Process Manual

Tempress® Systems, Inc.
Process manual
M220.383.02 January 2004

Preface

This set of manuals explains how to operate and maintain a Horizontal Diffusion/LPCVD furnace.

Refer to the Touchscreen reference manual (M440.00) or the TSC-2 reference manual (M450.00) for a full description of all operating screens.

For information about maintenance, refer to the maintenance manual (M230.00).

The Tempress Horizontal Diffusion Furnaces are fully described in the reference manuals (M300.00).

Tempress documentation set

The complete Tempress documentation set includes:

- Safety manual
- Operator manual
- Reference manuals
    1. Loadstation
    2. Furnace
    3. Gas cabinet
    4. Main Power cabinet
    5. DPC (Digital Process Controller)
    6. DTC (Digital Temperature Controller)
    7. ETC (Excess Temperature Controller)
    8. Touchscreen
    9. TSC-2 (+ SECS/GEM)
- Vendor documentation
    1. Digital pressure switch
    2. Mass Flow Controllers
    3. External torch controller (if used)

User Definition

It is strongly recommended that all users first read this manual before starting any procedure. To produce an accessible manual suiting on various responsibilities, Tempress defines the following users:

Operator

The operator is handling the process from loading until unloading of the wafers. Therefore the operator needs to select a recipe, put the wafers on the boat, fill in Lot ID, Start the process and monitor the progress using the Touchscreen and/or TSC-II.

Process engineer

The process engineer is a qualified chemical engineer, who is responsible for the process recipes and their results. The process engineer writes, tests and releases new process recipes.

Service or Maintenance engineer

The maintenance engineer is a qualified electrician or mechanic, who is responsible for a proper functioning system in accordance to its designated purpose. A Tempress qualified service engineer will perform the first installation.

Notes, Cautions and Warnings

Notes, Cautions and Warnings appear throughout this manual, where extra attention is required to a particular (safety) item. Three levels can be distinguished:

NOTE

Notes alert to pay attention to items or procedures of special importance.

CAUTION

Cautions alert for a potentially hazardous situation that may result in minor or moderate injuries.
Cautions can also alert for potential equipment and/or product damage.

WARNING

Warnings alert for conditions that may result in permanent and/or lethal injuries.

Contents description

This manual is divided into the following sections and appendices:

Section 1 *Introduction*
Provides an overview of the Tempress Systems Inc. Horizontal furnace, what it is and what it can do.

Section 2 *Safety*
Describes the safety components and functions. It describes all measures that are required to provide a safe way of working.

Section 3 *Process setup and acceptance*
Describes the basis of how to setup a process recipe and how to handle alarms that are generated during the process. Finally all minimal process requirements for acceptable process results are defined in process acceptance.

Section 4 *Process description*
Contains specific process information including chemicals used, start-up parameters and a basic recipe layout.

Section 5 *Operation Instruction*
Describes all procedures that are required for the process engineer.

Revision History

This manual is revision 0 of the Process Manual and is intended to explain the required procedures. The function and screens it describes are based on the following software releases:

- TSC 2 version 6.0 (17-02-2003)
- DPC 2.I.03 (17-02-2003)
- DTC 2.F.02 (17-02-2003)
- Touchscreen 2.I.05 (17-02-2003)

For minor software and hardware changes, addendum to this manual will be available. For major changes, a new revision will be available. For price information or other questions please contact Tempress Systems Inc.

1.Introduction

1.1 General

The horizontal furnaces of Tempress Systems Inc. are developed according to the latest European directives for Machinery (98/37/EC), Low Voltage (73/23/EC) and EMC (89/336/EEC).

The Tempress Diffusion system is a modular horizontal furnace designed to process (silicon) wafers as part of the manufacturing technology of semiconductor, optical, MEMS and solar devices.

Figure 1-1 shows an example of a L-shape diffusion system with 4 process tubes shown without the partition of a cleanroom wall.

It is a right-handed system, defined according to the position of the furnace relative to an operator.

Usually the system contains more than 1 tube. Based on the number and size of tubes, the system is referred to as a 2, 3 or 4 stack.

Figure 1-1 is an example of a 4-stack system, allowing up to 4 different processes at any time. The tubes are numbered from 1 to 4, with tube number 1 at the top and tube 4 at the bottom. All tubes operate fully independently.

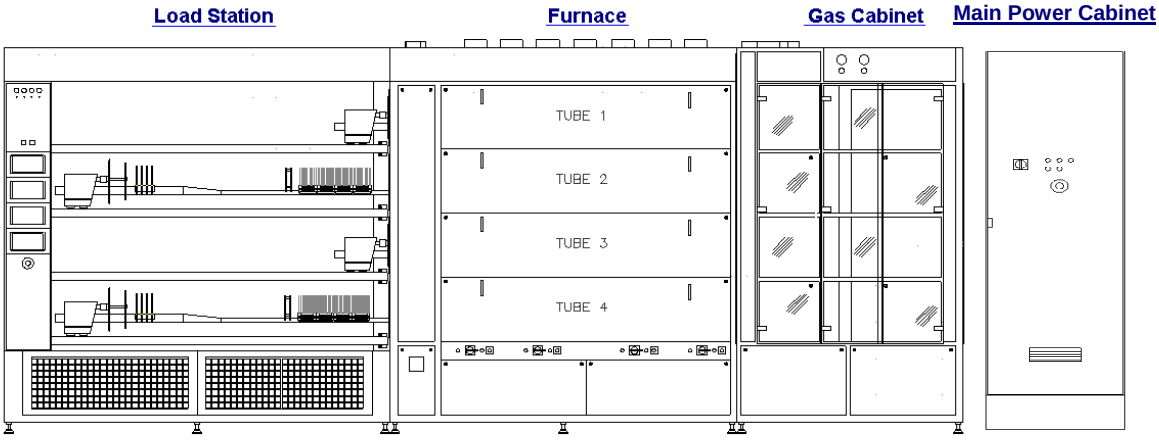


Figure 1-1 Schematic view of a right-handed 4-stack Diffusion System

1.2 Process engineer area description

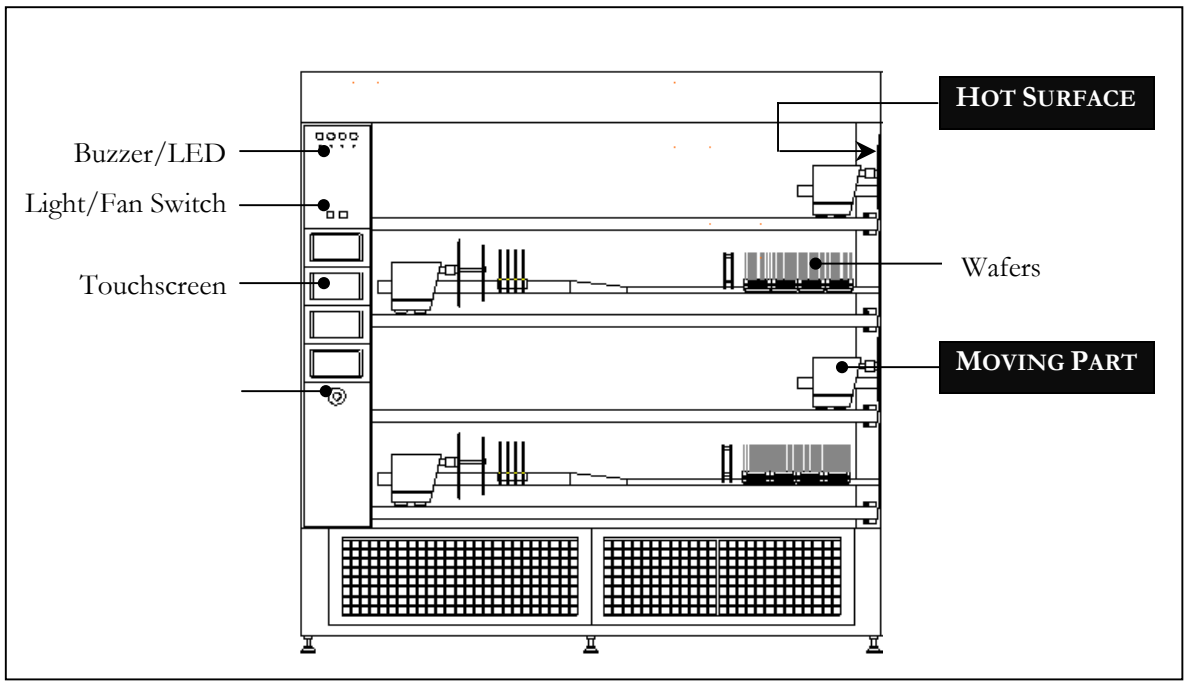


Figure 1-2 Loadstation

The process engineer area is limited to the loadstation only. Figure 1-2 shows all relevant items.

The Loadstation part of a Tempress System should be placed in the cleanroom. The Furnace and Gas cabinet can optionally be placed in the greyroom.

To load wafers, several loader types can be implemented, including the (default) inline loader, the Amtech Atmoscan® and the backmounted softlander. To prevent particles on the wafers during the loading process, a constant horizontal laminar flow is created from the loadstation into the cleanroom.

The loadstation is powered by 230V and has an illuminated On/Off switch for the fans and the lights.

The remote control cabinet in the loadstation contains TFT-Touchscreens, one for each tube. These are the user interface for communication with the Digital System Controllers (DPC, DTC and DMC).

2.Safety

This section contains a brief description of the safety features of a Tempress Horizontal Diffusion System for the process engineer.
Process engineers must have a general knowledge of the technology involved in diffusion systems. They should understand safety practices outlined in this manual. Process engineers must have additional knowledge about chemistry and chemicals used in the customer specific process applications.
The descriptions contained in this user manual are general in nature. The actual furnace may differ in minor detail from the furnace described in this manual, because of customer specific requirements or modifications. Please refer to the Tempress Safety manual (M110.00) for a complete description of available safety features.

2.1 Emergency Off (EMO)

Emergency Off (EMO) buttons are located around the system at accessible locations according to EN 60204-1 especially EN 418. Pressing an EMO button turns off all power to the system except to the fans on top of the furnace. This prevents fire hazard as a result of high heat concentration in the furnace cabinet. Also those parts that are connected to a UPS facility remain operational.

Press the EMO button when a person is in danger, when there is a fire, a water leak or any other event that could be hazardous to life.

2.2 Alarm Signals

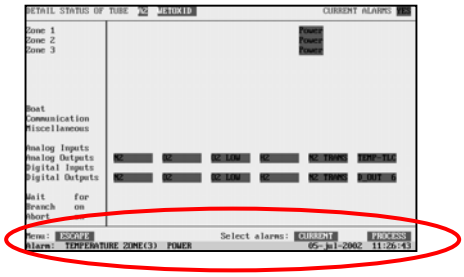
Alarms and alerts generated by tube controls are presented in several ways:

- Buzzer / LED
- Touch screen
- Light tower
- TSC-II

2.2.1 Buzzer / LED

Visible and audible alarm signals are generated by the process controller (DPC) and the temperature controller (DTC). The visible signals will be presented with a LED, located below the buzzer position as shown in Figure 1-1. Each process is represented by one LED and buzzer combination.

2.2.2 Touchscreen



The visible alarms will be presented on the touchscreen bottom line. Alarms on the Touchscreen are always in combination with an audible signal.
Touching the screen deactivates the audible signal.

2.2.3 Light tower

Alarms generated by the DPC, DTC and DMC will be made visible by three colors. Each color of the light tower represents particular circumstances.

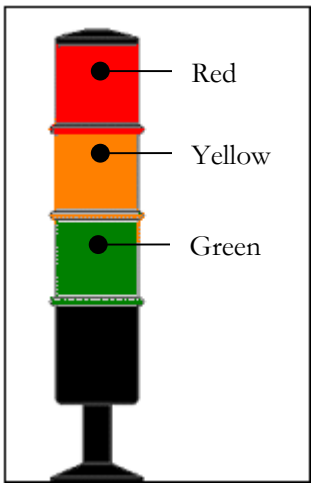
- Green represents safe, operational condition.
- Yellow represents warnings and alerts
- Red represents alarms

See section 2.3 for a full description.

2.2.4 TSC Alarm menu

Activating the alarm menu gives an overview of all active and passed alarms during the process. In case of an active alarm the "Alarm" button start flashing on and off.

2.3 Light tower signal description



Two light towers, one on top of the loadstation in the cleanroom and one on top of the furnace in the greyroom, are installed for fast anticipation on the status of the (production) process. This section describes the function of each light and its relation to the tube status.
A light tower is (default) comprised of 3 lights: from top to bottom RED, YELLOW and GREEN.

The green light can indicate 2 signals:

1) OFF
2) ON

The yellow and red light can indicate 2 signals:

1) OFF
2) BLINK

Figure 2-1 Default light tower configuration

The light tower is controlled by a tower signal PLC that receives its commands from the various controllers, among others DPC/DTC/DMC, Excess temperature controller, gas detection system alarm and the TSC Host control.

In case the EMO-switch is activated or a power failure occurs for more than 4 seconds, the power supply to the furnace will stop and also the light tower will be off.

The tower signal PLC is programmed by Tempress Systems Inc. and is not adjustable by customers.

Note: Per tube there are 2 PLC-Inputs available for customer specific applications, like H_2 detection.

For a functional description of the light tower signals see table 1:

Signal		*Mode*	*Description*
Green	*ON*	Operational	No warnings or messages
	OFF	Not operational	
Yellow	*BLINKING*	N_2 pressure-switch	No N_2 gas flow detected
		Air pressure switch	No Air flow detected
		Torch temp (750)	The torch temperature has to exceed 750°C
		Torch Flame failure	There is no flame, the H_2 valve will be closed
		Torch H_2/O_2 ratio	The H_2/O_2 ratio exceeds the safety value
		Torch shell	The skin temperature of the torch is too high
		Temperature sensor powerpack	Temperature powerpack is too high
		Bubbler temp	Bubbler temp is too high
		Bubbler level	Fluid level is too low
		O_2- low	O_2 flow is too low
		Exhaust (Low/High)	Exhaust flow out of limits
		Limit alarm (only if programmed in the process recipe)	Actual value is out of limits
		Wait for operator (only if programmed in the process recipe)	Operator action is required to continue
		Process is finished	
		Boat manual	Servo driver is in manual mode
		Maintenance mode	Maintenance mode is activated
	OFF	No alarm and/or alert	
Red	*BLINKING*	Excess temperature controller has been activated	Tube is overheated
	(Optional)	Leakage detection	A gas or water leak has been detected
	OFF	No alarm and/or alert	No actual dangerous or hazardous situation

Table 1 Light tower signal description

2.4 Toxic Material

The process engineer, responsible for all process related activities, has to inform the operator about the hazards of the process. See section 4 Process description or safety manual for a complete description of all details.

2.5 Safety measures

Safety measures are indicated in the appropriate procedures.

3. Process setup and acceptance

3.1 Process recipe setup procedure

3.1.1 Introduction

The Tempress Systems, Inc. process controller, DPC, has some unique features that enable the user to program any kind of process recipe in any way possible.

A process recipe is made of steps, and within one step several commands can be programmed.
The DPC is designed to execute commands in one particular step simultaneously. The sequence of commands is therefor not important (except for "Branch on" and "Abort on " alarm commands).
It is recommended, though, to use a consequent sequence to improve readability for the user.

3.1.2 6 steps to a process recipe

3.1.2.1 Step 1: Determine the required process temperature

The first step is to define the required process temperatures. These include the Load/Unload temperature and the Process temperature(s).
Settings that need to be determined are the setpoint, the slope, the Hi and Low limits and the type of temperature control (spike or paddle).

3.1.2.2 Step 2: Program the temperatures

The temperatures must be programmed in the DTC memory either using a touchscreen or using the TSC-2 computer(s).

Touchscreen

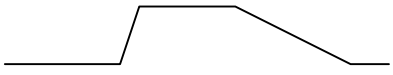
2. certifications menu
    2. temperature menu
        2. normal temperature table

TSC-2

Recipes menu
    Normal temperature menu

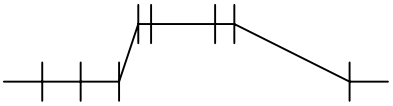
3.1.2.3 Step 3: Make temperature schematic

From the selected temperatures a schematic can be made that typically has the following shape:



3.1.2.4 Step 4: Make detailed schematic

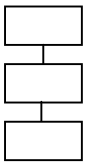
The schematic can be split into different sections. Each section is going to represent one process step. The detailed schematic typically has the following shape:



3.1.2.5 Step 5: Convert schematic to block diagram

The detailed schematic represents the individual steps that will be used in the process recipe. Each step can also be presented in a block diagram with the following shape:

Step 0
Step 1
Step 2



3.1.2.6 Step 6: Fill in each block

Each block can now be programmed. It must be recognized that Step 0 (the first step) has some unique properties that are not found in any other step:

1.'standby' step

2.selection of other recipe only here

3.must be started manually (no automatic continuation)

4.is the target for an Abort command

5.no time command available

6.no branch command available

7.no abort command available

3.1.3 Recommended command sequence

As stated previously, the DPC will execute all commands simultaneously, except for the "Branch on" and "Abort on" instructions.

To improve readability the following sequence is recommended:

1.message

2.time

3.temperature

4.boat

5.analog out (MFCs)
6.digital out (valves)
7.alarm limits
8.alarm on digital inputs
9.branch on
10.abort on
11.wait for
12.abort recipe

As step 0 has been designed as the *Standby* step all commands in step 0 must be programmed to create a **safe** condition.
This involves ***closing*** all ***gas*** flows and ***valves***, except for a small N_2 purge flow, setting a ***low temperature*** and programming the ***boat in***.

3.1.4 Modifying the default Tempress recipe

The default Tempress process recipe is designed with Step 0 as Standby for all atmospheric processes. Obviously customers are free to alter the default recipe to fit their particular needs. For example, a 24 hr production environment typically uses step 0 as Load/unload step, not as a standby condition, because the machine is actually never in standby.

The transition is easy:

1) Modify the step 0 settings such that it contains:
    1) Message Load/Unload with Sonalert
    2) Boat out
    3) Gas N_2 flow high
2) Remove step 1 Boat Out
3) Remove Step 2 Load Wafers

3.2 Process recipe startup and fine-tuning

3.2.1 Introduction

Process fine-tuning is required to reach the guaranteed process specifications and improve a current process. Many different methods lead to the same process result and any approach is valid as long as it satisfies the specifications. A few tips are described here that can be used as a guideline for process fine-tuning.

3.2.2 Prerequisites

The following items are required before process fine-tuning can be started.
- a fully functional system (leaktested, profiled)
- a process recipe
- appropriate temperature recipes

3.2.3 Initial settings

The initial settings can be copied from an existing recipe if that is available. Alternatively, the example recipes given later in this manual can be used. These recipes are based on a default system, therefore the example recipes need to be adapted to fit the customer specific machine.
Two different process conditions occur. The atmospheric processes and the LPCVD processes.

3.2.3.1 Atmospheric process

- calculate the required gasflow to obtain a refresh interval of 3 minutes for process conditions and 5 minutes for standby conditions. Take into account the tube volume and the gas expansion at high temperatures. For example flows see **Table 3-1**, and keep in mind that at 1000°C a gas expands 4.7x (and 3.6x at 700°C)
- use a flat temperature

The flat temperature is sufficient for most atmospheric processes anyway (especially (dry and wet) oxidations). A ramped temperature can be used later to counter the expected depletion effects that will occur in the $POCl_3$ deposition and diffusion process.
The reason to start of with a flat temperature is to make sure the machine is performing as expected (and therefore *should* give a depletion effect).

Table 3-1: Initial gas flows for atmospheric processes

	Tube length [dm]	Tube ID [dm]	Tube volume [liter]	MFC setting [slm] for 700°C 5 min	MFC setting [slm] for 1000°C 3 min
TS430x	13	1.6	26	1.5	1.9
TS460x	18	1.6	36	2.0	2.6
TS480x	20	1.6	40	2.3	2.9
TS4100x	25	1.6	50	2.8	3.6
TS630x	13	2.12	46	2.6	3.3
TS660x	18	2.12	64	3.6	4.5
TS680x	20	2.12	71	4.0	5.0
TS6100x	25	2.12	88	5.0	6.3
TS840x	13	2.7	74	4.2	5.3

TS860x	18	2.7	103	5.8	7.4
TS880x	20	2.7	115	6.4	8.2
TS8110x	25	2.7	143	8.0	10.2
TS1280x	20	4	251	14.1	18.0

3.2.3.2 LPCVD process

- due to the low pressure refresh intervals are not an issue. Use the initial gasflows and pressure settings recommended in the appropriate process description.
- use a flat temperature

Most LPCVD processes exhibit the depletion effect. *This shows as a reduction in the deposition rate at the pump side due to consumption of process gases.*

The reason to start of with a flat temperature is to make sure the machine is performing as expected (and therefore *should* give a depletion effect). A ramped temperature can be used after that to counter the expected depletion effects.

