2-inch Annealing Furnace (middle tube)

STANDARD OPERATING PROCEDURE (SOP) 2021 (v.1)

NCPRE FABRICATION LAB

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TABLE OF CONTENTS

INTRODUCTION

2 inch furnace is dedicated for high temperature processing of 2" wafers. The three quartz tubes are currently utilized for Boron diffusion, phosphorous diffusion and annealing purposes. For any other studies, different quartz tubes can be used.

Annealing Furnace: Bare RCA cleaned wafers and spray coated Al2O3 and SiO2 film deposited Si wafers are allowed. Spray coating has to be performed only in tool placed in NCPRE fab lab.

System Specification & Features

1. Capability to process 2" wafers.
2. Quartz tube.
3. Gas Inlets available: 5% FG, O_2, N_2.
4. Maximum temperature: 1100°C.
5. Temperature controller: TAIE PFU48.
6. Temperature indicators to show temperature at three points in the zone.
7. Natural cooling.
8. 8-step ramp up/ramp down programming of temperature controller.
9. Software interface for programming temperature controller & recording process recipes.

SAFETY PRECAUTIONS

1. Confirm that the exhaust is ON.
2. Check the facility team for cylinder and gas line pressures for FG, N_2 and O_2 before starting the process.
3. Check the status of the tools sharing the gas lines. Ask the user of those systems to inform in advance whenever the gas lines are used by them so that the gas flow rate through flow-meters can be monitored carefully during their operation.
4. Be careful while loading and unloading the wafers at high temperature from the furnace tube. Do not touch the furnace tube, furnace tube cap, quartz boat and pulling rod (which may be at high temperature) without wearing thermal insulating material fleece gloves provided with the system.
5. Do not keep the quartz boat/pulling rod on lint free cloth immediately after unloading from the furnace.

CLEANING METHOD

- Cleaning of the outer walls of the furnace, computer and table can be done using IPA and lint-free cloth.
- Furnace tube, pulling rods and quartz boats can be cleaned (if required) by keeping it in 2 % HF solution for 24 hours followed by cleaning using DI water. (Take the help of facility staff/ any AU for cleaning the furnace tube.)

Precaution:

- Do not touch the furnace tube, furnace tube cap, quartz boat and pulling rod (which may be at high temperature) without wearing thermal insulating material fleece gloves provided with the system.

STANDARD OPERATING PROCEDURE

Section1: General Procedure

1. Switch ON the computer system.
2. Start the appropriate gas flow by turning the valves, mounted on the wall behind the computer system, in downward direction (Figure. 1).
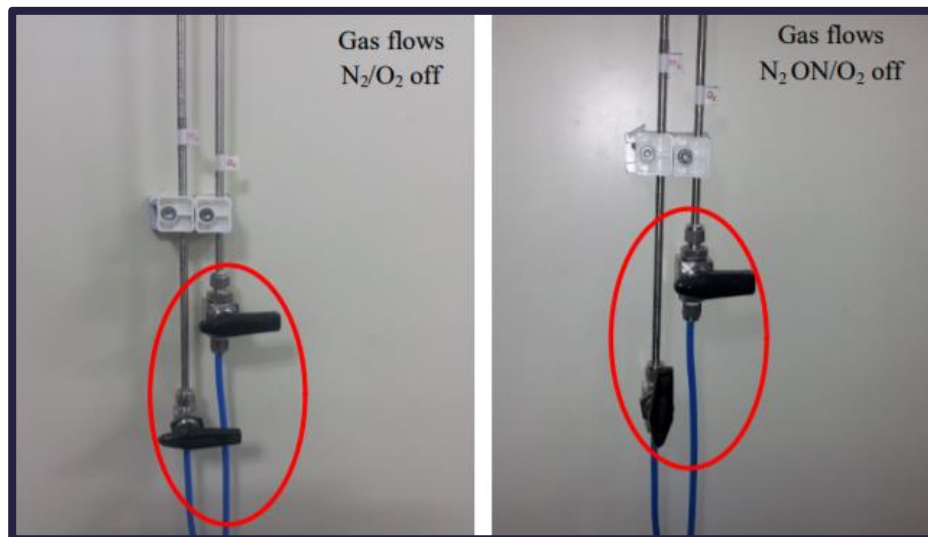

Figure.1

3. Start the gas flow through the flow-meters mounted on the system, by turning the appropriate (for N_2/O_2) valves in the direction indicated (Figure. 1).
4. Adjust the flow rates using the circular knob of flow-meter (anticlockwise- increase flow rate, clockwise- decrease flow rate) to appropriate value as per the recipe and monitor it carefully during the process to maintain them to desired values (Figure. 2).
5. Switch ON the furnace by turning on the switches with appropriate names on switch board behind the system as well as MAINS switch on the furnace front panel. Ensure that the furnace is ON by checking whether the MAINS lamp on front panel is glowing (Figure.3).

Figure. 2

Figure. 3

6. Ramp up/ ramp down recipe can be entered either manually from Temperature Controller on the front panel of the furnace or through the software. (The process is explained in detail in separate sections).

7. For loading/unloading the wafers in the furnace; remove the furnace tube cap carefully by holding it with hands and turning it slowly and rest it on the space in front of furnace on the table. Wear thermal insulating gloves while handling the tube cap which may be at high temperature.

8. When recipe is running, load the wafers in the quartz boat with the help of tweezers in appropriate slot of the boat. Note down the slot in quartz boat, since that decides the position of wafer in the furnace tube zone.

