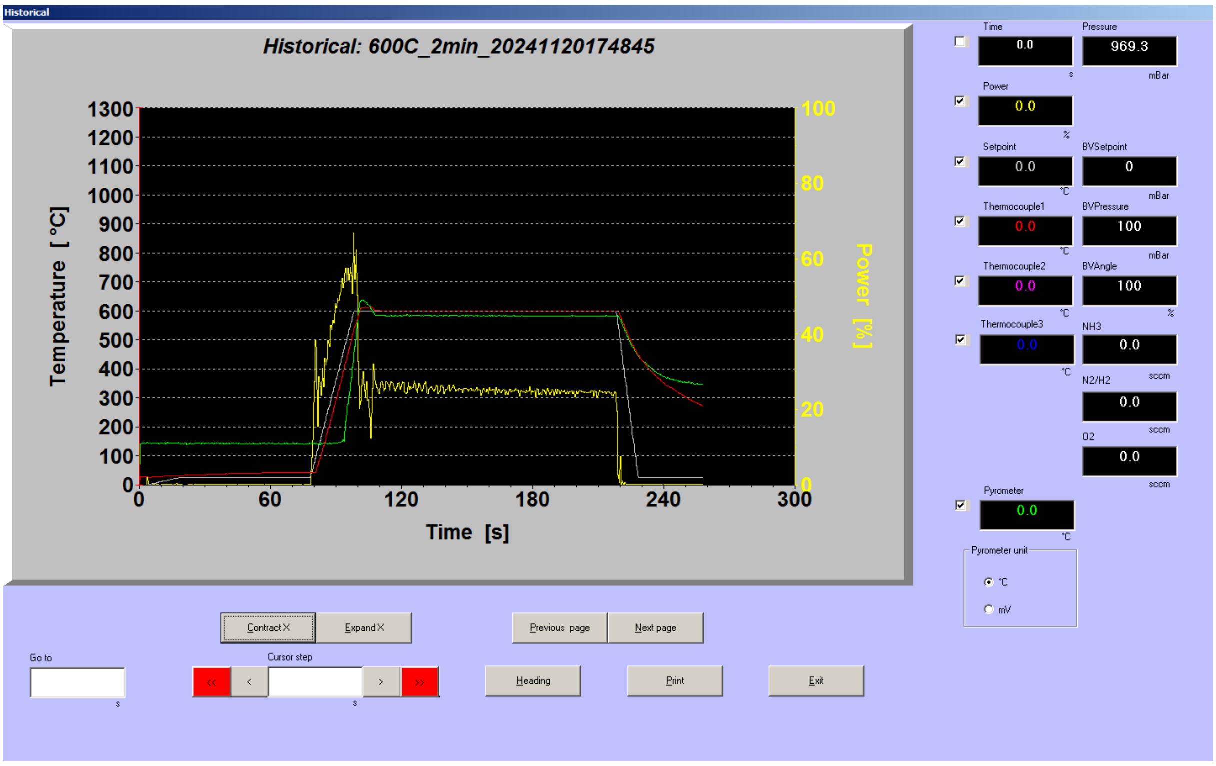


Figure 12

Historical window

You can export the graph to pdf by pression "***Print***". The .HIS format is a simply text format from where you can access the raw data to plot it with your favorite plotting software (Excel, python, …)