3.2.4 Further fine-tuning

Use the trouble shooting tables at each process desciption to fine-tune the process result, meet the specifications and/or improve the process.

3.3 Alarm handling with Branch and Abort commands

3.3.1 Introduction

The Tempress Systems, Inc. process controller, DPC, has some special features that allow alarm conditions to be handled automatically.

A process recipe is made of steps, and within one step several commands can be programmed.
Alarm conditions can be set, and when these conditions are compromised a very specific alarm message is generated. It is up to the process engineer to decide whether or not action is required on the specific alarm message.
Three options are available to the process engineer:
1) do nothing, the process recipe continues as programmed
2) branch to another step within the process recipe
3) abort the process recipe, which brings the tube back to step 0 of that process recipe.

The Branch on Alarm command is issued after 3 seconds of consecutive alarm condition and jumps to the designated step within the same process recipe.
The Abort on Alarm command is issued after 30 seconds of consecutive alarm condition and aborts the process recipe, either directly into step 0 of that process recipe, or via an assigned Abort Recipe.

3.3.2 Do nothing with an alarms

Some types of alarm conditions are not important enough to stop a running process. These alarms still need to be fixed, though, and can be traced in long term history using the Tempress Systems, Inc. host computer system TSC-2 and short term history using the touchscreen alarm status screen.
An example of this type of alarm is a temperature limit alarm during ramping, or a bubbler level alarm while the bubbler is not used in this particular process recipe.

3.3.3 Handling alarms with the Branch command

Any kind of alarm can be handled by the Branch command. It is often used to finish a process recipe trying to save valuable process wafers.

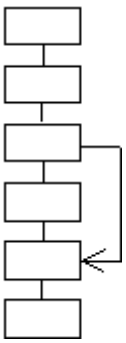


Figure 3-1: Branch command jumps to a specified step number

As the DPC has been designed to remember the last settings until they are changed, it is vital to verify the settings in the step one branches to.
For example, in step 3 of the schematic above a Branch on Alarm y has been programmed. If this Alarm y occurs for more than 3 consecutive seconds then the DPC will branch to step 5. While branching it bypasses any changes programmed in step 4.

3.3.4 Handling alarms with the Abort command

An Abort command can be issued in two ways:
1) programmed in a process recipe *in a specific step*
2) manually by an operator *at any time*

If any Abort command is issued the DPC will stop the running process recipe. The DPC will return to step 0 of the process recipe, either directly or via an Abort Recipe. An Abort recipe also contains steps and is used to bring the tube in a safe condition.

Note: An Abort recipe must be programmed such that a tube is automatically brought to a SAFE situation.

As step 0 of the process recipe is the target of an Abort command it should be programmed to contain a safe condition. In some applications however, such as in a 24hr production environment, this is likely not the case.
Therefore, the use of an Abort recipe must be applied as soon as in the process recipe potentially dangerous situations occur when that process recipe is aborted and brought back to step 0.

3.3.4.1 Abort command in a specific step

The programmed Abort command can be used similarly to the Branch on Alarm command. In fact, an Abort command could be interpreted as a Branch on Alarm to Step 0 command.

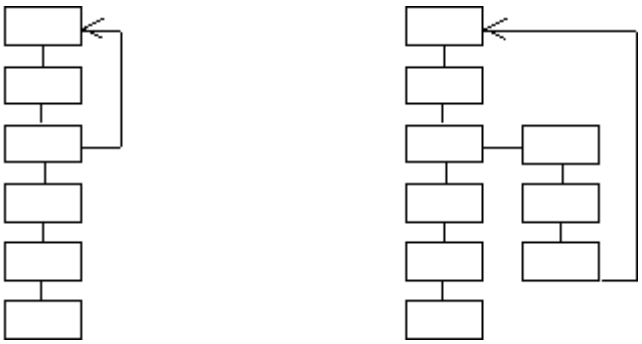


Figure 3-2: Abort command initiated from a specific alarm condition without (left) and with (rightt) the use of an Abort recipe

3.3.4.2 Manual abort command at any time

A manual Abort command can be issued *at any time* by an operator and should be used only if a potentially dangerous or damaging situation is likely to occur that can only be prevented by aborting the running process quickly.
Also, the manual Abort command is used to stop a process recipe with an endless loop.

Because the manual Abort command can be issued at any time, the use of an Abort recipe must be applied as soon as in the process recipe potentially dangerous situations occur when that process recipe is aborted and brought back to step 0.

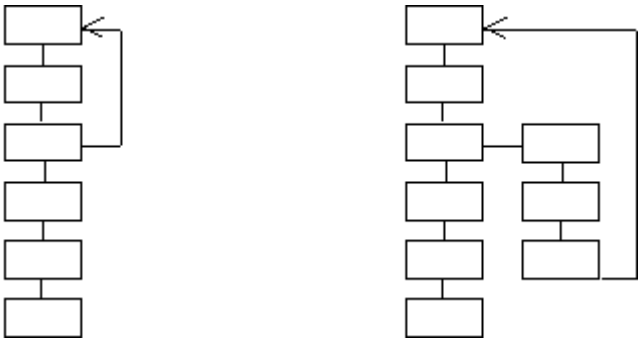


Figure 3-3: An operator initiated Abort command without (left) and with (right) the use of an Abort recipe

3.3.5 Recipe example: LPCVD Nitride abort recipe

1 00 EVACUATE
2 Message ABORTED !!! [16]. Sonalert alarm No
3 Time: 000:15:00 (hr:min:sec) Variable Command: No
4 Normal recipe 00 Zone1 800.0 °C Slope 10.00 °C/min Zone2 800.0 °C Slope 10.00 °C/min Zone3 800.0 °C Slope 10.00 °C/min Zone4 800.0 °C Slope 10.00 °C/min Zone5 800.0 °C Slope 10.00 °C/min , profile table A
5 Boat to 2000.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
6 Gas N2 [1] at 0.00 [SLM] Variable Command: No
7 Gas DCS 1 [2] at 0.0 [SCCM] Variable Command: No
8 Gas DCS 2 [3] at 0.0 [SCCM] Variable Command: No
9 Gas NH3 [4] at 0 [SCCM] Variable Command: No
10 Gas PRESSURE [8] at 0 [MTOR] Variable Command: No
11 Digital out „„„„„WATERVLV[8] = ON Variable Command: No
12 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
13 Alarm Limit Setting for All Analog Output Channel at 0 %
14 Alarm on digital in PRESS N2[1] = ON,PRESSAIR[2] = ON,DOORCLSD[3] = ON,VACFAIL[4] = ON,WATRCOOL[5] = ON,„TEMP SCR[7] = ON,EXCESS[8] = ON
15 Alarm on digital in FANCONTR[9] = ON,„„OPERATE[12] = ON,WARNING[13] = ON,FAILURE[14] = ON,„
16 01 PURGE

17 Message ABORTED !!! [16]. Sonalert alarm No
18 Time: 000:15:00 (hr:min:sec) Variable Command: No
19 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
20 02 EVACUATE
21 Message ABORTED !!! [16]. Sonalert alarm No
22 Time: 000:05:00 (hr:min:sec) Variable Command: No
23 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
24 03 READY
25 Message STANDBY [1]. Sonalert alarm Yes
26 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
27 Wait for operator
28 04 BACKFILL 1
29 Message BACKFILL [14]. Sonalert alarm No
30 Time: 000:01:00 (hr:min:sec) Variable Command: No
31 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = OFF Variable Command: No
32 05 BACKFILL 2
33 Message BACKFILL [14]. Sonalert alarm No
34 Time: 000:10:00 (hr:min:sec) Variable Command: No
35 Gas N2 [1] at 10.00 [SLM] Variable Command: No
36 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
37 END

3.4 Process acceptance conditions

The process specifications of Amtech/Tempress Systems, Inc. can only be guaranteed if the conditions are satisfied as described in the following sections.

3.4.1 Introduction

The Tempress process is characterised with either film thickness, sheet resistivity, added particle count, refractive index and/or dopant concentration, where applicable.

3.4.1.1 Uniformity definitions

Standard edge exclusion: 5 to 9 mm depending on wafer size and process unless otherwise stated in the process specifications.

Table 3-2: Default edge exclusion

Wafer diameter [mm]	Edge exclusion [mm]
76.2	4
100	5
125	5
150	6
200	9
300	9

Minimum, maximum and average values are measured over 5 or 9 points as shown in the picture below. Default amount of measurement points are indicated in Table 3-3.

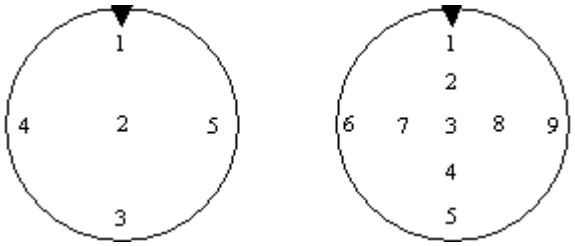


Figure 3-4: 5 or 9 measurement point indicator

Table 3-3: Default amount of measurement points

Wafer diameter [mm]	Measurement points [nr]
76.2	5
100	5
125	5
150	5
200	9
300	9

3.4.1.2 Formula's

- The general formula that is used for the uniformity calculation:

$$\text{Uniformity [+-\%]} = \frac{\text{maximum value} - \text{minimum value}}{2 * \text{average value}}$$

- The point-to-point (cross wafer) uniformity is presented as an average wafer value +/- the uniformity in %. It is based on 5 or 9 measurement points as indicated in section **Error! Reference source not found.**.

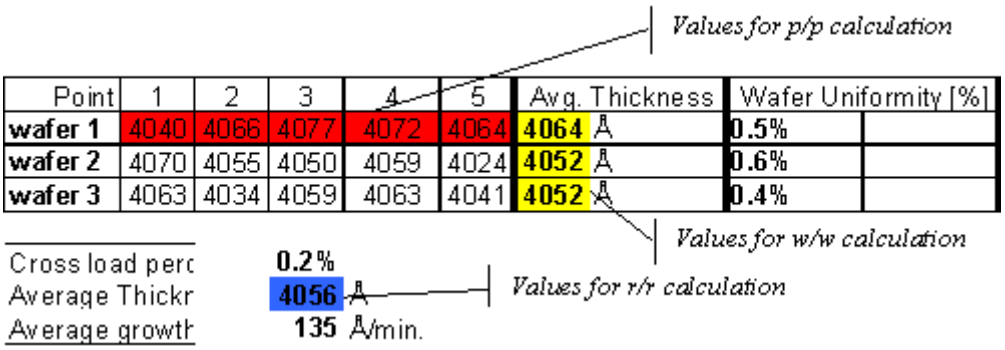
$$\text{P/P Uniformity [+-\%]} = \frac{\text{maximum (point) value} - \text{minimum (point) value}}{2 * \text{average (5 or 9 point) value}}$$

- The wafer-to-wafer (cross load) uniformity is presented as an average load value +/- the uniformity in %. It is based on the average wafer values as determined in the point-to-point uniformity calculation.

$$\text{W/W Uniformity [+-\%]} = \frac{\text{maximum (wafer average) value} - \text{minimum (wafer average) value}}{2 * \text{average (all wafer average) value}}$$

- The run-to-run uniformity is presented as an average run value +/- the uniformity in %. It is based on the average load values as determined in the wafer-to-wafer calculation.

$$\text{R/R Uniformity [+-\%]} = \frac{\text{maximum (load average) value} - \text{minimum (load average) value}}{2 * \text{average (run average) value}}$$



Example:

Figure 3-5 : Example of process result calculation

3.4.1.3 Equipment

- Standard Process recipes supplied by Amtech/Tempress Systems will be used for process acceptance runs.

- All measurement equipment should be supplied by the customer and be available to the Amtech/Tempress Systems Engineer.

- Thickness and refractive index measurements should be done with a Plasmos automated ellipsometer or comparable equipment.

- Sheet resistivity should be measured with an automated 4-point probe or comparable machine.

- Dopant concentration measurement should be supplied by the customer. Dopant variation will be characterised in absolute percentages and measured with SIMS or a comparable technique.

- Particle measurements should be done with a Tencor Surfscan 6420 or comparable equipment.

3.4.2 Default process test conditions

3.4.2.1 Test material requirements

Bare Si wafers are prime wafers, single or double side mirror polished and according to SEMI standard M1-0298.
Standard film thickness, sheet resistivity and/or dopant concentration as indicated in this section apply unless otherwise stated in the customer specific process specifications.

3.4.2.2 Tempress Systems, Inc. Atmospheric processes

Atm-01 Anneal

Test: temperature overshoot and stability

Atm-02 Metalalloy anneal

Test: temperature overshoot and stability

Atm-03 Dry oxidation

test thickness: 500Å
test temperature: 1000°C
time indication: 60 min
base: bare Si wafer
testmethod: ellipsometer

Atm-04 Dry oxidation + liquid cleaning

test thickness: 500Å
test temperature: 1000°C
time indication: 60 min
base: bare Si wafer
testmethod: ellipsometer

Atm-04s Thin gate oxidation +Atmoscan®

test thickness: 500Å
test temperature: 1000°C
time indication: 60 min
base: bare Si wafer
testmethod: ellipsometer

Atm-05 Pyrogenic oxidation

Equipment: Tempress Systems, Inc. external torch
test thickness: 2000Å
test temperature: 1000°C
time indication: 30 min

base: bare Si wafer
testmethod: ellipsometer

Atm-06 Pyrogenic oxidation + liquid cleaning

Equipment: Tempress Systems, Inc. external torch
test thickness: 2000Å
test temperature: 1000°C
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer

Atm-07 reserved

Atm-08 $POCl_3$ diffusion

Test sheet resistivity: 8 or 30 ohm/square
test temperature: 900°C deposition - 1000 drive-in °C
time indication: 30 min – 30 min
base: bare Si wafer
testmethod: four-point probe

Atm-09 reserved

Atm-10 reserved

Atm-11 reserved

Atm-12 Wet oxidation H_2O bubbler

test thickness: 2000Å
test temperature: 1000°C
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer

Atm-13 Wet oxidation H_2O injection

Equipment: Tempress Systems, Inc. water injection
test thickness: 2000Å
test temperature: 1000°C
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer

3.4.2.3 Tempress Systems, Inc. LPCVD processes

LP-01 Ramped poly

test thickness: 3000Å
test temperature: 625°C (ramped)
time indication: 30 min
base: 1000Å dryoxide on Si wafer
testmethod: ellipsometer

LP-02 Flat poly

test thickness: 3000Å
test temperature: 610°C
time indication: 30 min
base: 1000Å dryoxide on Si wafer
testmethod: ellipsometer

LP-03 Sipos

test thickness: 2000Å
test temperature: 670°C (ramped)
time indication: 30 min
base: 1000Å dryoxide on Si wafer
testmethod: incremental thickness/mass method or ellipsometer

LP-04 Nitride

test thickness: 900Å (blue)
test temperature: 800°C (ramped)
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer

LP-04s Low stress nitride

test thickness: 3000Å
test temperature: 850°C
time indication: 30 min
test refractive index: 2.15
test stress: <= 200MPa tensile
base: bare Si wafer
testmethod: ellipsometer, curvature

LP-05 Oxynitride

test thickness: 900Å
test temperature: 800°C
time indication: 30 min
test refractive index: 1.8
base: bare Si wafer
testmethod: ellipsometer

LP-06 undoped TEOS

test thickness: 2000Å
test temperature: 725°C
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer

LP-07 undoped LTO

test thickness: 1500 Å
test temperature: 425°C
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer

LP-08 HTO

test thickness: 900 Å
test temperature: 900°C
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer

LP-09 Phosphorous doped poly

test thickness: 5000Å
test temperature: 600°C
time indication: 400 min
test sheet resistivity: 20 ohm/square (after 30 min 900°C N_2 anneal)
base: 1000Å dryoxide on Si wafer
testmethod: ellipsometer (thickness), four-point probe (sheet resistivity)

LP-10 Boron doped poly

test thickness: 5000Å
test temperature: 600°C
time indication: 400 min
test sheet resistivity: 20 ohm/square (after 30 min 900°C N_2 anneal)
base: 1000Å dryoxide on Si wafer
testmethod: ellipsometer (thickness), four-point probe (sheet resistivity)

LP-11 reserved

LP-12 reserved

LP-13 reserved

0

LP-15 BPSG TEOS

test thickness: 3000 Å
dopant concentration: 4%B, 4%P
test temperature: 680°C
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer (thickness), SIMS (dopant)

LP-16 PSG LTO

test thickness: 2000 Å
dopant concentration: 8%P
test temperature: 425°C
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer (thickness), SIMS (dopant)

LP-17 reserved

LP-18 BPSG LTO

test thickness: 2000 Å
dopant concentration: 4%B, 4%P
test temperature: 425°C
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer (thickness), SIMS (dopant)

LP-19 Thantalum oxide

test thickness: 600 Å
test temperature: 400°C
time indication: 30 min
base: bare Si wafer
testmethod: ellipsometer

LP-20 reserved

4.Process description

A variety of guaranteed processes are available on the Tempress Diffusion systems, including:

Atmospheric

- Anneal
- Dry Oxidation (with or without TransLC® cleaning)
- Wet Oxidation (with or without TransLC® cleaning)
- $POCl_3$

Low pressure

- Ramped Poly
- Flat Poly
- Nitride
- TEOS
- LTO
- Ta_2O_5

Because of the flexibility of the Tempress Systems Inc. systems variations on these processes are available as well and will be manufactured on customer request.

4.1 Nitride from NH_3 and SiH_2Cl_2

4.1.1 Basic configuration

NH_3, SiH_2Cl_2 (DCS)
Temperature ramp at 700-800°C

4.1.2 Description

4.1.2.1 Purpose

Nitride is used as an insulating and masking layer in electrical applications, and as an anti-reflecting coating in optical applications.

4.1.2.2 Chemicals

SiH_2Cl_2, also known as DCS (DiChloroSilane), is a liquid at room temperature with a vapor pressure of 16 psi. Due to this relatively low vapor pressure it easily condensates at cold spots and care should be taken to prevent these.
The residue of the reaction of DCS and NH_3 is NH_4Cl.
Some properties of NH_4Cl:
Sublimation at 320°C @ 1 atm.
Sublimation at 120°C @ 100 mtor. See also its vapor pressure curve in the appendix.
Two different forms are likely to occur:
A white powdery form and a glassy solid form. The glassy form is what occurs as the gasses cool down abruptly on a cold surface. This is the form that is wanted on the coldtrap. The white form occurs from condensation in the gas phase, and will not be trapped by the coldtrap. Instead, it will be found at the inlet filter of the dry pump and in the exhaust of the same pump, or in the oil of a wet pump.

4.1.2.3 Process

The chemical reaction is as follows assuming a complete reaction:

$$\mathbf{3SiH_2Cl_2 + 7NH_3 \rightarrow Si_3N_4 + 6H_2 + 3HCl + 3NH_4Cl}$$

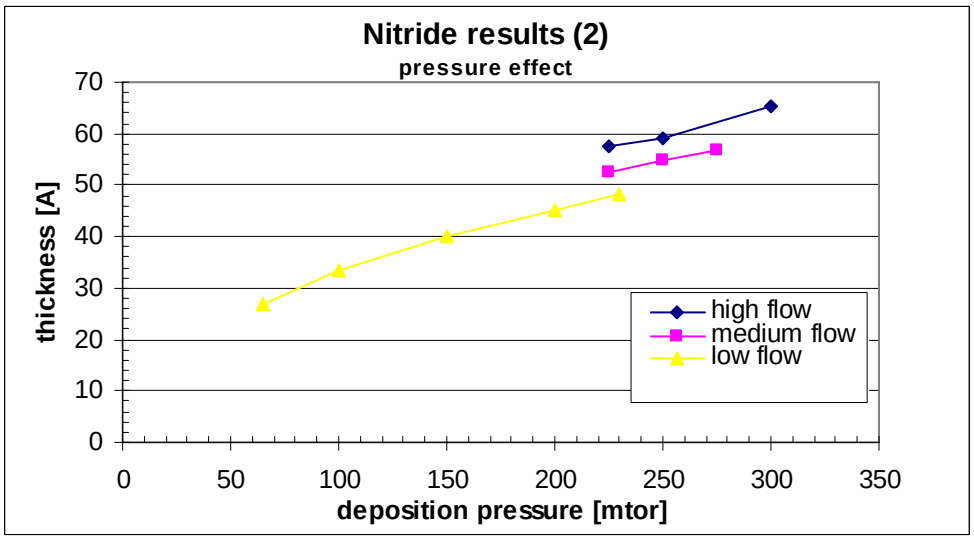
The thickness uniformity decreases along the load due to depletion of DCS, much like depletion of SiH_4 in the poly-Si process.

A temperature ramp as high as of + and – 30°C around the center temperature is sufficient to overcome this problem. Cross-wafer uniformity is usually very good, since the deposition process is limited by the surface reaction part. A decreasing process pressure does improve the uniformity, mainly the cross load. If relatively small wafers are used compared to the tube diameter an increased gas flow improves cross-wafer and cross-load uniformity dramatically.