9. Put the quartz boat in the boat holder and load the quartz boat in the furnace tube at appropriate temperature with the help of boat holder and pull rod. Ensure that the position of quartz boat is correct (preferably in the flat zone) with the help of the length of the pull rod introduced inside the tube. Flat zone is the region in the furnace where the temperature remains constant. Temperature profiling data which gives the flat zone information, of the currently installed tube furnace is saved in the desktop folder of the computer. Temperature profiling needs to be re-done whenever there is a furnace tube change.

10. Put the cap of the furnace tube back and turn it gently.

11. Unload the wafers in the quartz boat after desired duration and at appropriate temperature with the help of pull rod and boat holder.

12. Place the boat holder on table and do NOT touch it with lint free or nitrile gloves.

13. Do NOT unload wafers from quartz boat unless they reach room temperature.

14. After unloading the wafers, put the quartz boat, the boat holder and pull rod properly to obviate their contamination.

15. After ramp down is complete, switch off the furnace. Turn OFF the gas supply from the table top system as well as from wall mounted lines. Ensure gas cylinders are turned OFF in service area.

16. Enter all the details in the online logbook appropriately.

Section 2: Manual Operation of Temperature Controller

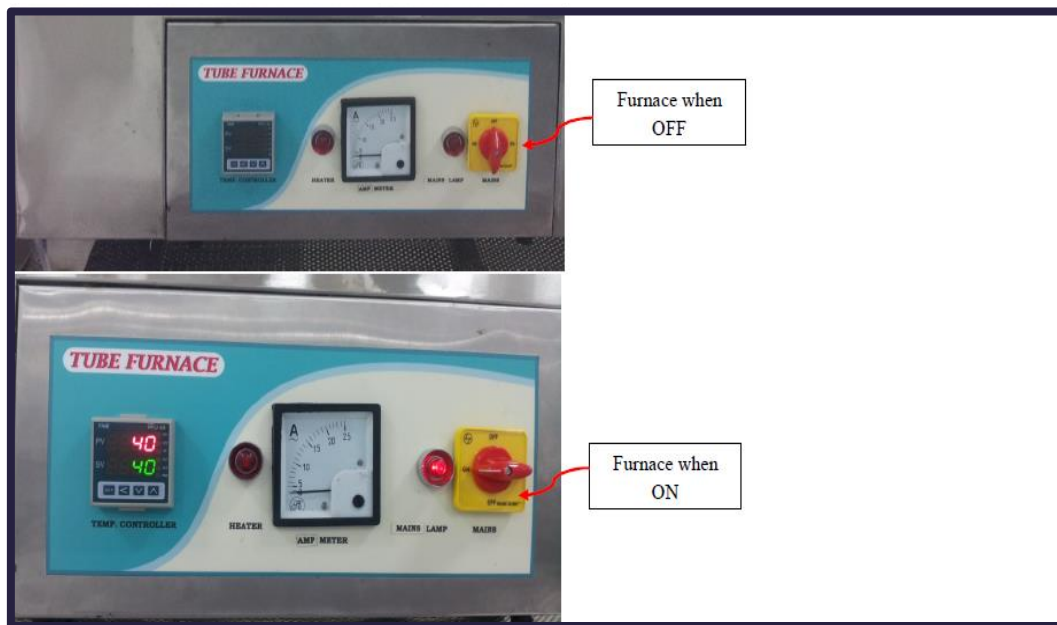1. Start furnace by turning MAINS switch on front panel of the furnace (Figure.4).

Figure. 4

2. Controller displays following values when powered on. Then it shows input type (Figure. 5).

Figure. 5

3. Ensure that "At" shows "no" unless execution of "Auto-tuning" is required (Figure. 6).

Figure. 6

4. "PV" on the temperature indicates present value whereas "SV" indicates set value of the temperatures. Set the furnace temperature to single value by changing the SV using "SET", side arrow "<", down arrow "v" and up arrow "Л" on the temperature controller; when "PRO" LED is glowing but NOT flashing.

5. Check for the recipe/program stored in the memory of the controller, when controller is powered ON, by checking current running segment shown by "SEG" on the controller. This can be done at any instant during the entire operation of the furnace by clicking on the "SET" symbol till you reach SEG value. SEG indicates currently running step in the program. Click on "SET" one more time, to see the time remaining for this segment (Figure.7).

Figure. 7

6. Enter multi-step recipes/programs for the furnace operations by manually entering the SV (ie. Set value) of the temperature (in °C), the time duration (in hr: min) and the output power (in %) with the

fields "SV_1", "t0_1", "OUT_1" respectively; using "SET", side arrow "<", down arrow "v" and up arrow "^" on the temperature controller (Figure.8).

Figure. 8

7. Enter SV for these fields (SV_1, SV_2…SV_8; t0_1, t0_2… t0_8; OUt_1, Out_2….Out_8) up to 8 steps to program the furnace with ramp up/ramp down or annealing at any temperature for required time (Figure. 9).