4.1.2.4 Typicalities

Due to the low vapor pressure condensation may occur at any cold spot in the supply line. Condensation leads to droplets formation, which cause MFC blockage. Heat tracing the supply line strongly depends on the customer situation. A long distance between the bottle cabinet and tube necessitates heating. This includes the bottle and lines supplied by the customer, and the lines in the gas cabinet up to the MFC.
On the other hand, a small distance may not require heating and simple insulation may be sufficient. Therefore, insulation and heating of the supply lines needs to be addressed at each location. If it is a necessity apply an increased temperature from bottle to tube.
Due to the lower pressure downstream the MFC heating is not required from the MFC to the tube and insulation is sufficient.
As DCS reacts with NH_3 the residual product is NH_4Cl. That must be trapped using a coldtrap. These gasses should be cooled down with a shock, not with a gradual decrease.
A cooled flange is required to extent O-ring lifetime, due to the high temperature of 770-800-830°C. Especially at unloading conditions, the door O-ring is likely to burn. Also, the balljoint O-ring receives a lot of heat, especially at pumping down conditions.
However, a too cold flange will cause NH_4Cl condensation, which shows as a white powder deposit on the flange.
To improve cross-wafer uniformity in the first few wafers it is necessary to apply a set of dummy wafers at the gas inlet side of the load. An extra boat might be necessary.

4.1.3 Process result indication



4.1.4 Startup parameters for processing

The optical properties of a new and/or cleaned quartz tube change most dramatically after the first deposition of foreign (=different refractive index) material. For accurate temperature control a new and/or cleaned tube needs therefore to be coated before any (automatic) profiling is performed. Use the default process settings for 1 hour to obtain a reasonable coating.

Type	Wafer Size [mm]	Process Time [min]	Pressure [mtor]	Thickness [Å]	Temp. [°C]	SiH_2Cl_2 [sccm]	NH_3 [sccm]

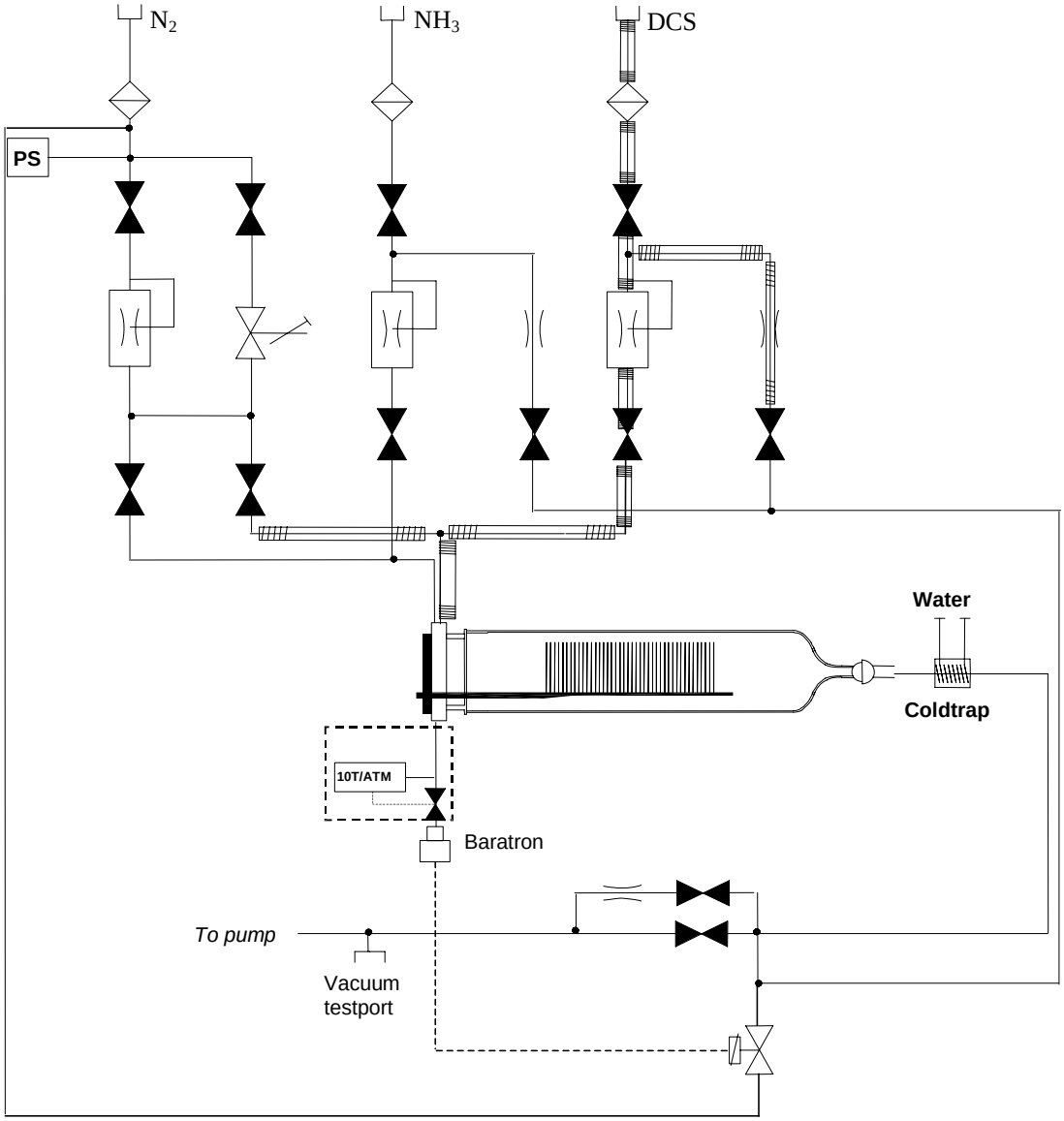
TS630x	100 150	30	250	1000	800	20	60
TS660x	100 150	30	250	1000	800	30	90
TS680x	100 150	30	250	1000	800	40	120
TS6100x	100 150	30	250	1000	800	50	150
TS840x	150 200	30	250	1000	800	50	150
TS860x	150 200	30	250	1000	800	60	180
TS8100x	150 200	30	250	1000	800	100	300
TS1280x	200 300	30	200	1000	800	150	450

4.1.5 Recommended cleaning interval

Cleaning interval for the several components after cumulative deposition in microns on the wafers.

	Tube	Cassettes / baffles	SiC paddle	Trap (upstream tubing)	Oil and filter change
Nitride	4	2	4	2	10

4.1.6 Gas schematic example: LPCVD siliconnitride



4.1.7 Recipe example: LPCVD siliconnitride from SiH_2Cl_2 and NH_3

1 00 START RECIPE
2 Message LOAD/UNLOAD [4]. Sonalert alarm No
3 Normal recipe 00 Zone1 800.0 °C Slope 10.00 °C/min Zone2 800.0 °C Slope 10.00 °C/min Zone3 800.0 °C Slope 10.00 °C/min , profile table A
4 Boat to 2000.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
5 Gas N2 [1] at 0.00 [SLM] Variable Command: No
6 Gas DCS 1 [2] at 0.0 [SCCM] Variable Command: No
7 Gas DCS 2 [3] at 0.0 [SCCM] Variable Command: No
8 Gas NH3 [4] at 0 [SCCM] Variable Command: No
9 Gas PRESSURE [8] at 0 [MTOR] Variable Command: No
10 Digital out „„„„„WATERVLV[8] = ON Variable Command: No
11 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = OFF,PROCESS[11] = OFF,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
12 Alarm Limit Setting for All Analog Output Channel at 0 %
13 Alarm on digital in PRESS N2[1] = ON,PRESSAIR[2] = ON,doorclsd[3] = OFF,VACFAIL[4] = OFF,WATRCOOL[5] = OFF„TEMP SCR[7] = ON,EXCESS[8] = ON
14 Alarm on digital in FANCONTR[9] = ON„„OPERATE[12] = ON,WARNING[13] = ON,FAILURE[14] = ON„
15 01 BOAT OUT
16 Message BOAT OUT [3]. Sonalert alarm No
17 Time: 000:10:00 (hr:min:sec) Variable Command: No
18 Boat to 10.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
19 Gas N2 [1] at 10.00 [SLM] Variable Command: No
20 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = OFF,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
21 Wait for boat to reach setpoint
22 02 LOAD WAFERS
23 Message LOADWAFERS [5]. Sonalert alarm Yes
24 Wait for operator
25 03 BOAT IN
26 Message BOAT IN [2]. Sonalert alarm No
27 Time: 000:10:00 (hr:min:sec) Variable Command: No
28 Boat to 2000.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
29 Wait for boat to reach setpoint
30 Wait on digital in PRESS N2[1] = OFF,PRESSAIR[2] = OFF,doorclsd[3] = ON,VACFAIL[4] = OFF,WATRCOOL[5] = OFF„TEMP SCR[7] = OFF,EXCESS[8] = OFF
31 04 EVAC 1
32 Message EVACUATE 1 [8]. Sonalert alarm No
33 Time: 000:01:00 (hr:min:sec) Variable Command: No
34 Gas N2 [1] at 0.00 [SLM] Variable Command: No
35 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = OFF,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = OFF Variable Command: No
36 05 EVAC 2

Message EVACUATE 2 [9]. Sonalert alarm No
Time: 000:05:00 (hr:min:sec) Variable Command: No
Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = OFF,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
Wait on digital in PRESS N2[1] = OFF,PRESSAIR[2] = OFF,doorclsd[3] = OFF,VACFAIL[4] = ON,WATRCOOL[5] = OFF,„TEMP SCR[7] = OFF,EXCESS[8] = OFF
Branch on wait alarm to step BACKFILL 1. Sonalert alarm Yes
06 EVAC 3
Message EVACUATE 3 [10]. Sonalert alarm No
Time: 000:05:00 (hr:min:sec) Variable Command: No
Digital out „„„„„WATERVLV[8] = OFF Variable Command: No
Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
Abort recipe 01
07 PURGE
Message PURGE [12]. Sonalert alarm No
Time: 000:05:00 (hr:min:sec) Variable Command: No
Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
Alarm limit setting for Gas PRESSURE [8] at 0 % (± 0 MTOR) Variable Command: No
08 EVACUATE
Message EVACUATE 3 [10]. Sonalert alarm No
Time: 000:05:00 (hr:min:sec) Variable Command: No
Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = ON Variable Command: No
09 LEAKCHECK
Message LEAKCHECK [11]. Sonalert alarm No
Time: 000:02:00 (hr:min:sec) Variable Command: No
Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
Alarm limit setting for Gas PRESSURE [8] at 2 % (± 40 MTOR) Variable Command: No
Branch on gas/pressure PRESSURE [8] to step PURGE. Sonalert alarm Yes
10 EVACUATE
Message EVACUATE 3 [10]. Sonalert alarm No
Time: 000:00:30 (hr:min:sec) Variable Command: No
Normal recipe 01 Zone1 800.0 °C Slope 0.00 °C/min Zone2 800.0 °C Slope 0.00 °C/min Zone3 800.0 °C Slope 0.00 °C/min , profile table A
Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = ON Variable Command: No
Alarm limit setting for Gas PRESSURE [8] at 0 % (± 0 MTOR) Variable Command: No
11 SET NH3
Message PURGE [12]. Sonalert alarm No
Time: 000:01:00 (hr:min:sec) Variable Command: No
Gas [NH3 [4]] at [180] [SCCM] Variable Command: Yes

12 SET PRESSURE
Message PURGE [12]. Sonalert alarm No
Time: 000:02:00 (hr:min:sec) Variable Command: No
Gas [PRESSURE [8]] at [250] [MTOR] Variable Command: Yes
Alarm limit setting for Gas NH3 [4] at 10 % (± 50 SCCM) Variable Command: No
Branch on gas/pressure NH3 [4] to step NH3 PURGE. Sonalert alarm Yes
13 DEPOSITION
Message DEPOSITION [13]. Sonalert alarm No
Time: [000:30:00] (hr:min:sec) Variable Command: Yes
Gas DCS 1 [2] at [60.0] [SCCM] Variable Command: Yes
Alarm limit setting for Gas DCS 1 [2] at 10 % (± 20.0 SCCM) Variable Command: No
Alarm limit setting for Gas PRESSURE [8] at 5 % (± 100 MTOR) Variable Command: No
Branch on gas/pressure DCS 1 [2] to step NH3 PURGE. Sonalert alarm Yes
Branch on gas/pressure NH3 [4] to step NH3 PURGE. Sonalert alarm Yes
Branch on gas/pressure PRESSURE [8] to step NH3 PURGE. Sonalert alarm Yes
14 NH3 PURGE
Message PURGE [12]. Sonalert alarm No
Time: 000:02:00 (hr:min:sec) Variable Command: No
Gas DCS 1 [2] at 0.0 [SCCM] Variable Command: No
Gas PRESSURE [8] at 0 [MTOR] Variable Command: No
Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
Alarm Limit Setting for All Analog Output Channel at 0 %
15 EVAC CONTINUED
Message EVACUATE 3 [10]. Sonalert alarm No
Time: 000:05:00 (hr:min:sec) Variable Command: No
Gas NH3 [4] at 0 [SCCM] Variable Command: No
Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
16 PURGE
Message PURGE [12]. Sonalert alarm No
Time: 000:05:00 (hr:min:sec) Variable Command: No
Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
17 EVACUATE
Message EVACUATE 3 [10]. Sonalert alarm No
Time: 000:05:00 (hr:min:sec) Variable Command: No
Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
18 LEAKCHECK
Message LEAKCHECK [11]. Sonalert alarm No
Time: 000:02:00 (hr:min:sec) Variable Command: No
Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
Alarm limit setting for Gas PRESSURE [8] at 2 % (± 40 MTOR) Variable Command: No

113 Branch on gas/pressure PRESSURE [8] to step EVAC CONTINUED. Sonalert alarm Yes
114 19 READY
115 Message STANDBY [1]. Sonalert alarm No
116 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = ON Variable Command: No
117 Wait for operator
118 20 BACKFILL 1
119 Message BACKFILL [14]. Sonalert alarm No
120 Time: 000:01:00 (hr:min:sec) Variable Command: No
121 Gas N2 [1] at 0.00 [SLM] Variable Command: No
122 Gas DCS 1 [2] at 0.0 [SCCM] Variable Command: No
123 Gas DCS 2 [3] at 0.0 [SCCM] Variable Command: No
124 Gas NH3 [4] at 0 [SCCM] Variable Command: No
125 Gas PRESSURE [8] at 0 [MTOR] Variable Command: No
126 Digital out „„„„„WATERVLV[8] = ON Variable Command: No
127 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = OFF Variable Command: No
128 Alarm on digital in PRESS N2[1] = ON,PRESSAIR[2] = ON,doorclsd[3] = ON,VACFAIL[4] = OFF,WATRCOOL[5] = ON,„TEMP SCR[7] = ON,EXCESS[8] = ON
129 Abort recipe 08
130 21 BACKFILL 2
131 Message BACKFILL [14]. Sonalert alarm No
132 Time: 000:10:00 (hr:min:sec) Variable Command: No
133 Gas N2 [1] at 10.00 [SLM] Variable Command: No
134 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACDCS1[12] = OFF,EVACDCS2[13] = OFF,EVACNH3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
135 END

4.1.8 Troubleshooting a standard-nitride process

Problem:	Cause:	Solution:
Wafers are thick at door side and thin at pump side.	• Depletion of DCS • Temperature ramp is not correct. • Insuffient dummywafers	• Increase temperature ramp (door side temperature lower then pump side temperature). • Decrease process pressure. • Increase DCS flow. • Use 5-10 dummy wafers at pump side
Wafers are thick at the pump side and thin at the door side.	• Temperature ramp is not correct. • Insuffient dummywafers	• Reduce temperature ramp (door side temperature higher then pump side temperature). • Use 12-25 dummy wafers at doorside
Wafers are thick at the top and thin at the bottom.	• The paddle is situated too high in the tube.	• Adjust height of the paddle at the cantilever system.

	• The paddle is colder then the wafers and the tube.	• Insert temperature stabilization step in the recipe after 'evacuate' and/or 'heat up' step.
Wafers are thick at the edges and thin at the center.	• Temperature is not homogeneous within wafer. • Process pressure is too high.	• Insert temperature stabilization step in the recipe after 'boat in' and/or 'heat up' step. • Decrease process pressure.
No consistency in uniformity.	• Dirty quartz ware or wafers. • No constant pressure control. • Draft along the furnace.	• Clean tube, quartz ware and paddle. • Use clean wafers. • Check pressure control. • Decrease draft by reducing overpressure cleanroom or close possible draft holes.
Layer is too thin cross load.	• Deposition time is too short. • Pressure is too low.	• Increase deposition time in recipe. • Increase pressure.
Layer is too thick cross load	• Deposition time is too long. • Pressure is too high.	• Decrease deposition time in recipe. • Decrease pressure.

4.1.9 NH_4Cl vapor pressure curve

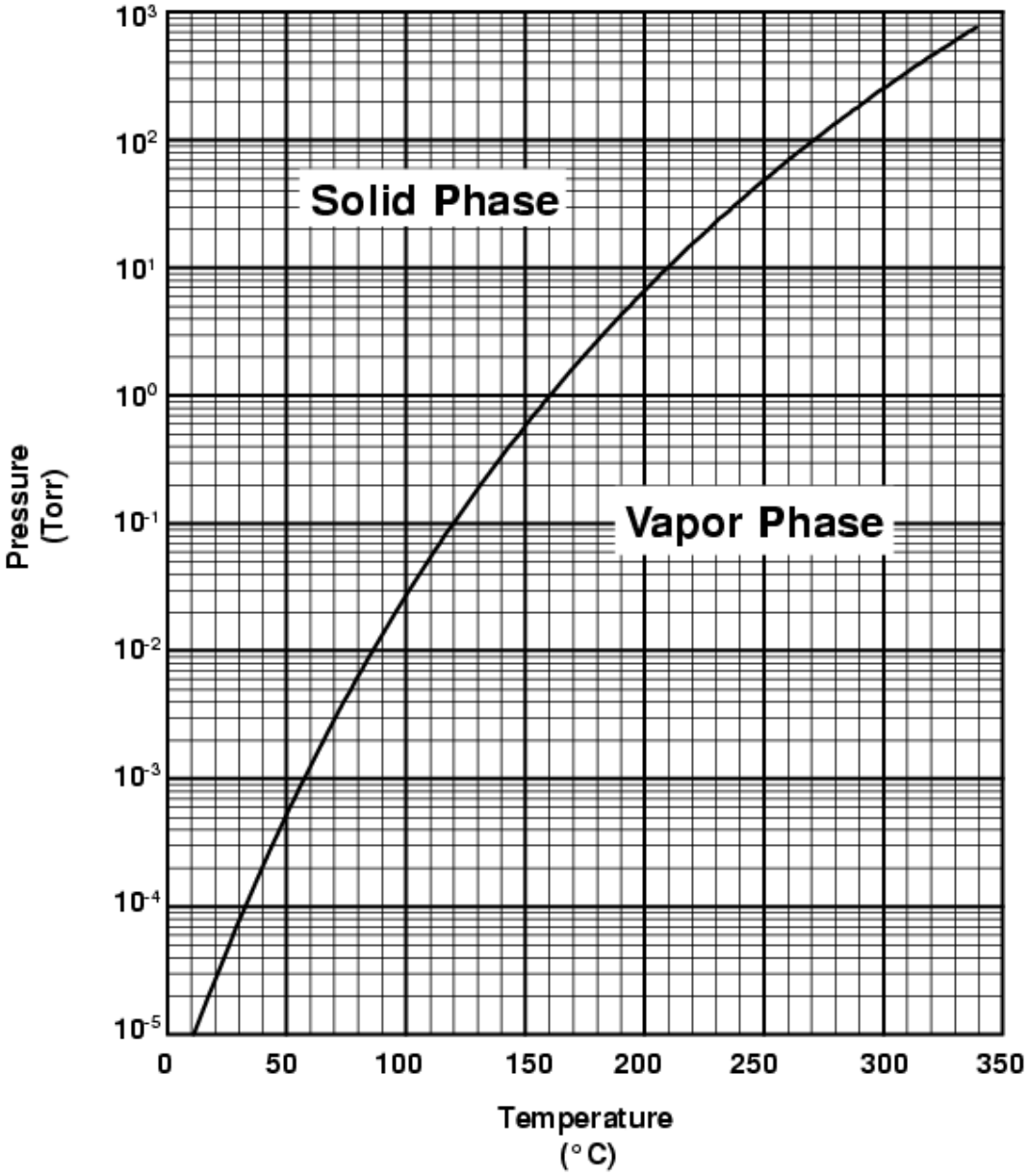


Figure 1: NH_4Cl vapor pressure

4.2 Flat Polycrystalline Si from SiH_4

4.2.1 Basic configuration

SiH_4
Temperature flat
610°C (fine grain)
650°C (coarse grain)

4.2.2 Description

4.2.2.1 Purpose

A flat poly-Si process is used in situations with a strong demand for exactly dimensioned grain structures. As diffusion source it is required to have small grains (more grain boundaries to diffuse along) and as "bulk material" in Thin Film Transistor (TFT) applications the grain structure is involved in the mobility of charge carriers (larger grain means less grain boundaries, less barriers to cross for the charge carriers and a higher mobility).