Figure. 9

8. Start the program by clicking on up arrow "^"; ensure this by confirming that "PRO" LED is flashing. Stop the running program at any instant by clicking on down arrow "v", if required. Ensure program is stopped by confirming the "PRO" LED is glowing, but NOT flashing (Figure. 10).
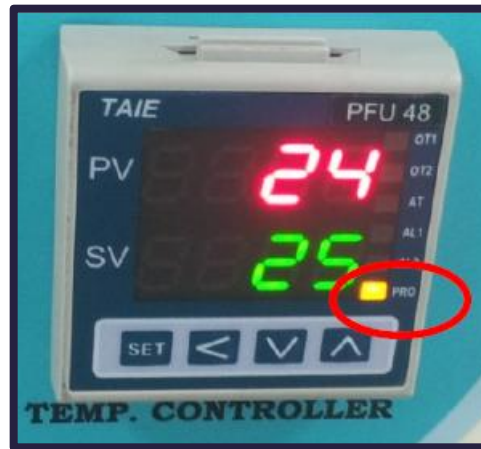
Figure. 10

9. Based on the recipe entered, the "SV" changes during the operation based on "ramp up/down' rate. "PV" tries to catch with "SV" by flowing current through heater coil and turning it off, once the instantaneous PV reached the instantaneous SV. Observe this change, with AMP METER and HEATER Lamp on furnace front panel (Figure. 11).
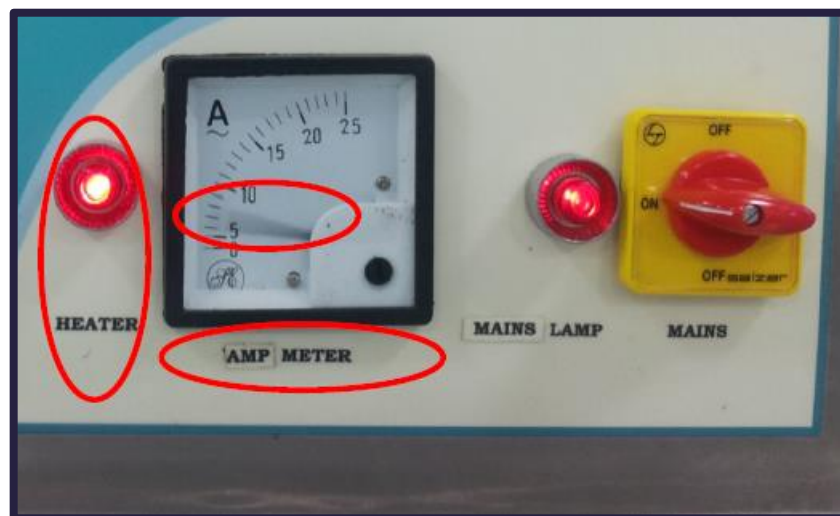

Figure. 11

10. Ensure that the maximum temperature in the recipe is NOT above 1100°C, which is the set maximum temperature of the furnace. This is incorporated by setting alarm at 1100°C in AL1 field (Figure. 12).
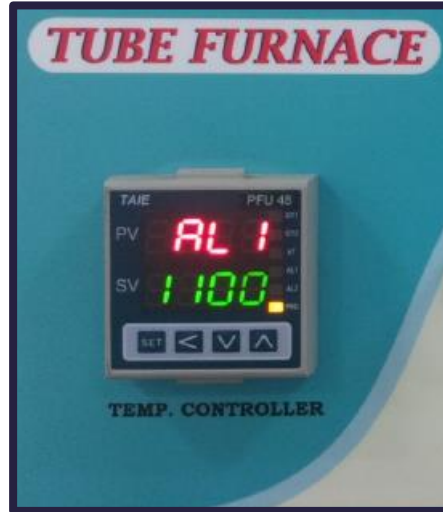
Figure. 12

Section 3: Temperature Controller Programming through software interface

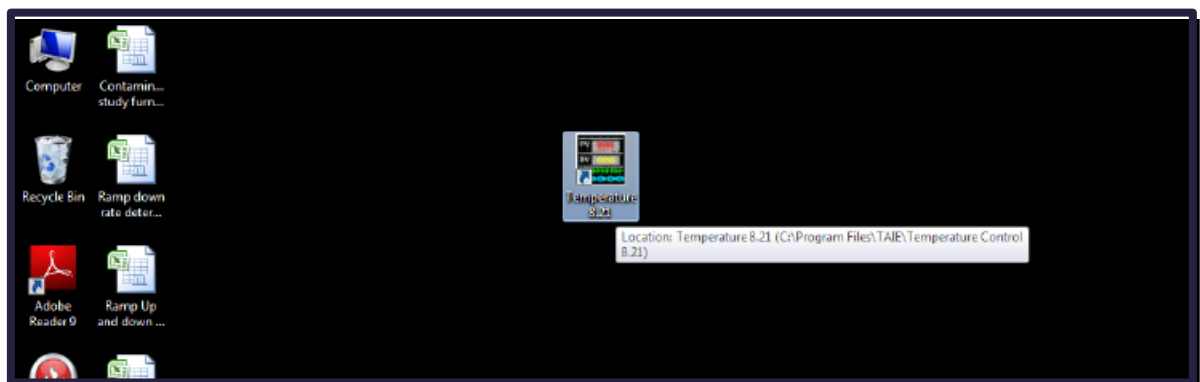1. Click on the "Temperature 8.21" icon on the desktop of computer system (Figure. 13).

Figure. 13

2. Ensure that the furnace MAINS switch is ON (Figure. 14).

Figure. 14

3. Ensure the "Communication Settings" in software are in sync with the actual connection between the computer and the hardware of the furnace temperature controller. Click on "Communication" tab of the "Monitor" tab (Figure. 15).

4. "Communication Settings" window will pop up. Check whether the data is as follows (Figure. 16).