4.2.2.2 Chemicals

SiH_4 is a pyrogenic gas, which means it will burn spontaneously when it comes into contact with O_2 or air. It is also toxic, but generally it will burn before it gets toxic.

4.2.2.3 Process

Since the temperature is flat and the reaction consumes SiH_4 (depletion) the thickness decreases along the load.
This can be improved in basically two manners: by using a high flow of (inert) gases to dilute the SiH_4 and reduce its consumption. This will affect the growth rate since the partial pressure of SiH_4 is reduced. Or, use a specially designed set of injectors to create a homogeneous local SiH_4 concentration. This latter approach is described in the next section.

Cross-wafer uniformity is generally pretty good, since the deposition process is limited by the surface reaction part. A decreasing process pressure does improve the uniformity, both the cross wafer and the cross load. If relatively small wafers are used compared to the tube diameter an increased gas flow improves cross-wafer and cross-load uniformity drastically.

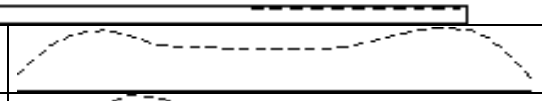
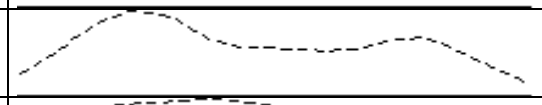
4.2.2.4 Typicalities

To improve cross-wafer uniformity of the edge wafers it is necessary to apply a set of dummy wafers at the gas inlet side of the load. An extra boat might be necessary.

The injector design is crucial and consists of a tube with front- and back-flange, through which one long double-sided injector is placed. An extra injector position is available to add some extra SiH_4 at a specific position should that be required.

4.2.3 Process result indication

A schematic view of the thickness profile along the load as function of normalized gasflows is given in the figure below.

Door		Pump
A sccm		A sccm Saddle profile
B sccm		C sccm
D sccm F sccm		E sccm

The extra injector can also be removed to simplify processing.

4.2.4 Startup parameters for processing

The optical properties of a new and/or cleaned quartz tube change most dramatically after the first deposition of foreign (=different refractive index) material. For accurate temperature control a new and/or cleaned tube needs therefore to be coated before any (automatic) profiling is performed. Use the default process settings for 1 hour to obtain a reasonable coating.
An oxidized substrate wafer is required to enable accurate measurement, typically 1000Å thermally oxidized wafers are used.

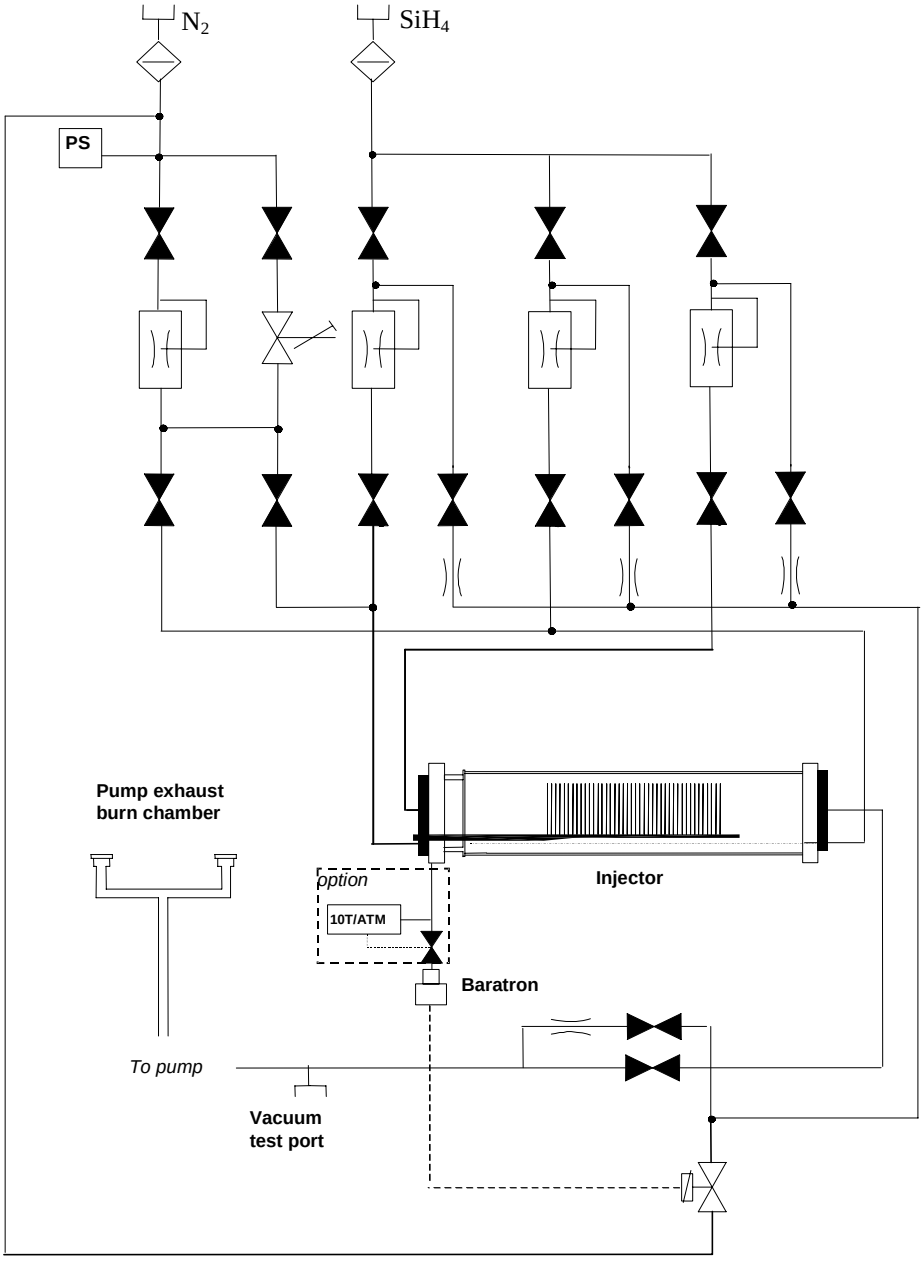
Type	Wafer Size [mm]	Process Time [min]	Pressure [mtor]	Thickness [Å]	Temp. [°C]	SiH_4 [sccm]
TS630x	100 150	30	250	3000	610	30-30-10
TS660x	100 150	30	250	3000	610	40-40-20
TS680x	100 150	30	250	3000	610	60-60-30
TS6100x	100 150	30	250	3000	610	60-60-30
TS840x	150 200	30	250	3000	610	60-60-30
TS860x	150 200	30	250	3000	610	80-80-40
TS8100x	150 200	30	250	3000	610	100-100-50
TS1280x	200 300	30	250	3000	610	200-150-50

4.2.5 Recommended cleaning interval

Cleaning interval for the several components after cumulative deposition in microns on the wafers.

	Tube	Cassettes / baffles	SiC paddle	Trap (upstream tubing)	Oil and filter change
Poly	20/100	10	10	-	80

4.2.6 Gas schematic example: LPCVD Flat poly



4.2.7 Recipe example: LPCVD Flat poly-silicon from SiH_4

1 00 LOAD/UNLOAD
2 Message LOAD/UNLOAD [4]. Sonalert alarm No
3 Normal recipe 00 Zone1 610.0 °C Slope 10.00 °C/min Zone2 610.0 °C Slope 10.00 °C/min Zone3 610.0 °C Slope 10.00 °C/min , profile table A
4 Boat to 2000.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
5 Gas N2 [1] at 0.0 [slm] Variable Command: No
6 Gas SIH4DOOR [2] at 0.0 [sccm] Variable Command: No
7 Gas SIH4REAR [3] at 0.0 [sccm] Variable Command: No
8 Gas PRESSURE [8] at 0.0 [mtor] Variable Command: No
9 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = OFF,PROCESS[11] = OFF,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
10 Alarm Limit Setting for All Analog Output Channel at 0 %
11 Alarm on digital in PRESS N2[1] = ON,PRESSAIR[2] = ON,doorclsd[3] = OFF,VACFAIL[4] = OFF,,,TEMP SCR[7] = ON,EXCESS[8] = ON
12 Alarm on digital in FANCONTR[9] = ON,,,OPERATE[12] = ON,WARNING[13] = ON,FAILURE[14] = ON,,
13 01 BOAT OUT
14 Message BOAT OUT [3]. Sonalert alarm No
15 Time: 000:10:00 (hr:min:sec) Variable Command: No
16 Boat to 10.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
17 Gas N2 [1] at 10.0 [slm] Variable Command: No
18 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = OFF,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
19 Wait for boat to reach setpoint
20 02 LOAD WAFERS
21 Message LOADWAFERS [5]. Sonalert alarm Yes
22 Wait for operator
23 03 BOAT IN
24 Message BOAT IN [2]. Sonalert alarm No
25 Time: 000:10:00 (hr:min:sec) Variable Command: No
26 Boat to 2000.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
27 Wait for boat to reach setpoint
28 Wait on digital in PRESS N2[1] = OFF,PRESSAIR[2] = OFF,doorclsd[3] = ON,VACFAIL[4] = OFF,,,TEMP SCR[7] = OFF,EXCESS[8] = OFF
29 04 EVAC 1
30 Message EVACUATE 1 [8]. Sonalert alarm No
31 Time: 000:01:00 (hr:min:sec) Variable Command: No
32 Gas N2 [1] at 0.0 [slm] Variable Command: No
33 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = OFF,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = OFF Variable Command: No
34 05 EVAC 2
35 Message EVACUATE 2 [9]. Sonalert alarm No
36 Time: 000:05:00 (hr:min:sec) Variable Command: No

37 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = OFF,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
38 Wait on digital in PRESS N2[1] = OFF,PRESSAIR[2] = OFF,doorclsd[3] = OFF,VACFAIL[4] = ON,„TEMP SCR[7] = OFF,EXCESS[8] = OFF
39 Branch on wait alarm to step BACKFILL 1. Sonalert alarm Yes
40 06 EVAC 3
41 Message EVACUATE 3 [10]. Sonalert alarm No
42 Time: 000:05:00 (hr:min:sec) Variable Command: No
43 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
44 Abort recipe 01
45 07 PURGE
46 Message PURGE [12]. Sonalert alarm No
47 Time: 000:05:00 (hr:min:sec) Variable Command: No
48 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
49 Alarm limit setting for Gas PRESSURE [8] at 0 % (± 0.0) Variable Command: No
50 08 EVACUATE
51 Message EVACUATE 3 [10]. Sonalert alarm No
52 Time: 000:05:00 (hr:min:sec) Variable Command: No
53 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = ON Variable Command: No
54 09 LEAKCHECK
55 Message LEAKCHECK [11]. Sonalert alarm No
56 Time: 000:02:00 (hr:min:sec) Variable Command: No
57 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
58 Alarm limit setting for Gas PRESSURE [8] at 2 % (± 0.0) Variable Command: No
59 Branch on gas/pressure PRESSURE [8] to step PURGE. Sonalert alarm Yes
60 10 EVACUATE
61 Message EVACUATE 3 [10]. Sonalert alarm No
62 Time: 000:00:30 (hr:min:sec) Variable Command: No
63 Normal recipe 01 Zone1 610.0 °C Slope 0.00 °C/min Zone2 610.0 °C Slope 0.00 °C/min Zone3 610.0 °C Slope 0.00 °C/min , profile table A
64 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = ON Variable Command: No
65 Alarm limit setting for Gas PRESSURE [8] at 0 % (± 0.0) Variable Command: No
66 11 SET GASFLOWS
67 Message PURGE [12]. Sonalert alarm No
68 Time: 000:01:00 (hr:min:sec) Variable Command: No
69 Gas [SIH4DOOR [2]] at [60.0] [sccm] Variable Command: Yes
70 Gas [SIH4REAR [3]] at [60.0] [sccm] Variable Command: Yes
71 12 SET PRESSURE
72 Message PURGE [12]. Sonalert alarm No
73 Time: 000:02:00 (hr:min:sec) Variable Command: No
74 Gas [PRESSURE [8]] at [250.0] [mtor] Variable Command: Yes
75 Alarm limit setting for Gas SIH4DOOR [2] at 10 % (± 30.0) Variable Command: No

76 Alarm limit setting for Gas SIH4REAR [3] at 10 % (± 30.0) Variable Command: No
77 Branch on gas/pressure SIH4DOOR [2] to step EVACUATE. Sonalert alarm Yes
78 Branch on gas/pressure SIH4REAR [3] to step EVACUATE. Sonalert alarm Yes
79 13 DEPOSITION
80 Message DEPOSITION [13]. Sonalert alarm No
81 Time: [000:30:00] (hr:min:sec) Variable Command: Yes
82 Alarm limit setting for Gas PRESSURE [8] at 5 % (± 0.0) Variable Command: No
83 Branch on gas/pressure SIH4DOOR [2] to step EVACUATE. Sonalert alarm Yes
84 Branch on gas/pressure SIH4REAR [3] to step EVACUATE. Sonalert alarm Yes
85 Branch on gas/pressure PRESSURE [8] to step EVACUATE. Sonalert alarm Yes
86 14 EVACUATE
87 Message EVACUATE 3 [10]. Sonalert alarm No
88 Time: 000:05:00 (hr:min:sec) Variable Command: No
89 Gas N2 [1] at 0.0 [slm] Variable Command: No
90 Gas SIH4DOOR [2] at 0.0 [sccm] Variable Command: No
91 Gas PRESSURE [8] at 0.0 [mtor] Variable Command: No
92 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
93 Alarm limit setting for Gas SIH4DOOR [2] at 0 % (± 0.0) Variable Command: No
94 Alarm limit setting for Gas SIH4REAR [3] at 0 % (± 0.0) Variable Command: No
95 Alarm limit setting for Gas PRESSURE [8] at 1 % (± 0.0) Variable Command: No
96 Wait for gas PRESSURE [8]
97 15 PURGE
98 Message PURGE [12]. Sonalert alarm No
99 Time: 000:05:00 (hr:min:sec) Variable Command: No
100 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
101 16 EVACUATE
102 Message EVACUATE 3 [10]. Sonalert alarm No
103 Time: 000:05:00 (hr:min:sec) Variable Command: No
104 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
105 17 READY
106 Message STANDBY [1]. Sonalert alarm No
107 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = ON Variable Command: No
108 Wait for operator
109 18 BACKFILL 1
110 Message BACKFILL [14]. Sonalert alarm No
111 Time: 000:01:00 (hr:min:sec) Variable Command: No
112 Gas N2 [1] at 0.0 [slm] Variable Command: No
113 Gas SIH4DOOR [2] at 0.0 [sccm] Variable Command: No
114 Gas PRESSURE [8] at 0.0 [mtor] Variable Command: No
115 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = ON,MAINVAC[16] = OFF Variable Command: No
116 Alarm on digital in PRESS N2[1] = ON,PRESSAIR[2] = ON,doorclsd[3] = ON,VACFAIL[4] = OFF,„TEMP SCR[7] = ON,EXCESS[8] = ON
117 Abort recipe 08

118 19 BACKFILL 2
119 Message BACKFILL [14]. Sonalert alarm No
120 Time: 000:10:00 (hr:min:sec) Variable Command: No
121 Gas N2 [1] at 100.0 [slm] Variable Command: No
122 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIL1[12] = OFF,EVACSIL2[13] = OFF,EVACSIL3[14] = OFF,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
123 END

4.2.8 Troubleshooting a flat poly process

Problem:	Cause:	Solution:
Wafers are thick at door side and thin at pump side.	• Gas distribution is incorrect	• Increase gasload from the pump side
Wafers are thick at the pump side and thin at the door side.	• Gas distribution is incorrect	• Increase gasload from the doorside
Wafers are thick at the top and thin at the bottom.	• The paddle is situated too high in the tube. • The paddle is colder then the wafers and the tube.	• Adjust height of the paddle at the cantilever system. • Insert temperature stabilization step in the recipe after 'evacuate' and/or 'heat up' step.
Wafers are thick at the edges and thin at the center.	• Temperature is not homogeneous within wafer. • Pressure is too high.	• Insert temperature stabilization step in the recipe after 'boat in' and/or 'heat up' step. • Decrease pressure.
No consistency in uniformity.	• Dirty quartz ware or wafers. • No constant pressure control. • Draft along the furnace.	• Clean tube, quartz ware and paddle. • Use clean wafers. • Check pressure control. • Decrease draft by reducing overpressure cleanroom or close possible draft holes.
Layer is too thin cross load.	• Deposition time is too short. • Pressure is too low.	• Increase deposition time in recipe. • Increase pressure.
Layer is too thick cross load	• Deposition time is too long. • Pressure is too high.	• Decrease deposition time in recipe. • Decrease pressure.

4.3 Silicondioxide (LTO SiO_2) from SiH_4 and O_2

4.3.1 Basic configuration

LPCVD Low Temperature Oxide (LTO)
SiH_4, O_2, (PH_3 and/or TMB optional)
Injectors are used for SiH_4+PH_3+TMB, and for O_2
Flat temperature of 425°C
Quartz caged cassettes

4.3.2 Description

4.3.2.1 Purpose

Low Temperature Oxide (LTO) is mainly used as a passivation layer over devices, which already have metal contacts. Aluminum is widely used but with melting point of roughly 600°C a passivation layer deposition technique with a deposition temperature higher than the aluminum melting point is not possible.
LTO is used to create a passivation layer while maintaining the aluminum contact integrity.
The low temperature reduces the electrical and mechanical properties of the deposited SiO_2 film, which makes it typically unsuitable for electrical applications.

4.3.2.2 Chemicals

Oxygen is the basic gas of every combustion reaction and therefore leaks can be dangerous near hot areas.
SiH_4 is a pyrogenic gas, which means it will burn spontaneously when it comes into contact with O_2 or air. It is also toxic and should be handled accordingly, although generally it will burn before it gets toxic.

4.3.2.3 Process

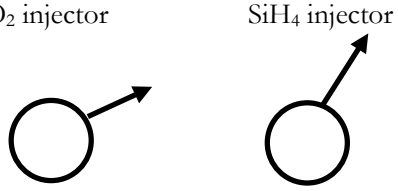
Due to the pyrophoric nature of SiH4 combining SiH_4 and O_2 to do a process requires a distinct handling procedure. This includes reduction of the process pressure and applying a specific gas distribution system.
The deposition of LTO from SiH_4 and O_2 is a very physical process. This means, the deposition rate strongly depends on the gas flows and diffusion properties. The gas flow is mainly affected by the hardware configuration and not so much by the temperature. The result is, that the deposition rate and thickness uniformity do not react much on temperature changes, but do react on hardware changes such as cage and injector design, position of these in view of each other, injector alignment and wafer alignment.
Additionally, as with most LPCVD processes, the pressure will also affect the process results.

The chemical reaction of a basic LTO process is as follows:

$$\mathbf{SiH_4 + O_2 \rightarrow SiO_2 + 2\ H_2}$$

4.3.2.4 Typicalities

The cage design is critical for the cross wafer thickness uniformity, while the injector design and the position of the cage(s) compared to the position of the injector holes are critical for the cross load uniformity. If the cross wafer uniformity is above 5% a new cage design is required.
The cage(s) almost fully cover the holes of the injector. In other words, the holes are distributed in between the first and last cage. Note that the front of the cages is leaded by 1 or 2 holes to get sufficient SiH_4 before the cages.
The O_2 and SiH_4 injectors should be aligned as indicated in the following picture:



If the gas entry mounting points are mirrored also the injector alignment should be mirrored, the O_2 should mix in the SiH_4 stream.
For O_2 one or two extra holes are added at the door side.

If strong depletion is observed and the cross load uniformity is not improving some N_2 can be added to the SiH_4 injector.
The pressure should be kept as low as possible while maintaining an acceptable deposition rate. Decreasing the pressure will improve cross load uniformity some and reduce the deposition rate.
The temperature is not an important parameter, a temperature ramp of +- 10 to 20°C is typical but has limited effect.

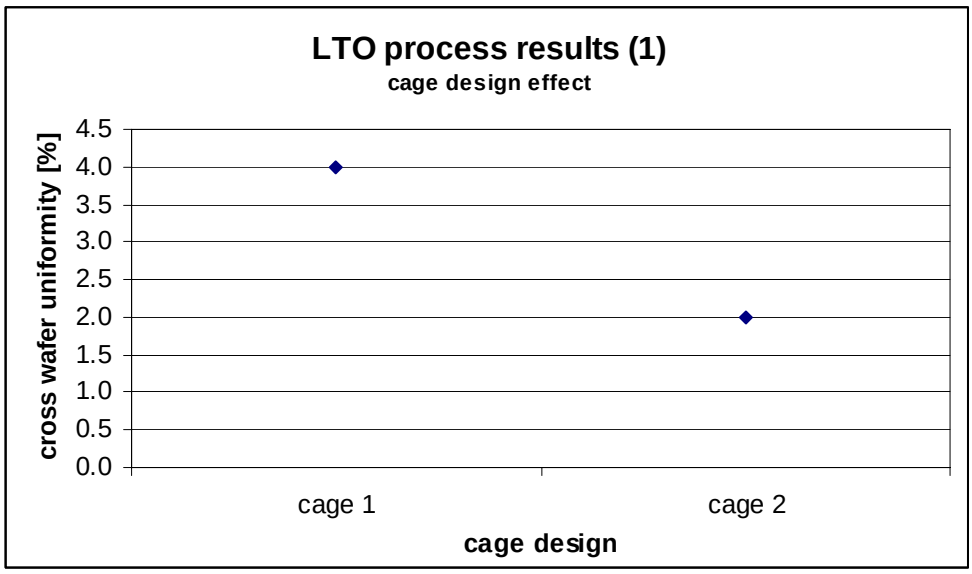
4.3.3 Startup parameters for processing

Type	Wafer Size [mm]	Process Time [min]	Pressure [mtor]	Thickness [Å]	Temp. [°C]	SiH_4 [sccm]	O_2 [sccm]	N_2 [sccm]
TS630x	100 150	30	200	2000	425	30	90	500
TS660x	100 150	30	200	2000	425	40	120	500
TS680x	100 150	30	200	2000	425	50	150	500
TS6100x	100 150	30	200	2000	425	70	200	500

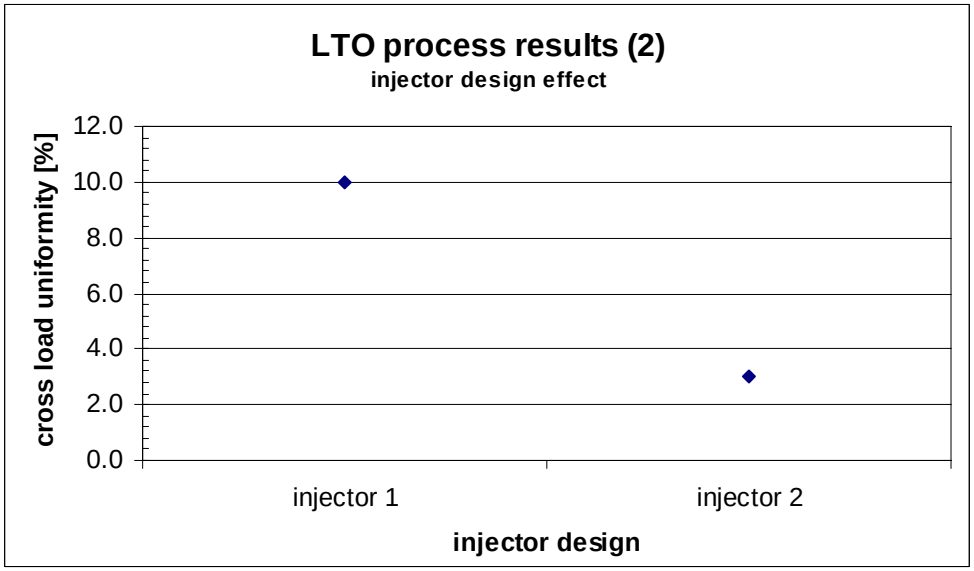
4.3.4 Recommended cleaning interval

Cleaning interval for the several components after cumulative deposition in microns on the wafers.

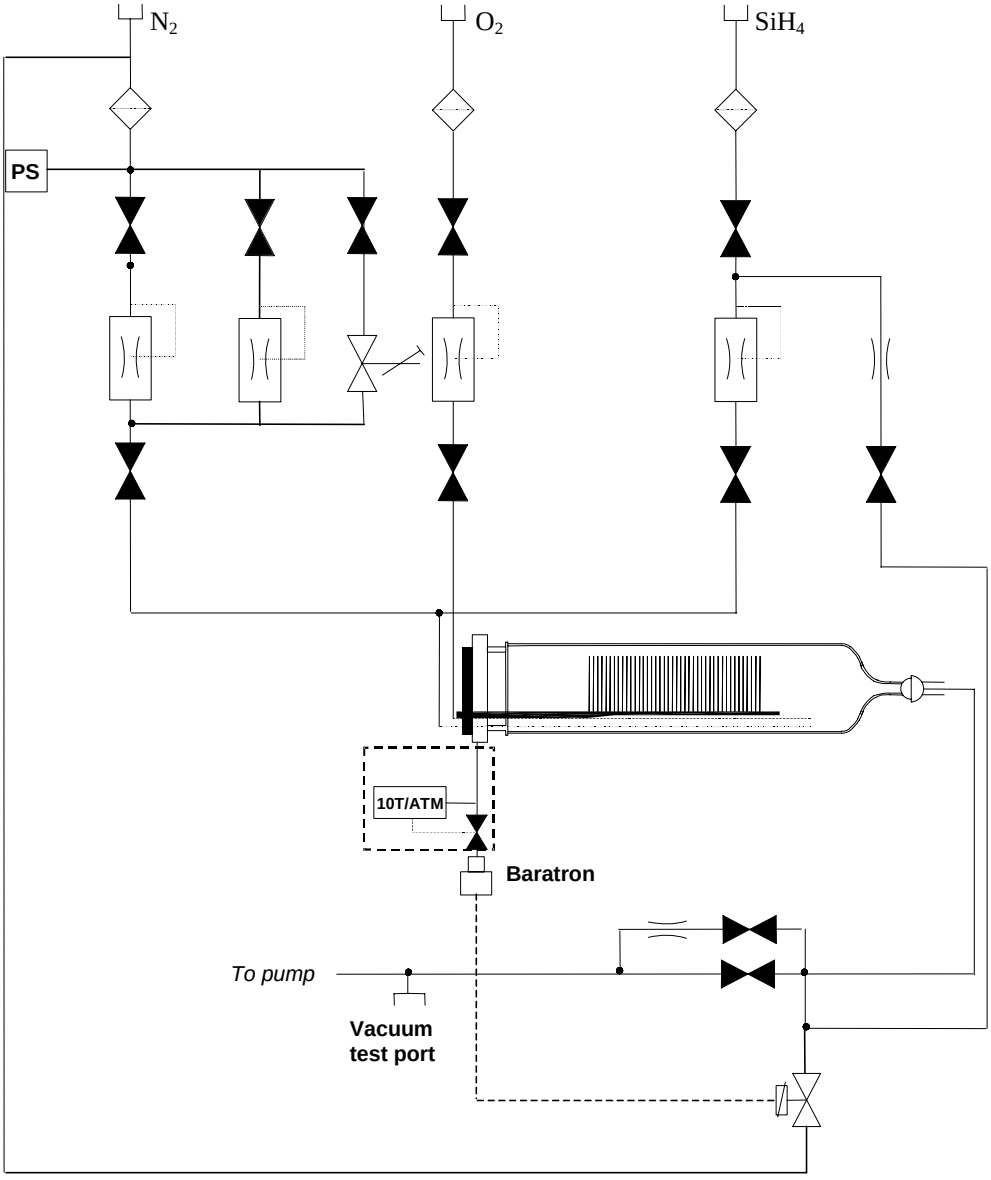
	Tube	Cassettes / baffles	SiC paddle	Trap (upstream tubing)	Oil and filter change
LTO	20	10	10	10	50



4.3.5 Process result indication



4.3.6 Gas schematic example: LPCVD LTO



4.3.7 Recipe example: LPCVD silicondioxide from LTO SiH_4 and O_2

1 00 START RECIPE
2 Message LOAD/UNLOAD [4]. Sonalert alarm No
3 Normal recipe 00 Zone1 425.0 °C Slope 10.00 °C/min Zone2 425.0 °C Slope 10.00 °C/min Zone3 425.0 °C Slope 10.00 °C/min , profile table A
4 Boat to 2000.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
5 Gas N2 [1] at 0.00 [SLM] Variable Command: No
6 Gas O2 [2] at 0 [SCCM] Variable Command: No
7 Gas SIH4 [3] at 0.0 [SCCM] Variable Command: No
8 Gas PRESSURE [8] at 0 [MTOR] Variable Command: No
9 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = OFF,PROCESS[11] = OFF,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
10 Alarm Limit Setting for All Analog Output Channel at 0 %
11 Alarm on digital in PRESS N2[1] = ON,PRESSAIR[2] = ON,doorclsd[3] = OFF,VACFAIL[4] = OFF,,,TEMP SCR[7] = ON,EXCESS[8] = ON
12 Alarm on digital in FANCONTR[9] = ON,,,OPERATE[12] = ON,WARNING[13] = ON,FAILURE[14] = ON,,
13 01 BOAT OUT
14 Message BOAT OUT [3]. Sonalert alarm No
15 Time: 000:10:00 (hr:min:sec) Variable Command: No
16 Boat to 10.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
17 Gas N2 [1] at 10.00 [SLM] Variable Command: No
18 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = OFF,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
19 Wait for boat to reach setpoint
20 02 LOAD WAFERS
21 Message LOADWAFERS [5]. Sonalert alarm Yes
22 Wait for operator
23 03 BOAT IN
24 Message BOAT IN [2]. Sonalert alarm No
25 Time: 000:10:00 (hr:min:sec) Variable Command: No
26 Boat to 2000.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
27 Wait for boat to reach setpoint
28 Wait on digital in PRESS N2[1] = OFF,PRESSAIR[2] = OFF,doorclsd[3] = ON,VACFAIL[4] = OFF,,,TEMP SCR[7] = OFF,EXCESS[8] = OFF
29 04 EVAC 1
30 Message EVACUATE 1 [8]. Sonalert alarm No
31 Time: 000:01:00 (hr:min:sec) Variable Command: No
32 Gas N2 [1] at 0.00 [SLM] Variable Command: No
33 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = OFF,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = ON,MAINVAC[16] = OFF Variable Command: No
34 05 EVAC 2
35 Message EVACUATE 2 [9]. Sonalert alarm No
36 Time: 000:05:00 (hr:min:sec) Variable Command: No

37 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = OFF,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
38 Wait on digital in PRESS N2[1] = OFF,PRESSAIR[2] = OFF,doorclsd[3] = OFF,VACFAIL[4] = ON,,,TEMP SCR[7] = OFF,EXCESS[8] = OFF
39 Branch on wait alarm to step BACKFILL 1. Sonalert alarm Yes
40 06 EVAC 3
41 Message EVACUATE 3 [10]. Sonalert alarm No
42 Time: 000:05:00 (hr:min:sec) Variable Command: No
43 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
44 Abort recipe 01
45 07 PURGE
46 Message PURGE [12]. Sonalert alarm No
47 Time: 000:05:00 (hr:min:sec) Variable Command: No
48 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
49 Alarm limit setting for Gas PRESSURE [8] at 0 % (± 0 MTOR) Variable Command: No
50 08 EVACUATE
51 Message EVACUATE 3 [10]. Sonalert alarm No
52 Time: 000:05:00 (hr:min:sec) Variable Command: No
53 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = OFF,MAINVAC[16] = ON Variable Command: No
54 09 LEAKCHECK
55 Message LEAKCHECK [11]. Sonalert alarm No
56 Time: 000:02:00 (hr:min:sec) Variable Command: No
57 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
58 Alarm limit setting for Gas PRESSURE [8] at 2 % (± 40 MTOR) Variable Command: No
59 Branch on gas/pressure PRESSURE [8] to step PURGE. Sonalert alarm Yes
60 10 EVACUATE
61 Message EVACUATE 3 [10]. Sonalert alarm No
62 Time: 000:00:30 (hr:min:sec) Variable Command: No
63 Normal recipe 01 Zone1 425.0 °C Slope 0.00 °C/min Zone2 425.0 °C Slope 0.00 °C/min Zone3 425.0 °C Slope 0.00 °C/min , profile table A
64 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = OFF,MAINVAC[16] = ON Variable Command: No
65 Alarm limit setting for Gas PRESSURE [8] at 0 % (± 0 MTOR) Variable Command: No
66 11 SET O2
67 Message PURGE [12]. Sonalert alarm No
68 Time: 000:01:00 (hr:min:sec) Variable Command: No
69 Gas [O2 [2]] at [150] [SCCM] Variable Command: Yes
70 12 SET PRESSURE
71 Message PURGE [12]. Sonalert alarm No
72 Time: 000:02:00 (hr:min:sec) Variable Command: No
73 Gas [PRESSURE [8]] at [250] [MTOR] Variable Command: Yes

74 Alarm limit setting for Gas O2 [2] at 10 % (± 50 SCCM) Variable Command: No
75 Branch on gas/pressure O2 [2] to step O2 PURGE. Sonalert alarm Yes
76 13 DEPOSITION
77 Message DEPOSITION [13]. Sonalert alarm No
78 Time: [000:30:00] (hr:min:sec) Variable Command: Yes
79 Gas [SIH4 [3]] at [50.0] [SCCM] Variable Command: Yes
80 Alarm limit setting for Gas SIH4 [3] at 10 % (± 10.0 SCCM) Variable Command: No
81 Alarm limit setting for Gas PRESSURE [8] at 5 % (± 100 MTOR) Variable Command: No
82 Branch on gas/pressure O2 [2] to step O2 PURGE. Sonalert alarm Yes
83 Branch on gas/pressure SIH4 [3] to step O2 PURGE. Sonalert alarm Yes
84 Branch on gas/pressure PRESSURE [8] to step O2 PURGE. Sonalert alarm Yes
85 14 O2 PURGE
86 Message PURGE [12]. Sonalert alarm No
87 Time: 000:02:00 (hr:min:sec) Variable Command: No
88 Gas N2 [1] at 0.00 [SLM] Variable Command: No
89 Gas SIH4 [3] at 0.0 [SCCM] Variable Command: No
90 Gas PRESSURE [8] at 0 [MTOR] Variable Command: No
91 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
92 Alarm limit setting for Gas SIH4 [3] at 0 % (± 0.0 SCCM) Variable Command: No
93 Alarm limit setting for Gas PRESSURE [8] at 0 % (± 0 MTOR) Variable Command: No
94 15 EVACUATE
95 Message EVACUATE 3 [10]. Sonalert alarm No
96 Time: 000:05:00 (hr:min:sec) Variable Command: No
97 Gas O2 [2] at 0 [SCCM] Variable Command: No
98 Alarm limit setting for Gas O2 [2] at 0 % (± 0 SCCM) Variable Command: No
99 16 PURGE
100 Message PURGE [12]. Sonalert alarm No
101 Time: 000:05:00 (hr:min:sec) Variable Command: No
102 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
103 17 EVACUATE
104 Message EVACUATE 3 [10]. Sonalert alarm No
105 Time: 000:05:00 (hr:min:sec) Variable Command: No
106 Digital out N2 PURGE[9] = OFF,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = ON,MAINVAC[16] = ON Variable Command: No
107 18 READY
108 Message STANDBY [1]. Sonalert alarm No
109 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = OFF,MAINVAC[16] = ON Variable Command: No
110 Wait for operator
111 19 BACKFILL 1
112 Message BACKFILL [14]. Sonalert alarm No
113 Time: 000:01:00 (hr:min:sec) Variable Command: No
114 Boat to 2000.0 mm at 300.0 mm/min with oscillation speed of 0.0 mm/min. Variable Command: No
115 Gas N2 [1] at 0.00 [SLM] Variable Command: No

116 Gas O2 [2] at 0 [SCCM] Variable Command: No
117 Gas SIH4 [3] at 0.0 [SCCM] Variable Command: No
118 Gas PRESSURE [8] at 0 [MTOR] Variable Command: No
119 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = ON,MAINVAC[16] = OFF Variable Command: No
120 Alarm on digital in PRESS N2[1] = ON,PRESSAIR[2] = ON,doorclsd[3] = ON,VACFAIL[4] = OFF,,,TEMP SCR[7] = ON,EXCESS[8] = ON
121 Abort recipe 08
122 20 BACKFILL 2
123 Message BACKFILL [14]. Sonalert alarm No
124 Time: 000:10:00 (hr:min:sec) Variable Command: No
125 Gas N2 [1] at 10.00 [SLM] Variable Command: No
126 Digital out N2 PURGE[9] = ON,N2PROCES[10] = ON,PROCESS[11] = ON,EVACSIH4[12] = OFF,,,SOFTSTRT[15] = OFF,MAINVAC[16] = OFF Variable Command: No
127 END

4.3.8 Troubleshooting an LTO process

Problem:	Cause:	Solution:
Wafers are thick at the door side and thin at the pump side.	• Temperature ramp is not correct. • Injector design is not optimal • Insufficient N_2 carrier gas	• Increase temperature ramp (door side temperature lower then pump side temperature). • Use different injector design • Increase N_2 carrier gas
Wafers are thick at the pump side and thin at the door side.	• Temperature ramp is not correct. • Injector design is not optimal • Too much N_2 carrier gas	• Reduce temperature ramp (door side temperature higher then pump side temperature). • Use different injector design • Reduce N_2 carrier gas
Wafers are thick at the top and thin at the bottom.	• Wafers are not aligned parallel.	• Place wafers parallel and flat side at the top
Wafers are thick at the edges and thin at the center.	• Wafers are placed too close together • Cage design is not optimal	• Place wafers further apart • Use different cage design
No consistency in uniformity.	• Dirty quartz ware or wafers. • No constant pressure control. • Draft along the furnace.	• Clean tube, quartz ware and paddle. • Use clean wafers. • Check pressure control. • Close possible draft holes.
Layer is too thin cross load.	• Deposition time is too short.	• Increase deposition time in recipe.
Layer is too thick cross load	• Deposition time is too long.	• Decrease deposition time in recipe.

5.Operation Instructions

This document describes the various procedures required for a process engineer. The procedures describe all information according to the process engineers.

5.1 Load or Unload process wafers

Loading and unloading process wafers on the paddle is required before and after each process run.

5.1.1 Load process wafers

- Place the wafers on the wafer carriers, depending on the situation with (vacuum) tweezers or a wafer transfer system.
- Pick-up wafer carriers with a pick-up fork or automated loading tool.
- Place the wafer carriers around the center of flatzone as indicated on the loadstation.

5.1.2 Unload wafers

CAUTION

Wafers and paddle are hot.

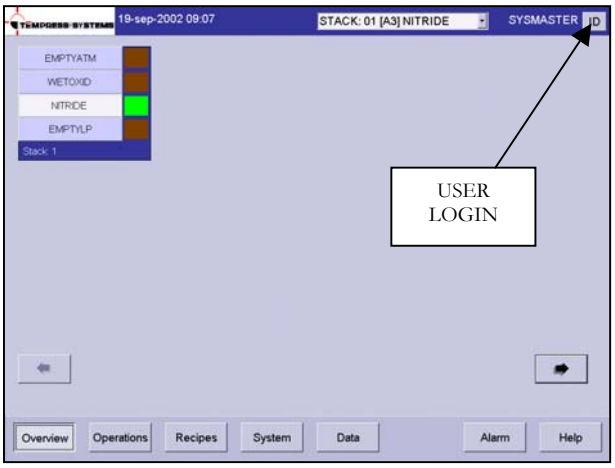
- Allow the wafers to cool down.
- Pick-up wafer carriers with a pick-up fork or automated loading tool. (Amtech Systems *S300*)
- Remove the wafers from the wafer carriers, depending on the situation with (vacuum) tweezers or a wafer transfer system.

5.2 Login TSC-2

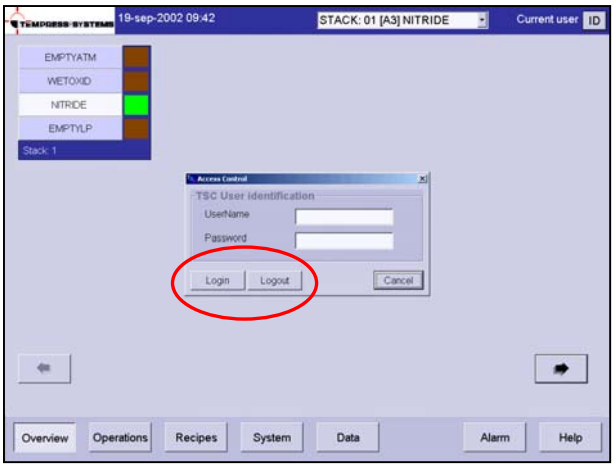
Changing login name may be required to couple process data to operator and process proceeding for logging data.