5. "Com Port", in the above pop up window, can be set to any of the 8 ports, since we have data to be maintained on just one port. Click on "OK" to go ahead with the settings.
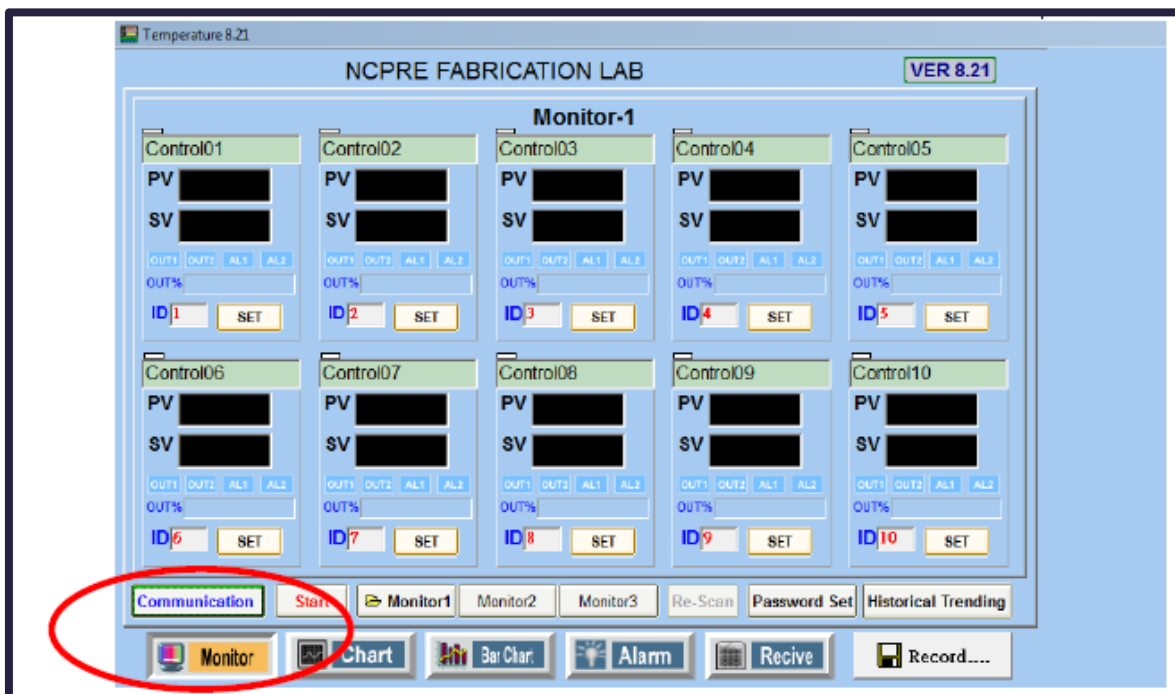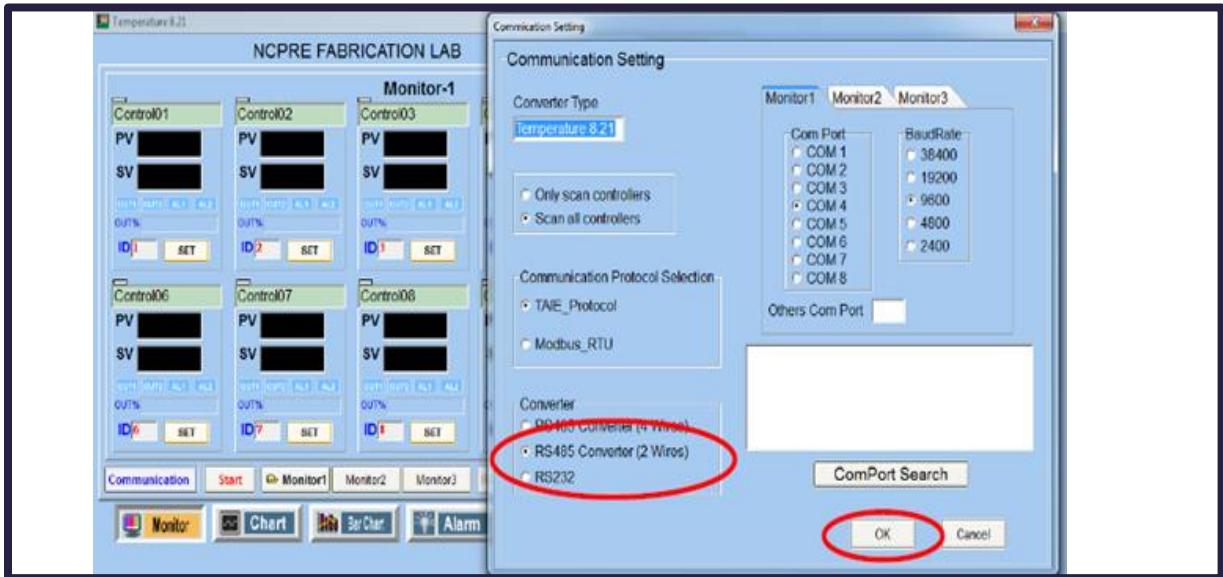