5.2.1 TSC-2

1) Press "ID" to Login as screen until following screen appears:



2) Type the personal username and password
3) Press "Login" to login or "Logout" to logout

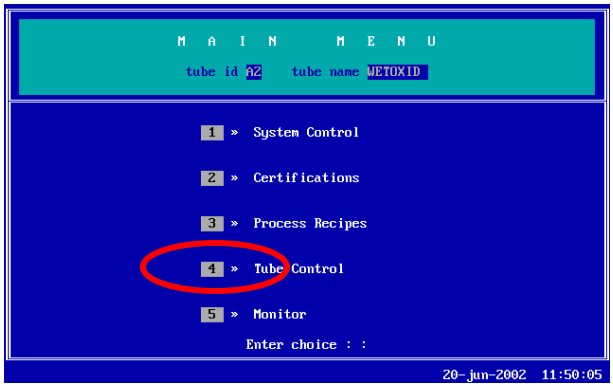


5.3 Selecting a new process recipe

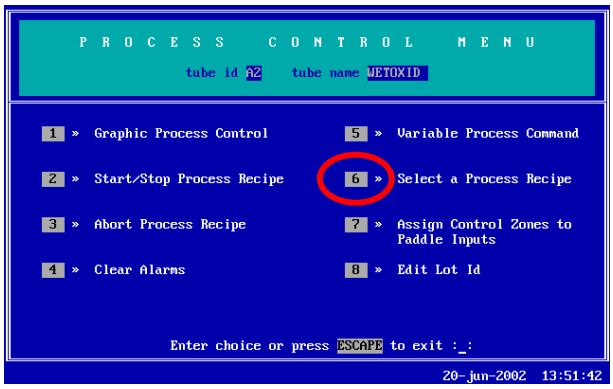
A new process recipe needs to be selected so the new instructions can be executed. A new process recipe can only be selected if the current process recipe is in 'Step 0'.

5.3.1 Touchscreen

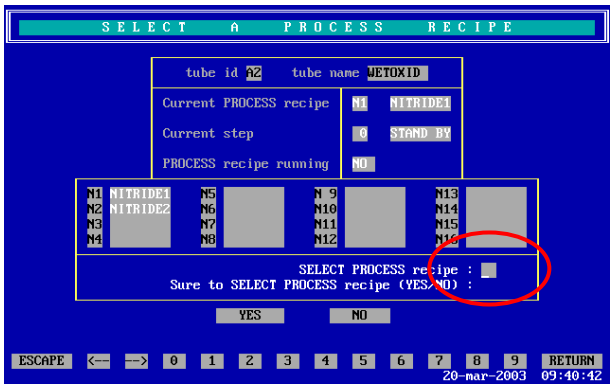
1) return to the Main Menu by pressing 'ESC' until the following screen appears:
2) press '4' to access 'Tube control'



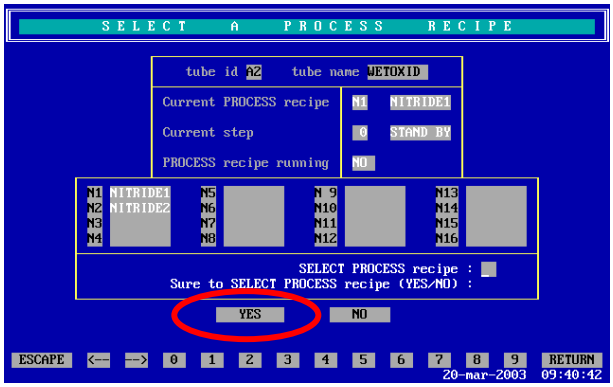
3) press '6' to 'Select a Process Recipes'



4) select the desired process recipe by entering its number.



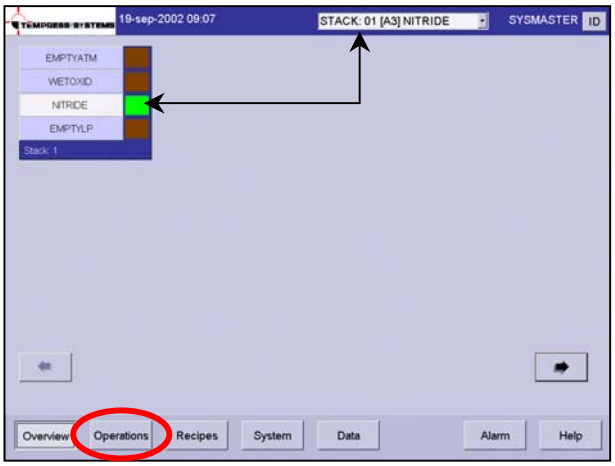
5) press 'Yes' to confirm the question 'Sure to SELECT PROCESS recipe (Yes/No)?'



Note: selecting another process recipe is only possible if the current process recipe is in Step 0.

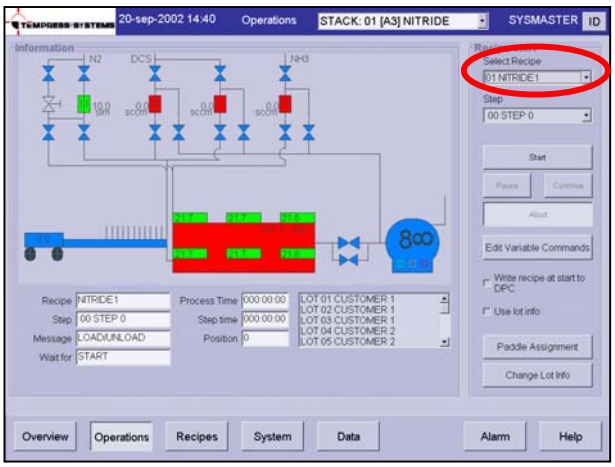
5.3.2 TSC-2

1) select the desired tube from the pull-down menu or from the 'Overview' screen.
2) select 'Operations' to access the operations screen.



3) Select the desired process recipe from the pull-down menu
4) Press 'Yes' to confirm the question 'Are you sure to select another process recipe?'

Note: selecting another process recipe is only possible if the current process recipe is in Step 0.

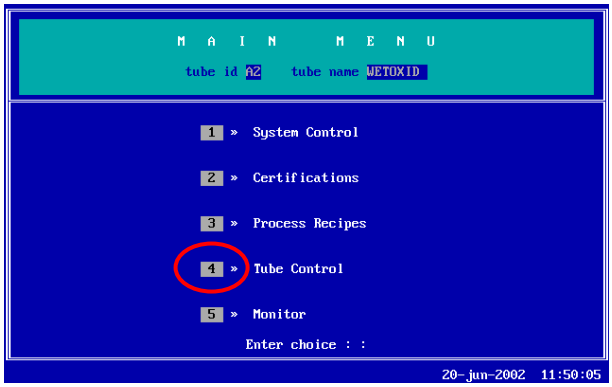


5.4 Start/Continue a new process recipe

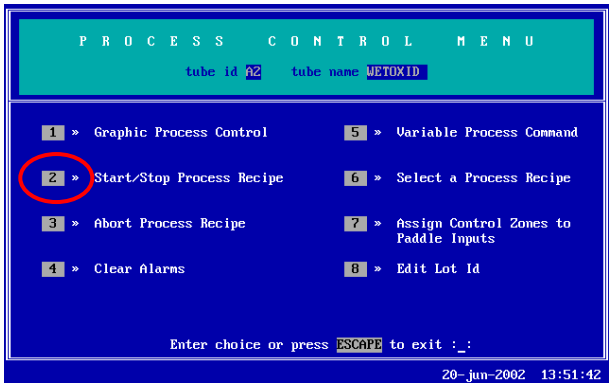
Two different situations require the 'Start' command.
The first situation is starting a newly selected process recipe so it starts running from Step 0.
The second situation is starting a process recipe that has been stopped or is waiting for an 'Operator' instruction.

5.4.1 Touchscreen

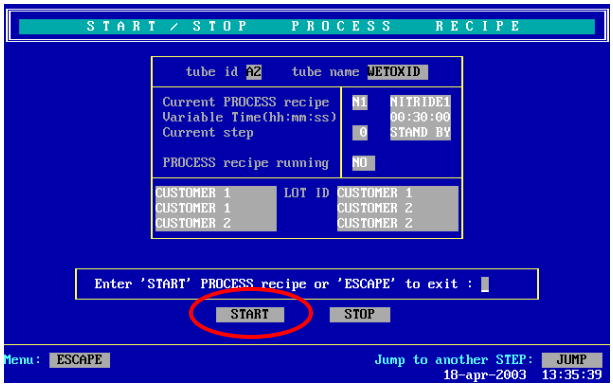
1) return to the Main Menu by pressing 'ESC' until the following screen appears:
2) press '4' to access 'Tube Control'



3) press '2' to access 'Start/Stop Process Recipe'.

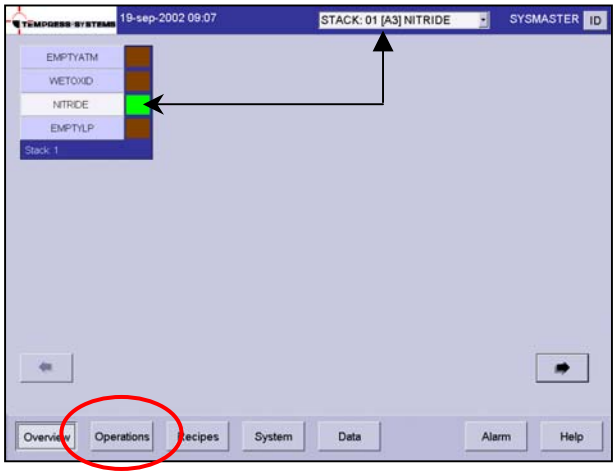


4) press 'Start' to start/continue the selected process recipe.

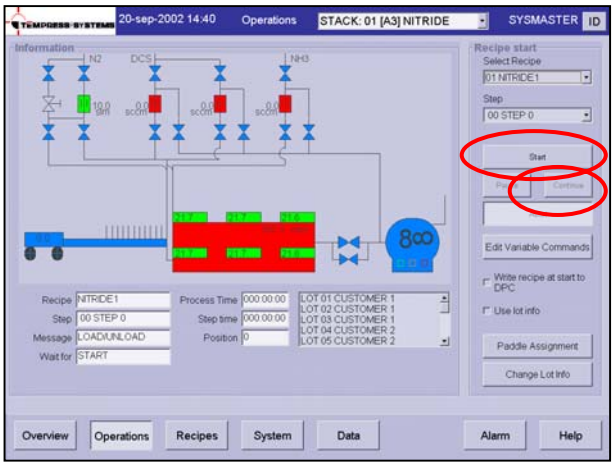


5.4.2 TSC-2

1) select the desired tube from the pull-down menu or from the 'Overview' screen.
2) select 'Operations' to access the operations screen.



3) press 'Start' to start the selected process recipe from 'Step 0'
4) press 'Continue' to start a process recipe that has been stopped or is waiting for an 'Operator' instruction.
5) press 'Yes' to confirm the question 'Do you want to start?'

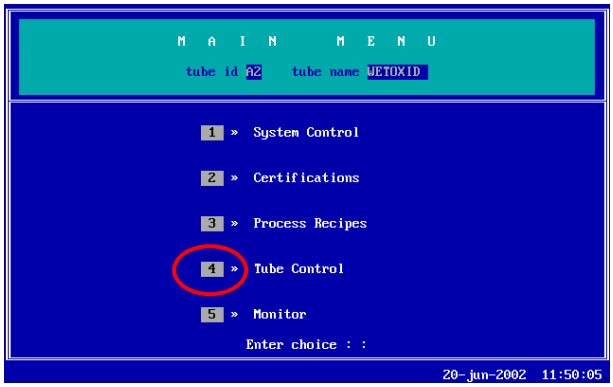


5.5 Stop a running process recipe

Stopping a running process recipe may be required to temporarily stop the process recipe. When activated, the 'Stop' command will stop the timer *while all given commands are maintained.*

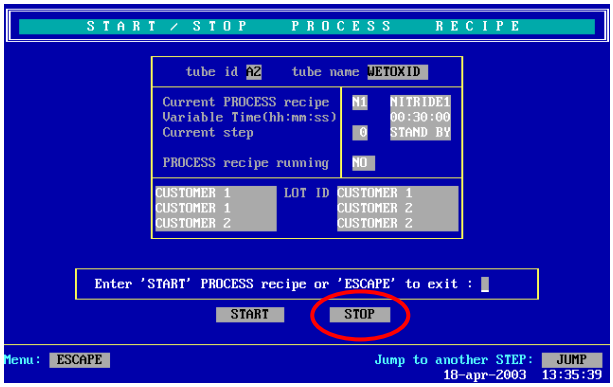
5.5.1 Touchscreen

1) return to the Main Menu by pressing 'ESC' until the following screen appears:
2) press '4' to access 'Tube Control'



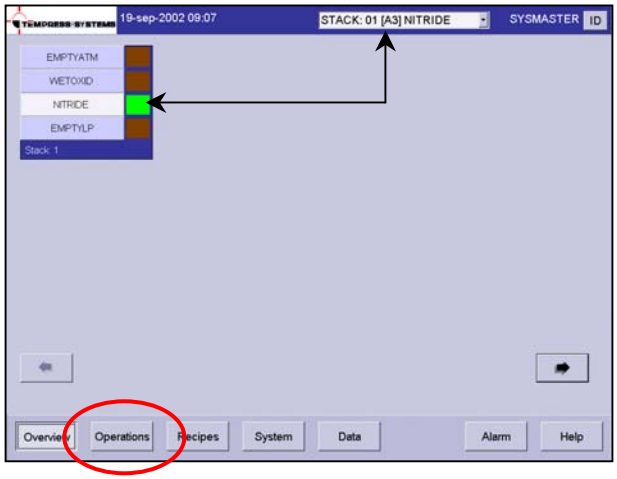
3) press '2' to access 'Start/Stop Process Recipe'

4) press 'Stop' to stop the selected process recipe

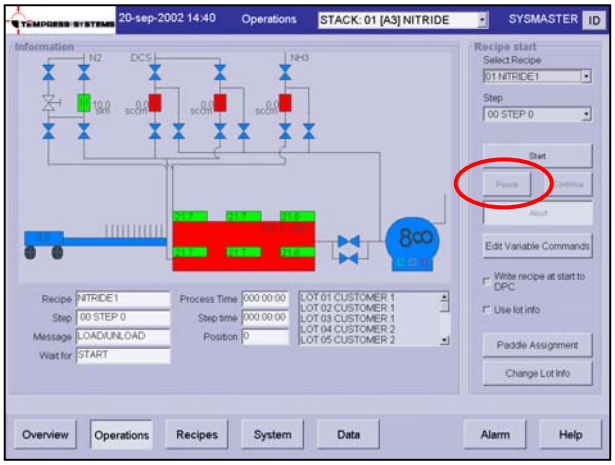


5.5.2 TSC-2

1) select the desired tube from the pull-down menu or from the 'Overview' screen.
2) select 'Operations' to access the operations screen.



3) Press 'Pause' to stop the selected process recipe from the current step.

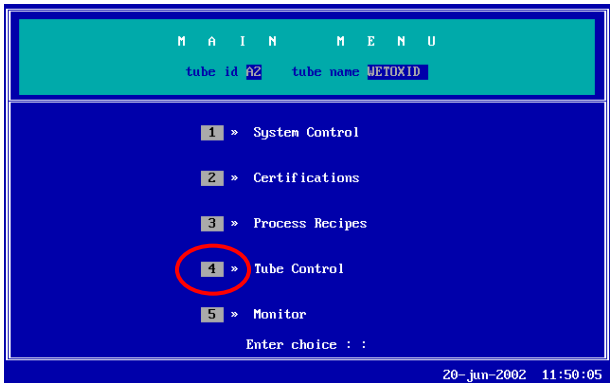


5.6 Abort a running process recipe

A manual 'Abort' instruction may be required if the operator foresees a dangerous situation or a continuous looped process recipe needs to be reset to Step 0 to allow selection of another process recipe.

5.6.1 Touchscreen

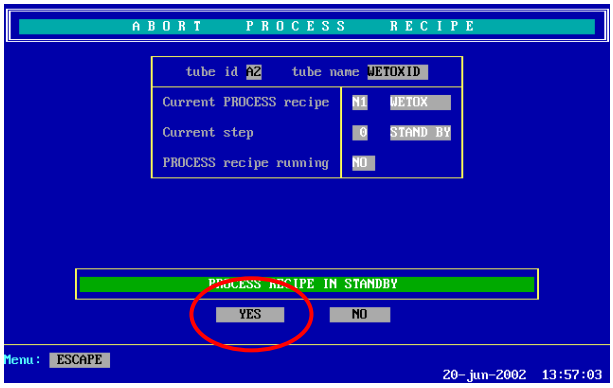
1) return to the Main Menu by pressing 'ESC' until the following screen appears:
2) press '4' to access 'Tube Control'



3) press '3' to access 'Abort Process Recipe'

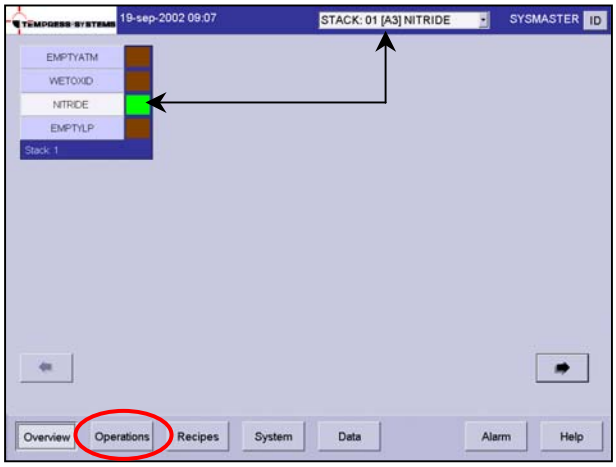
4) press 'Yes' to confirm the question 'Are you sure you want to abort?'

5) press 'Yes' again to activate the abort command

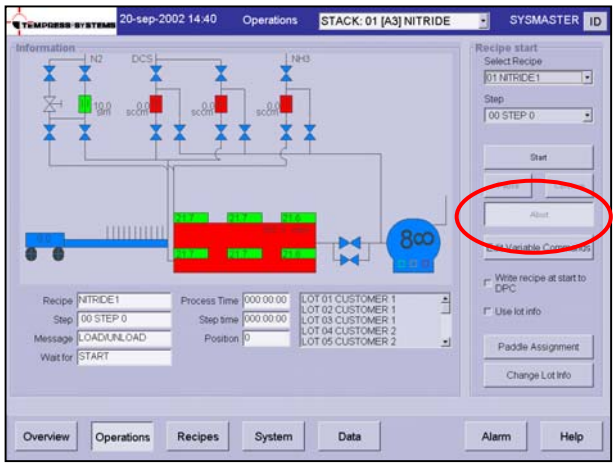


5.6.2 TSC-2

1) select the desired tube from the pull-down menu or from the 'Overview' screen.
2) select 'Operations' to access the operations screen.



3) Press 'Abort' to abort the selected process recipe.
4) Press 'Yes' to confirm the question 'Sure to abort?'

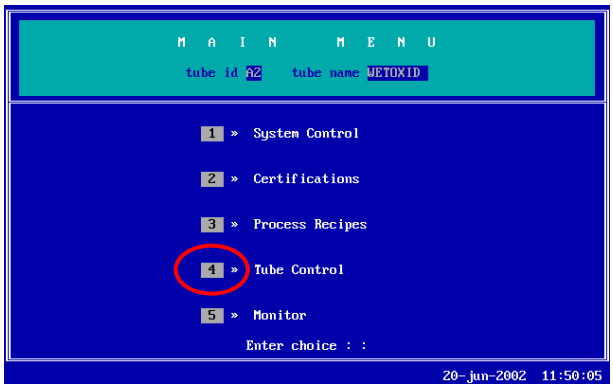


5.7 Edit 'Variable Process Command'

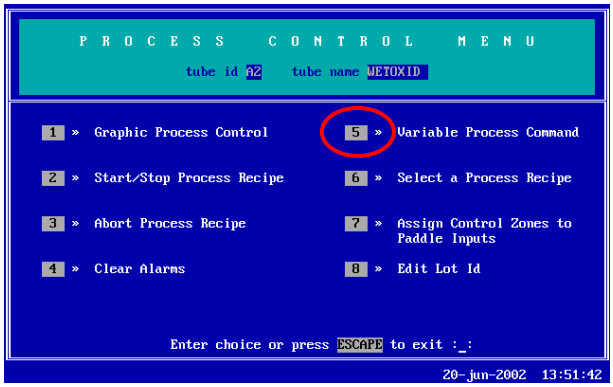
'Variable Process Command' can be used to quickly modify specific process settings. Only those lines in the process recipe that have been assigned as 'Variable Commands' will be presented in a list. From this list the desired process setting may be modified.
'Variable Process Command' can be set at all times until the recipe step is executed in which the specific 'Variable Command' is programmed.

5.7.1 Touchscreen

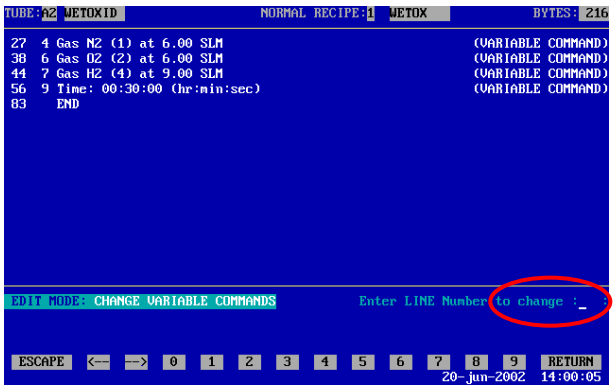
1) return to the Main Menu by pressing 'ESC' until the following screen appears:
2) press '4' to access 'Tube Control'



3) press '5' to access 'Variable Commands'



4) edit the desired process setting
   1) enter the corresponding line number
   2) modify to the desired setting
   3) press 'Return' to confirm the modification
5) repeat step 4) until all desired process settings have been set
6) Press 'Esc' to store the new commands. The message 'Process recipe variable

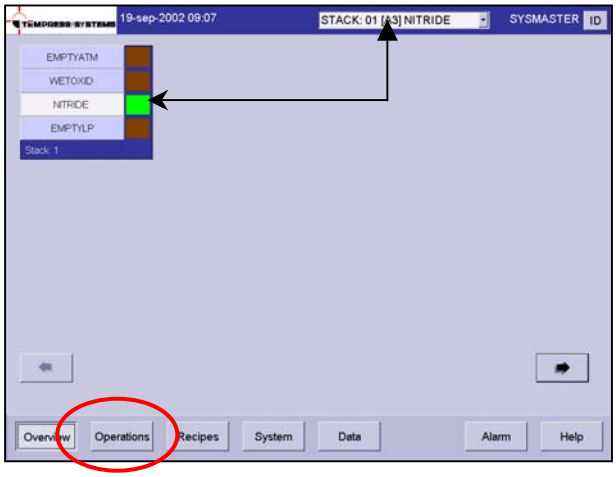


commands stored' appears.

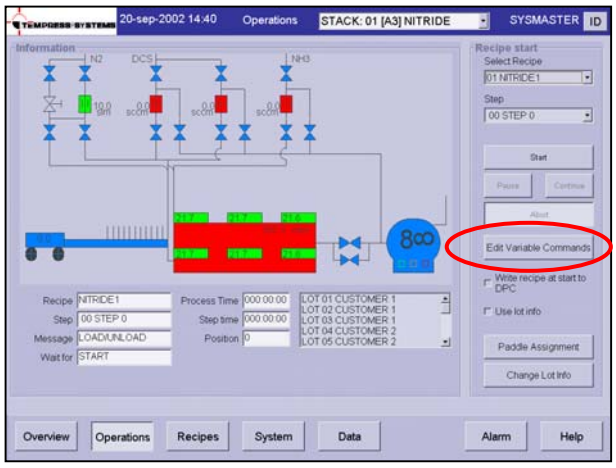
7) Go to the **Start/Continue a new process recipe** procedure to start the process recipe if it is not running.

5.7.2 TSC-2

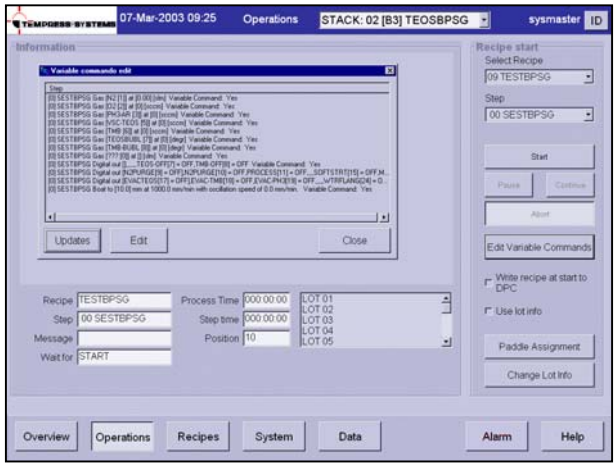
1) select the desired tube from the pull-down menu or from the 'Overview' screen.
2) select 'Operations' to access the operations screen.



3) Select 'Edit Variable Commands' to open the list with available Variable Commands



4) edit the desired process setting
1) highlight the desired process setting
2) press 'Edit' to open the Edit mode
3) modify to the desired process setting
5) press 'Updates' to store the new commands
6) go to the **Start/Continue a new process recipe procedure** to start the process recipe if it is not running.



5.8 Clear Alarms

Visible and audible Alarms signals are generated by the DPC and DTC. The visible alarms will be presented both on the touchscreen and the TSC-2 computer(s), the audible alarms are available on the touchscreen only.

Two different audible alarm signals are available:

- operator alert: an intermittent *beep-beep-beep* to alert an operator for action (press 'Start' for example)
- alarm signal: a continuous *beeeeeeeeeeeep* to alert for an alarm situation

5.8.1 Required action

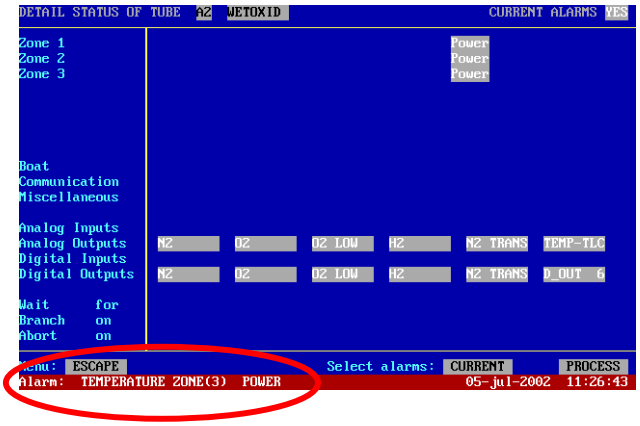
- Operator alert signals *(beep-beep-beep)* require the operator to press 'Start' to have the furnace proceed to the next step in the process.
- Alarm situation signals *(beeeeeeeeeeep)* require the operator to alert the responsible person(s) immediately.

5.8.2 Touchscreen

1) touch the touchscreen to silence the buzzer

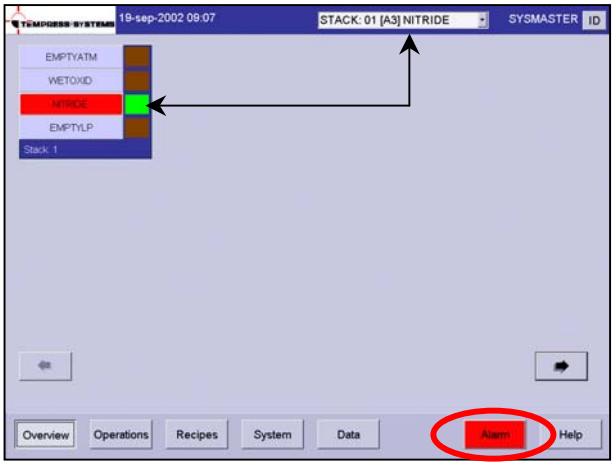
2) read the alarm message in the bottom line of the screen

3) take the appropriate action as described in section **Error! Reference source not found.**.

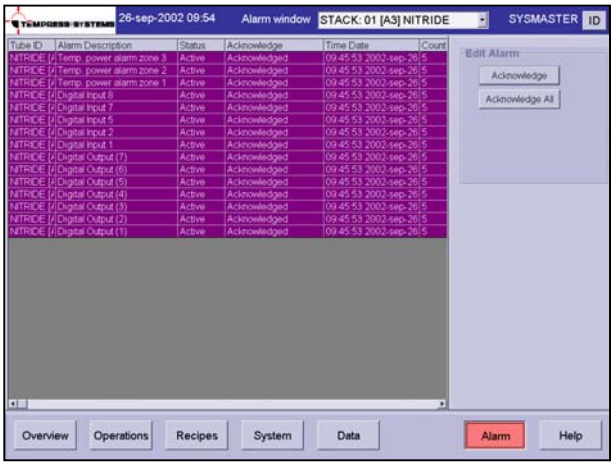


5.8.3 TSC-2

1) the overview screen gives an instant view of which tubes are in alarm in RED
2) select the desired tube from the pull-down menu or from the 'Overview' screen
4) select the 'Alarm' screen



3) read the alarm message(s)
4) take the appropriate action as described in section **Error! Reference source not found.**

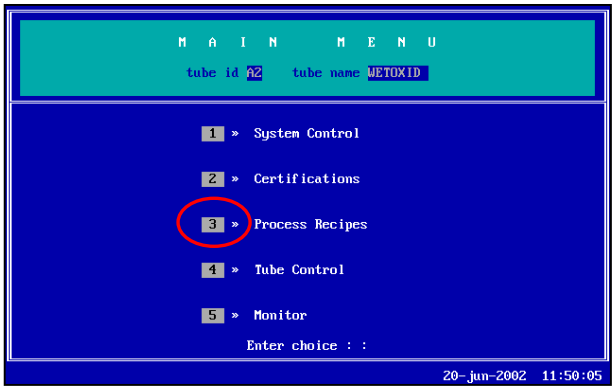


5.9 Write/Edit process recipe

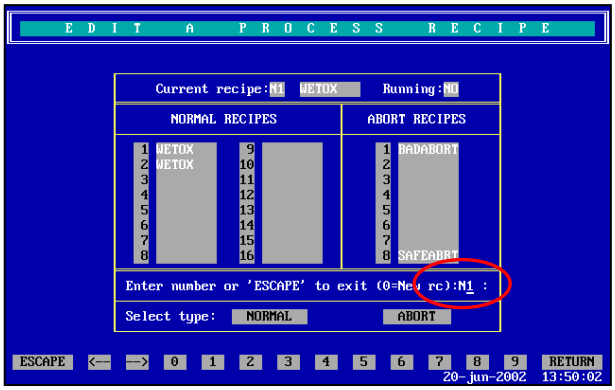
A new process recipe needs to be written or edited so the desired instructions are executed in the required order. A new process recipe can always be generated. Editing an existing and RUNNING recipe is possible but poses considerable danger. It is therefore NOT allowed, except when using variable commands only.

5.9.1 Touchscreen

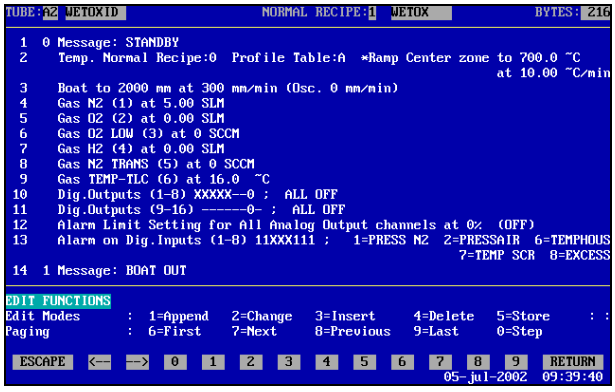
1) return to the Main Menu by pressing 'ESC' until the following screen appears:
2) press '3' to access 'Process Recipes'



3) enter recipe nr. to edit or '0' to create a new process recipe followed by 'RETURN'

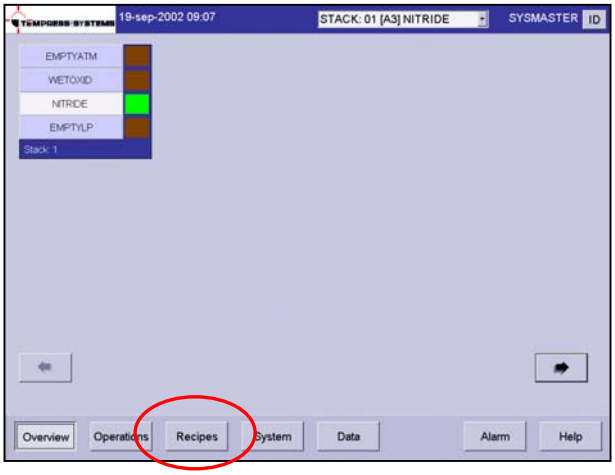


4) follow instruction at the bottom line to add or edit commands.

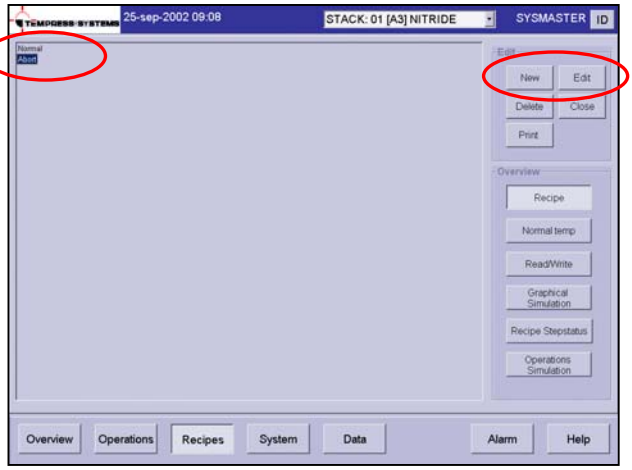


5.9.2 TSC-2

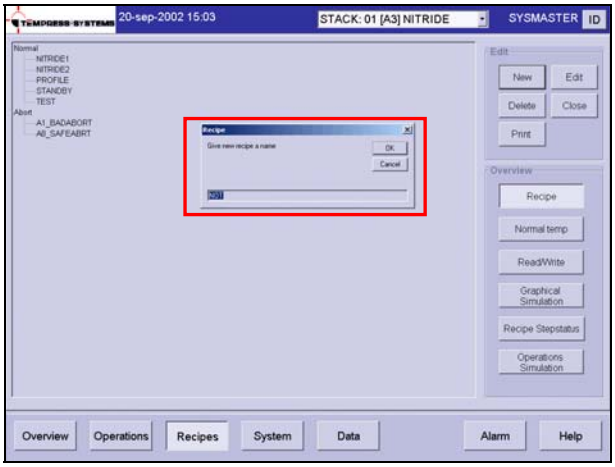
1) return to the main overview screen
2) select 'Recipes' in the navigation bar to access the recipe screen



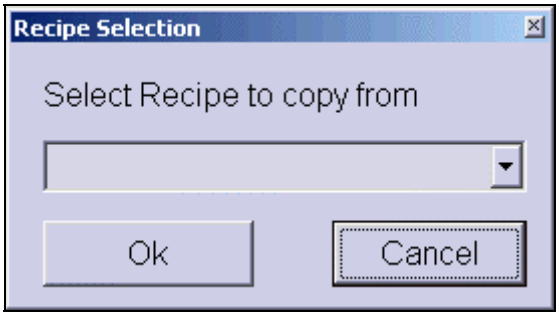
3) double click 'Normal' or 'Abort' in the mainfield
4) select 'New' to create a new or 'Edit' to edit a process recipe
5) for a new process recipe confirm the question: 'Do you want to add a new recipe'



6) give recipe name



7) select a recipe to copy from or cancel
8) repeat step 3-7 for each process step and command.



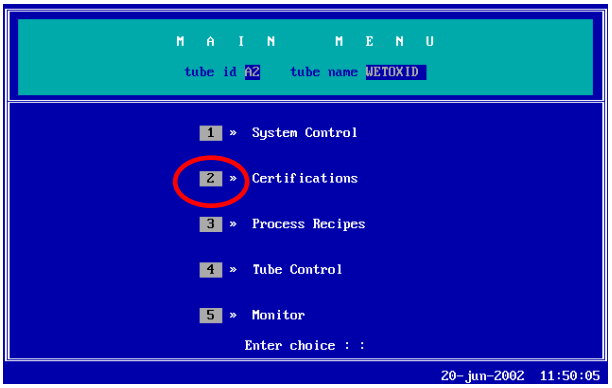
5.10 Edit graphical image

To support the process recipe and to give actual progress information during the process run a graphical representation of the tube and its components can be added to the process certifications.
The touchscreen allows predefined symbols and locations only, TSC-2 allows total freedom for the graphical operations screen layout.

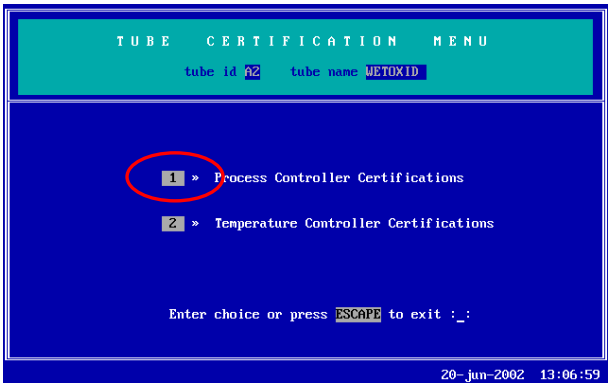
Note: For accurate representation keep the process gas schematic at hand.

5.10.1 Touchscreen

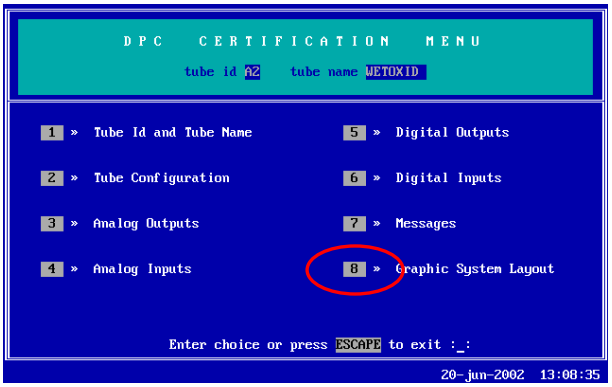
1) return to the Main Menu by pressing 'ESC' until the following screen appears:
2) press '2' to access 'Tube Certifications'



3) press '1' to access 'Process Controller Certifications'



4) press '8' to access 'Graphic System Layout'



5) select SCREEN to find the desired screen number (max 4)

6) define the tube configuration (Left or Right) and the amount of heating zones first

7) select L for Door on Left, select R for Door on Right

8) select the number of heating zones by pressing the correct number (typically 3 or 5). Press RETURN to confirm.