Figure. 15

Figure. 16

6. Establish the communication between the software on the computer system and the hardware of the furnace temperature controller by clicking on "Start" tab in the window below of the "Monitor" tab (Figure. 17).
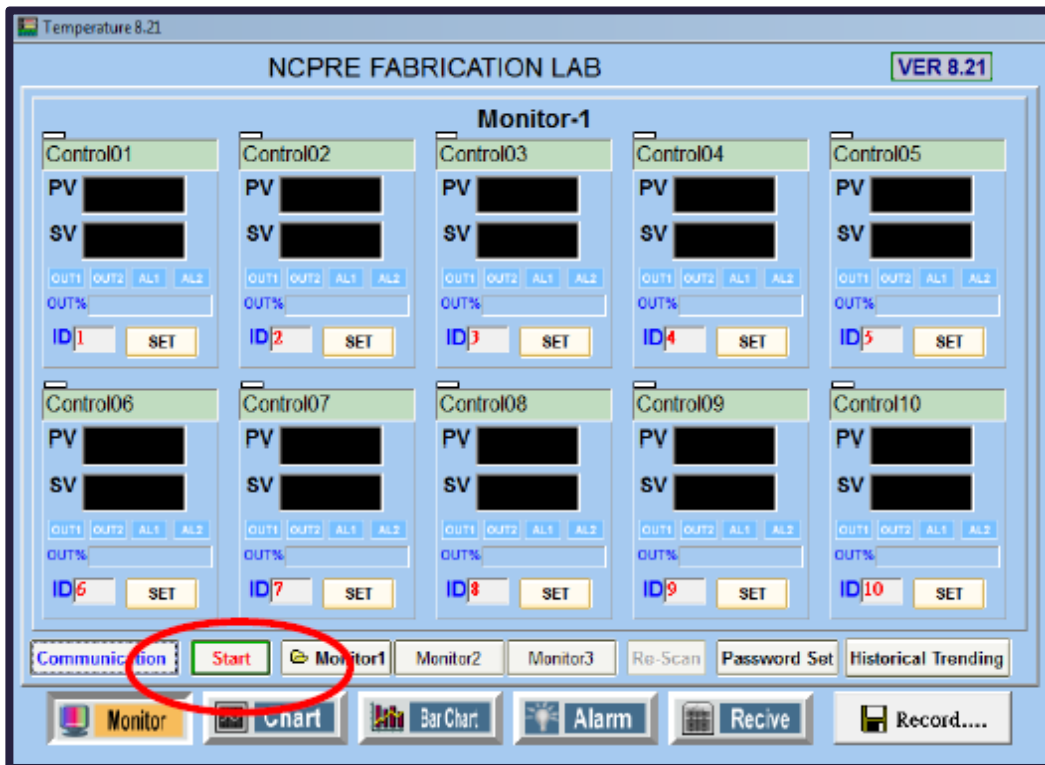

Figure. 17

7. The pop up window with "DP Reading" will appear and Red and Green LEDs on the"ATC-820 USB <=> RS-485 Interface converter" will glow. Ensure that the USB of the converter is connected to the CPU of the computer system and "Set Up" has been carried out (Figure. 18).
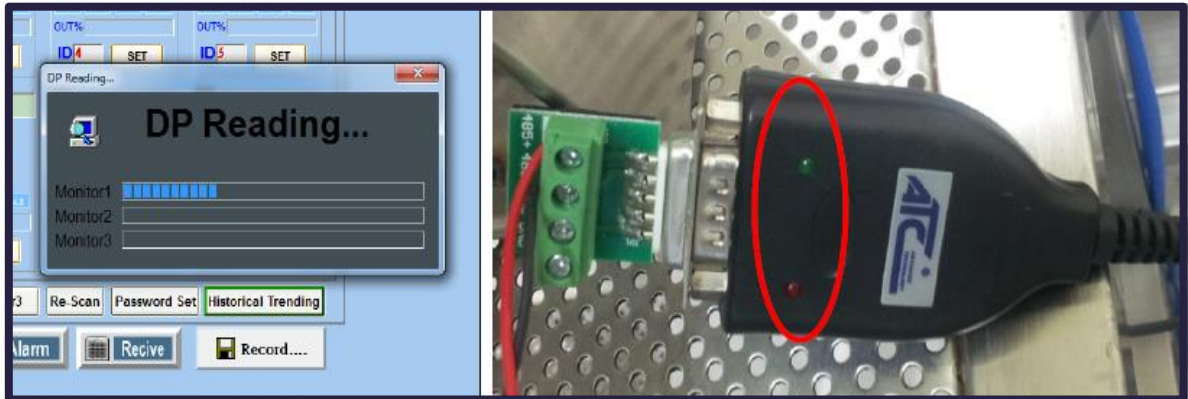

Figure. 18

8. Once the communication is established between the hardware and the software the PV (Present Value) and SV (Set value) of the temperatures will appear as follows (Figure. 19).
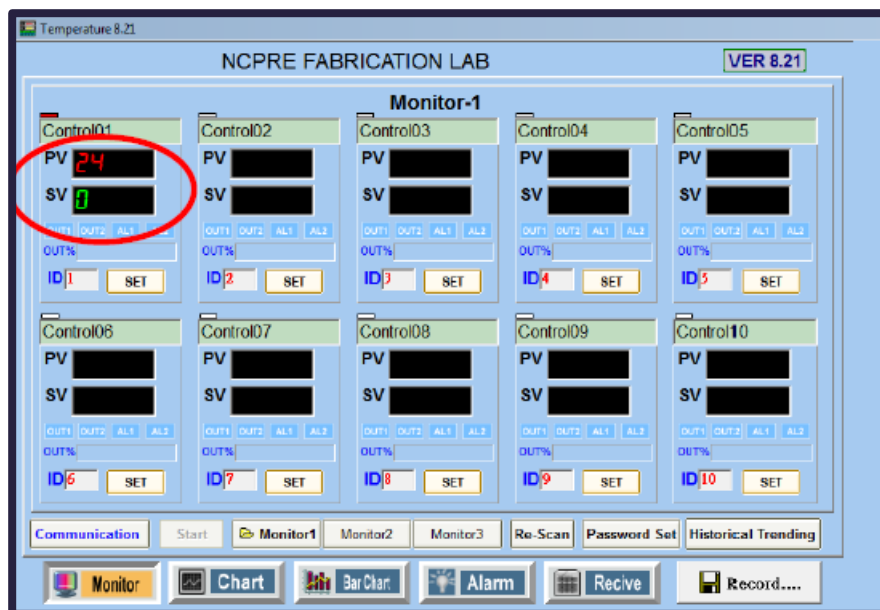

Figure. 19

9. Enter the recipe to be run in the software. Click on "SET" in Control01 (Figure. 20).
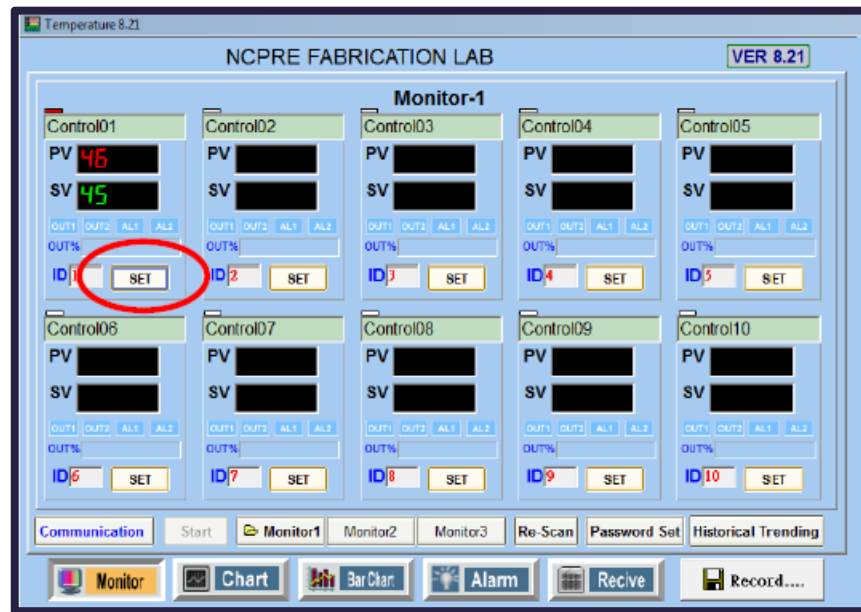
Figure. 20

10. Furnace can be either run with single set value with minimum time to reach that temperature or step by step recipe can be entered.

11. "Set Controller" pop up will appear after clicking on SET. To directly run the furnace to the desired temperature put the SV in Level 1 by clicking on the digits. Once the desired value appeared in blank field, then click on "Write" (Figure. 21).
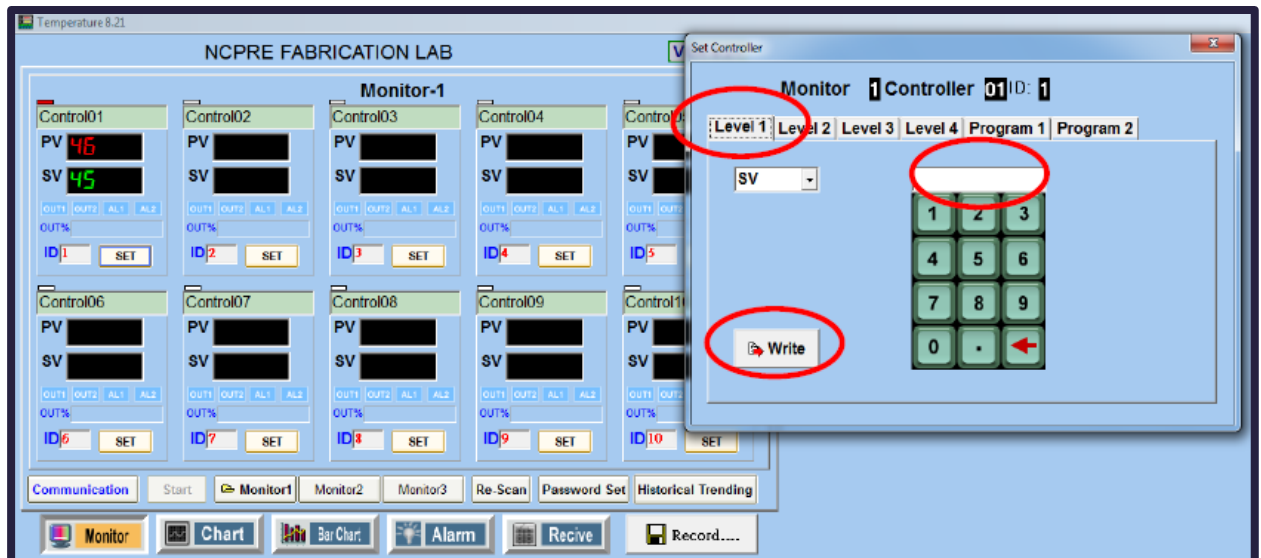

Figure. 21

12. To enter step by step recipe, click on the "Program 1" tab. It will ask for the set value of the temperature (in °C), the time duration for reaching it (in hr: min) and the output power (in %) with the fields

from drop down such as"SV_1", "TM_1" and "OUT_1"respectively. The digits in these fields change from 1 to 8, to enter 8 step programs (Figure. 22 & 23).
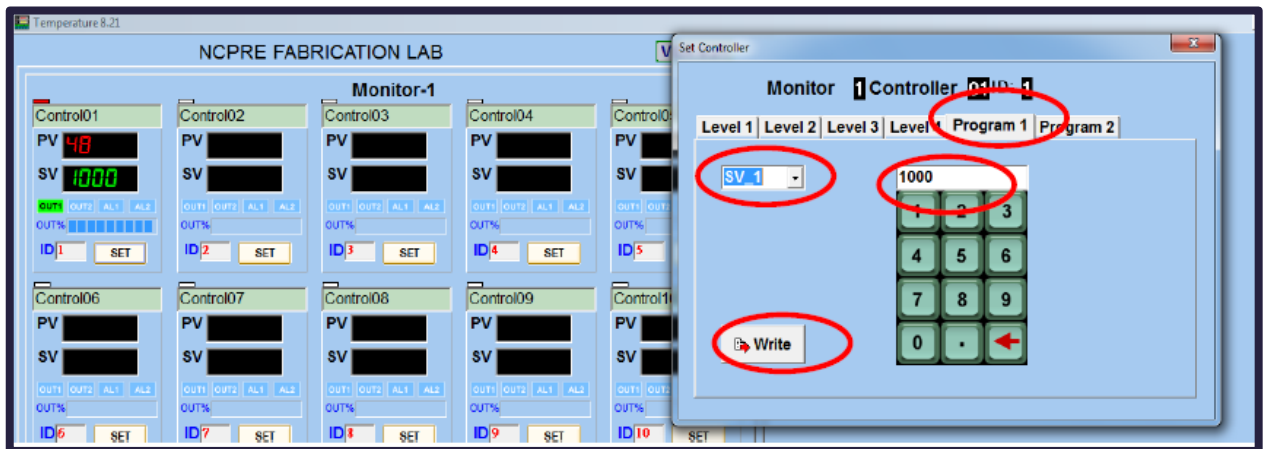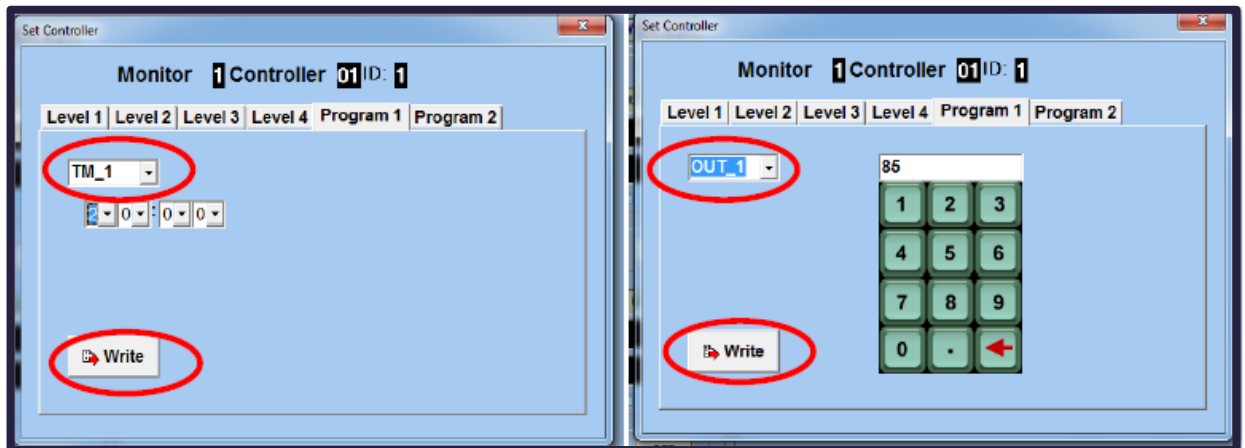

Figure. 22

Figure. 23

13. Once the recipe/program starts, it can be recorded in the text file and also can be viewed in the chart. Click on the "Chart" and then on the "Chart Property" to set the Axes (Figure. 24).
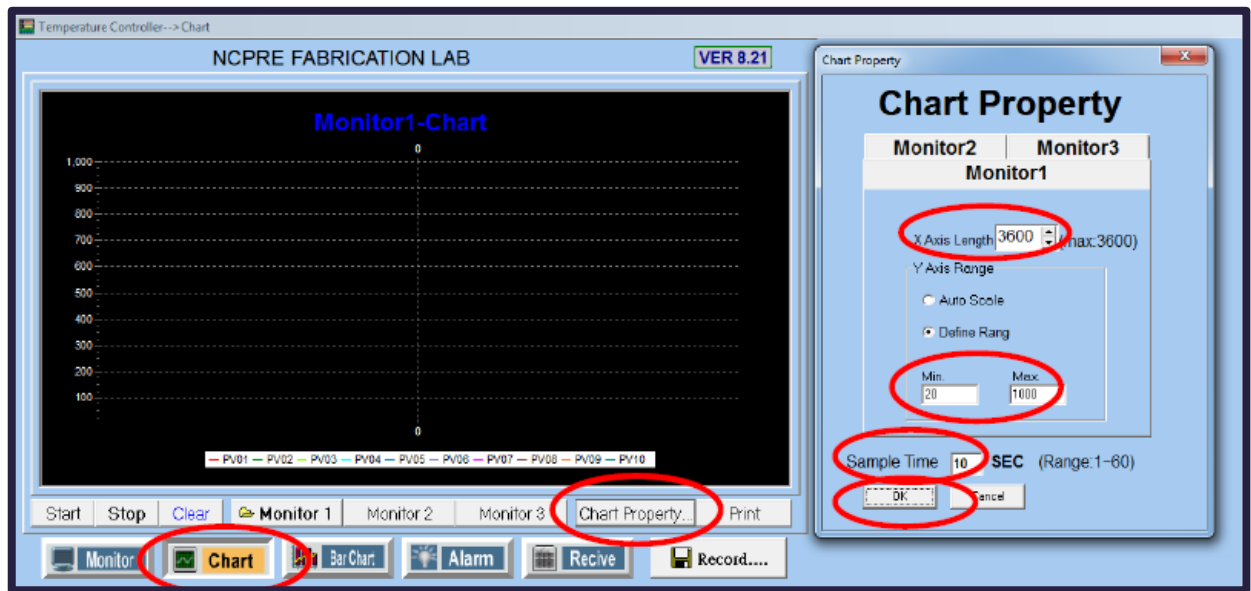
Figure. 24

14. "Chart Property" window will pop up. Enter appropriate values in X-Axis length (time in seconds), Y Axis Range (Min. and Max. temperature in °C) and the sample time in sec (time duration between the two captured readings) and then click on "OK".

15. Click on "Record" tab to save temperature data in the file. "Save Temperature Record" window will pop up, enter the Sample time, Save Cycle (file will be generated after the cycle time), File Type appropriately.

16. Enter the desired "File Path" by clicking on "Browse". Browse window will appear, choose the required destination or create new folder (Figure. 25).
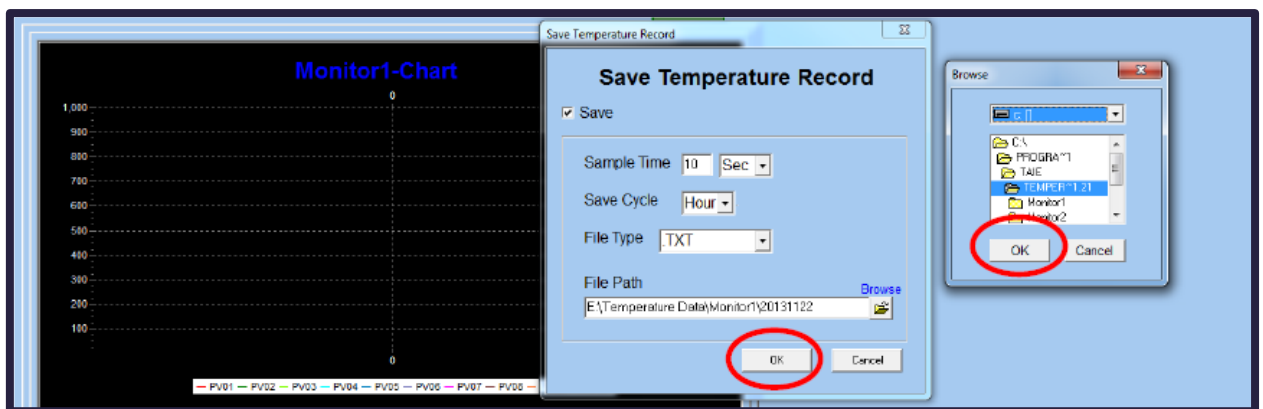

Figure. 25

17. Click on "OK" in both the windows and on "Start" in the main window of the "Chart" tab and then the recording of the temperature data will start. Time starts appearing in "Monitor 1-Chart" window along with temperature (Figure. 26).
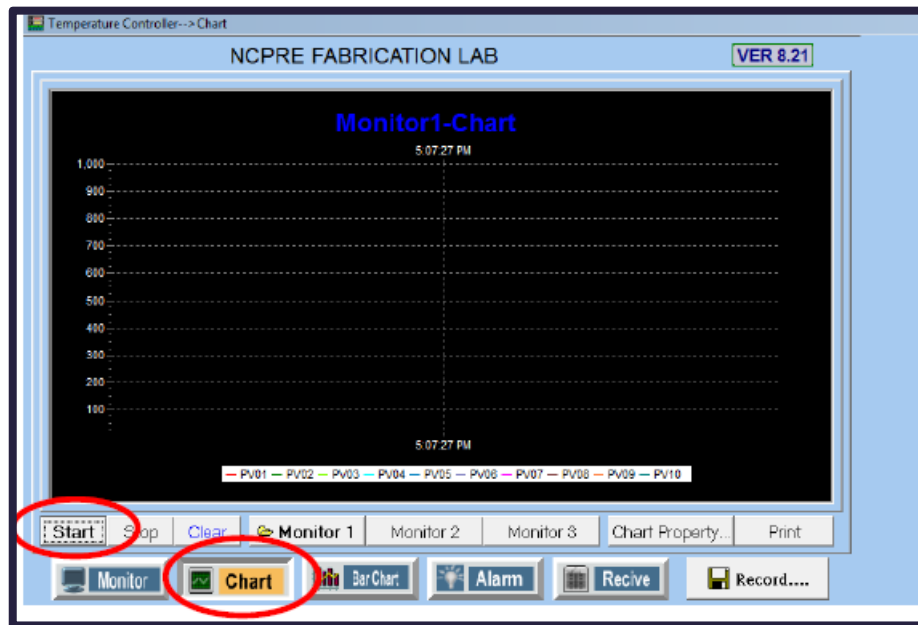

Figure. 26

18. View data anytime by browsing the files in the destination path.

19. To record the data for more than 6 hours (3600sec is the maximum limit of X Axis length), ensure all the required data recorded in destination folder, then click on the "Stop" and followed by "Clear" in the main window in the "Chart" tab. Then click on "Start" again to resume with the temperature data recording.

Section4: Temperature indicator for monitoring zone temperature

Observe the temperatures on the display of temperature indicator in Process 1 and Process 2fields. Process 1 displays the temperature sensed by thermocouple at gas outlet side and Process 2 displays the temperature sensed by thermocouple at gas inlet side (Figure. 27).

Figure.27

EQUIPMENT MAINTENANCE LOG BOOK			
SR. No.	Date	Issues faced	Measures taken

EQUIPMENT MAINTENANCE LOG BOOK			
SL. No.	Date	Issues faced	Measures taken