9) for LPCVD tubes define the Pressure Transducer valve up to the Top Tube Line Evacuate Valve if applicable. Select the appropriate Digital Output number (DOx)

10) select G-2 to access the second part of the graphical system layout

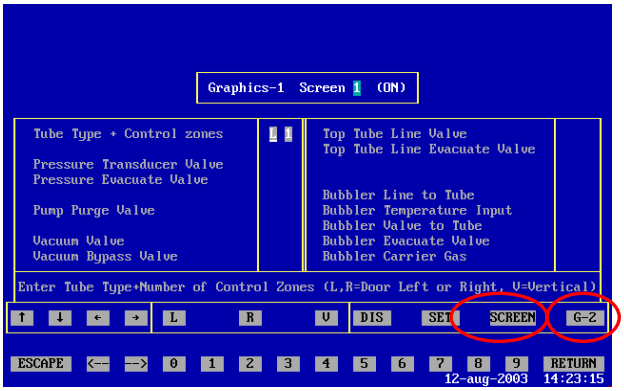
11) select the appropriate gas number (Analog Output number) to place the corresponding gasline in the desired column 1-8

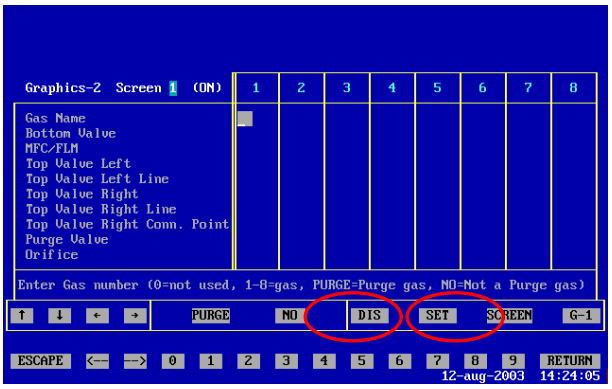
12) select Purge or No purge (default) to define its use for the gasline if applicable

13) select Bottom and/or Top valve + MFC or FLM to match the appropriate DOx numbers

14) select Top Valve Left Line and/or Top Valve Right Line and connect them to 1 out of 4 possible horizontal gaslines

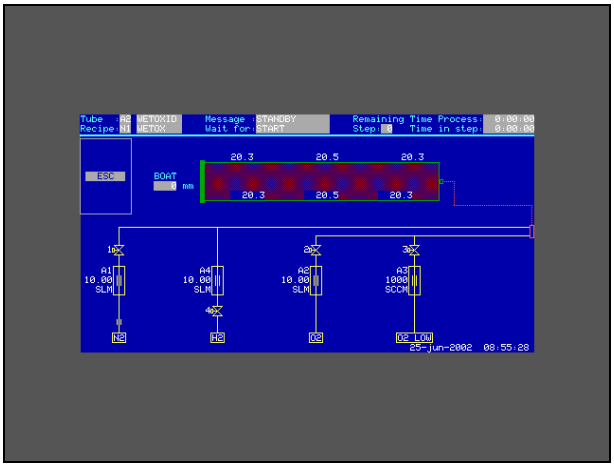
15) select the appropriate purge valve DOx and/or orifice if applicable





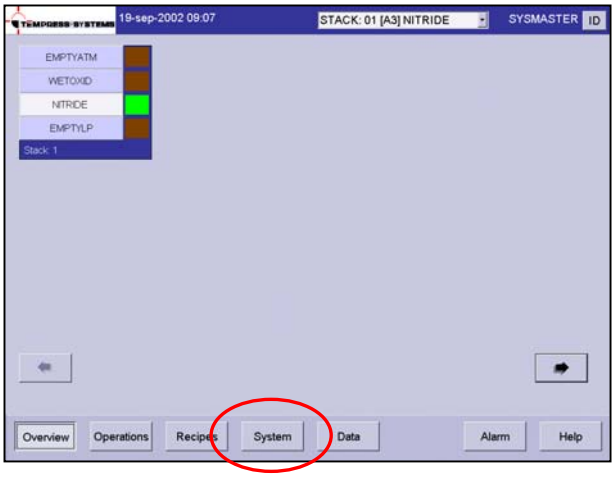
16) select DIS to test the graphical system layout

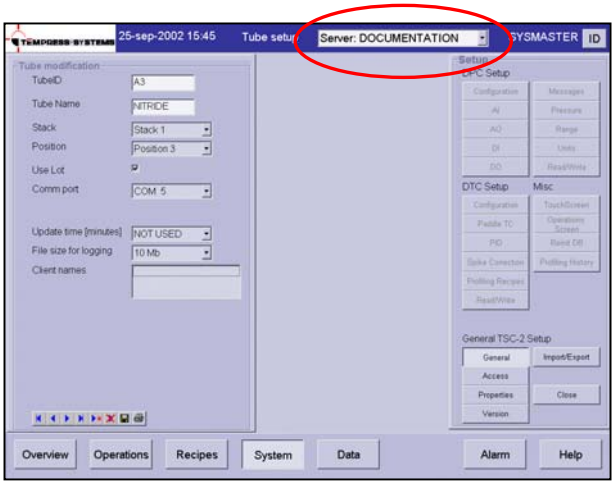
17) select SET to activate the selected screen



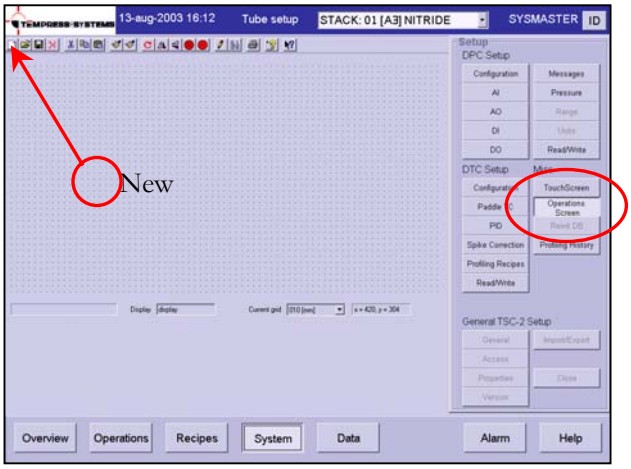
5.10.2 TSC-2

1) return to the main overview screen
2) select 'System' in the navigation bar to access the system overview screen
3) select the desired tube from the pull-down menu or from the previous 'Overview' screen.



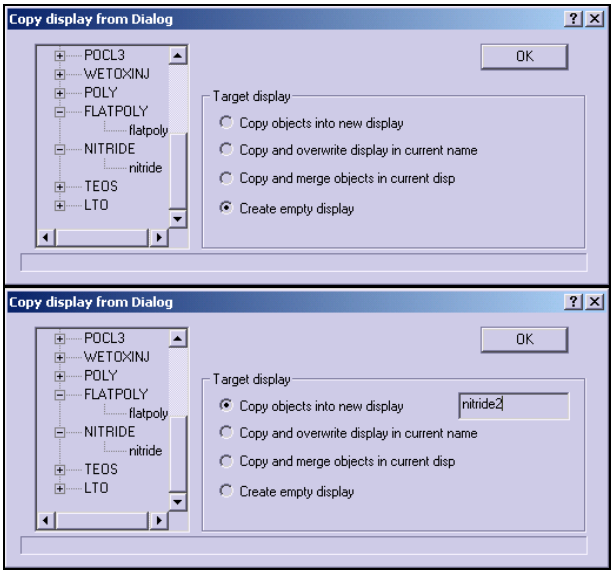


4) select 'Operations Screen' to access the operations screen editor.



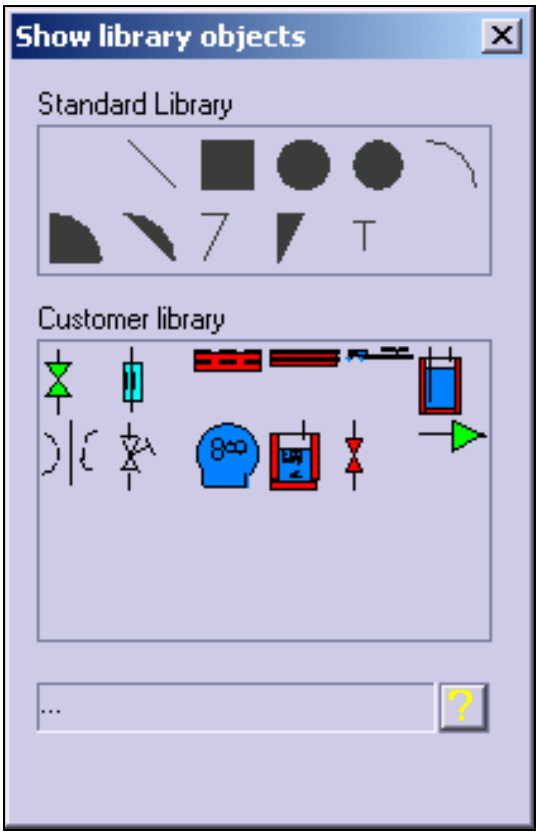
5) select New screen to create a new display
6) previously defined Operations Screens from the same or other tubes can be copied alternatively

Note: It is recommended to use unique display names among tubes by including tube numbers



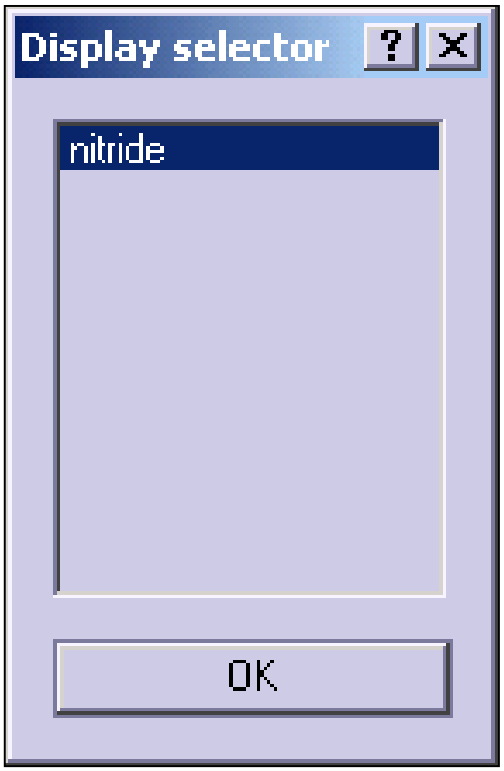
7) select the Object Library button  to gain access to predefined objects
8) standard objects include line, square, circle, ellipse, arc and text objects
9) customer objects include valve, MFC, 3- or 5-zone furnace, loader, bubbler, orifice, needle valve, pump and 3-way valve objects
10) select the desired object by clicking once and place it on the display editor grid

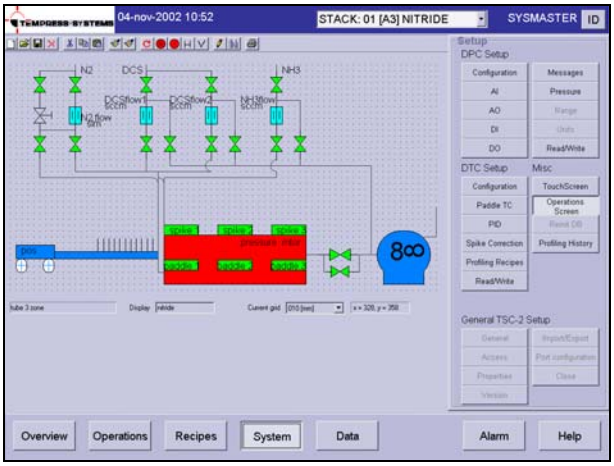
Note: objects can be resized, rotated and repositioned at any time



11) select the Open Dialog button to edit an existing screen

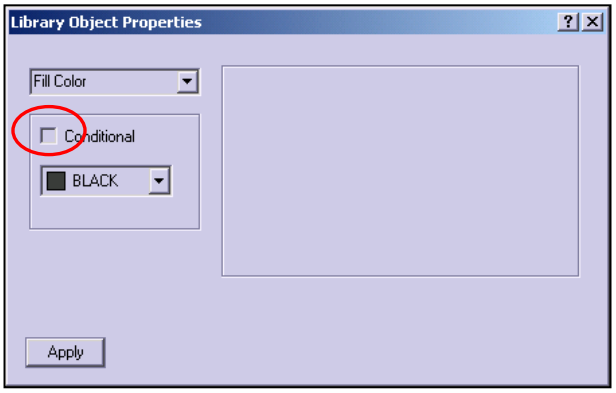
12) an example screen is presented next





13) connect object properties to DPC or DTC parameters by selecting the object and pressing the RMB.

14) Check the conditional box and the condition dialog appears



15) Select Digital condition for ON/OFF change of a property, such as the valve fill color connected to a DO status

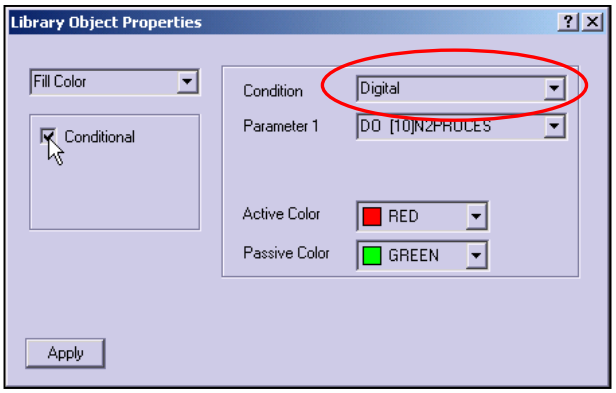
16) Select Data above value for AO minimum value change of a property, such as the MFC fill color connected to an AO status. Recommended value is 0.05

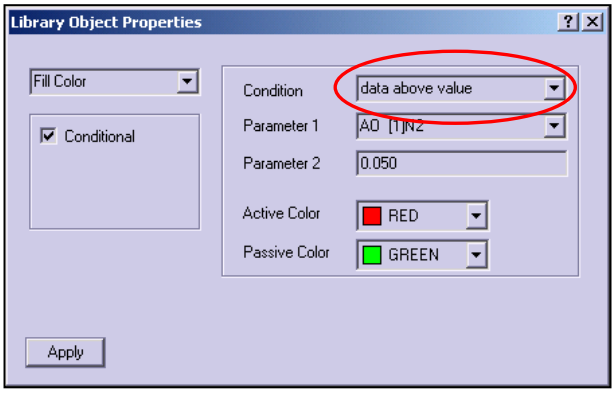
17) Select Absolute for real value change of a text object, such as gas flow (AO) or temperature (spike or paddle)

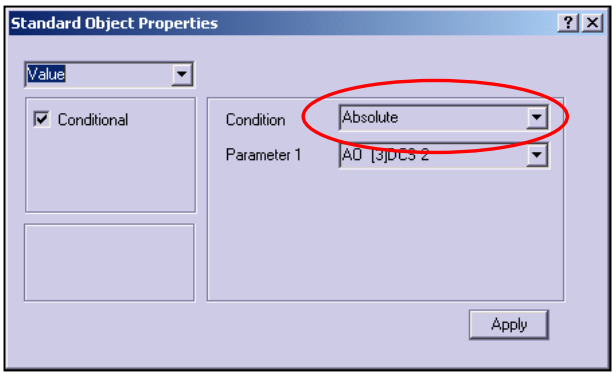
18) Select Relative with Multiply for a relative change, such as the loader object position on the screen connected to the real value boatloader position.

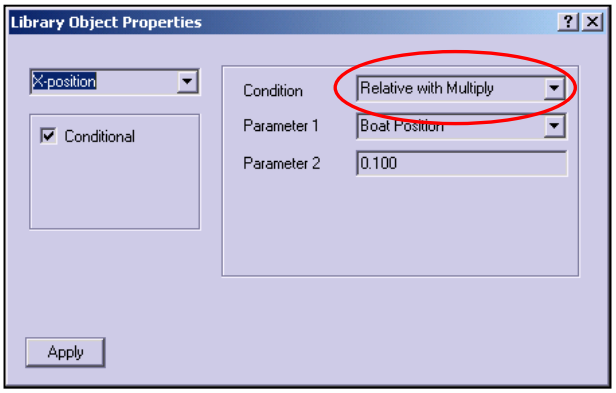
Note: Recommend value is 0.10, it must be verified with actual boatloader travel distance and screen position

Note: make sure to press SAVE to store any modification.







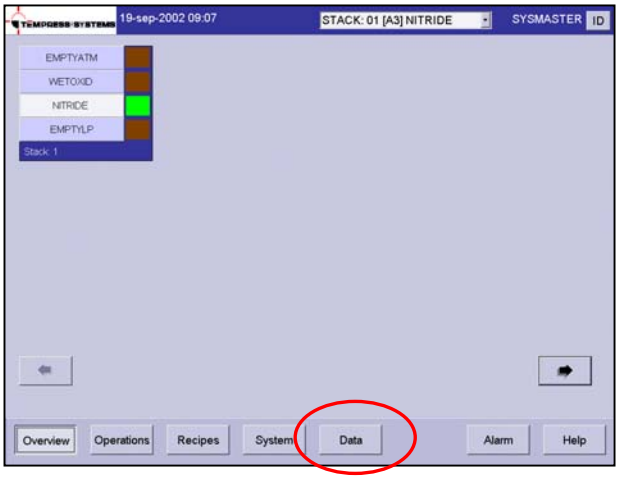


5.11 Logging process data

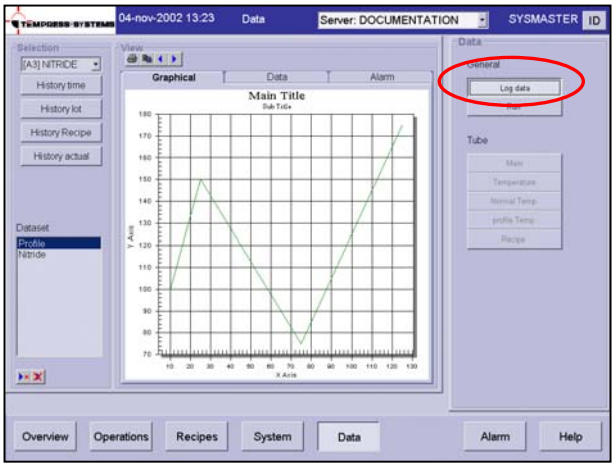
Logging data is automatically collected and can be used to optimize the process based on the process results.
This logging function is only available in TSC-2, not on a touchscreen.

5.11.1 TSC-2 (only)

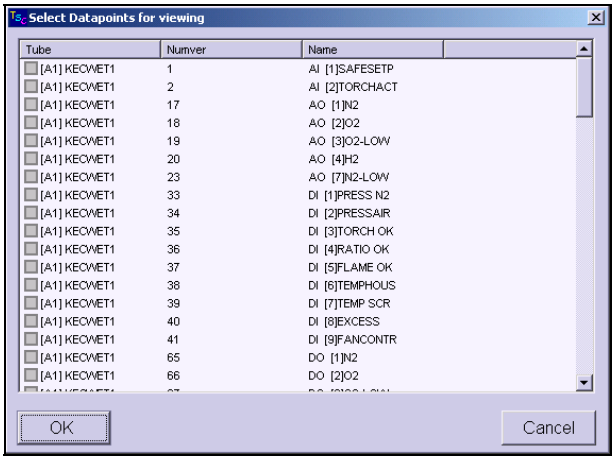
1) Return to the main overview screen
2) Select 'Data' in the navigation bar to access the data logging screen



3) Select Log Data

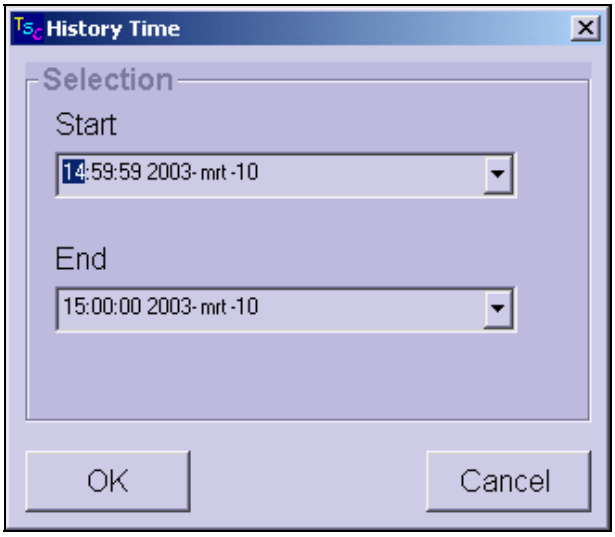


4) Double click on a predefined dataset or use the New button  to create one
5) Select the data points of interest



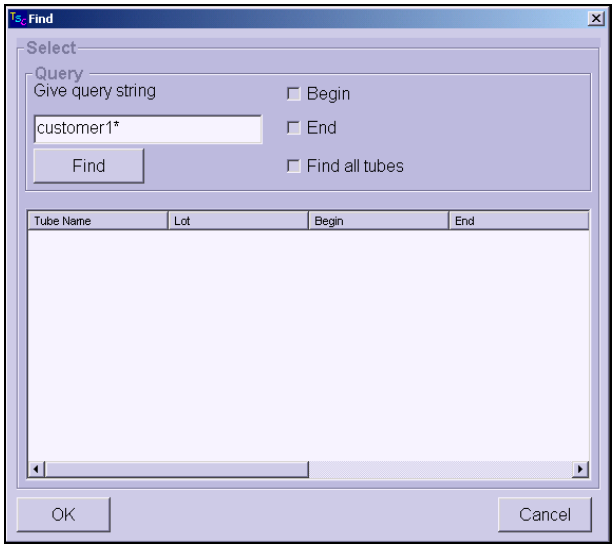
6) Select History Time to select logging data based on a Start and End time.

Note: if the desired Start Time is later than the time already shown, the END Time must be extended first.



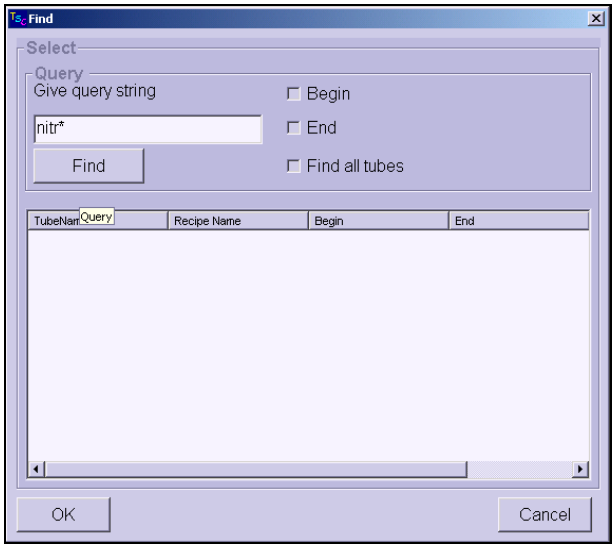
7) Select History Lot to search all logging data for matching Lot IDs.

Note: use wildcards to extend the search

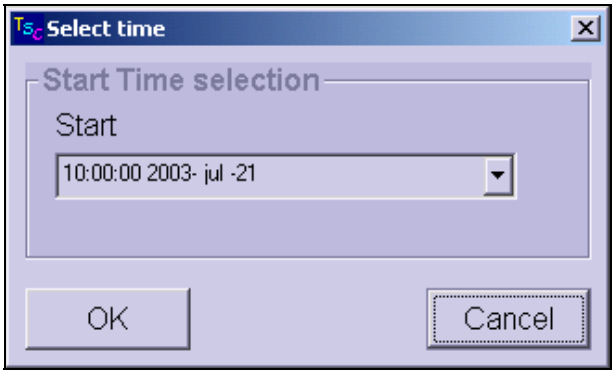


8) Select History Recipe to search all logging data for matching recipe names

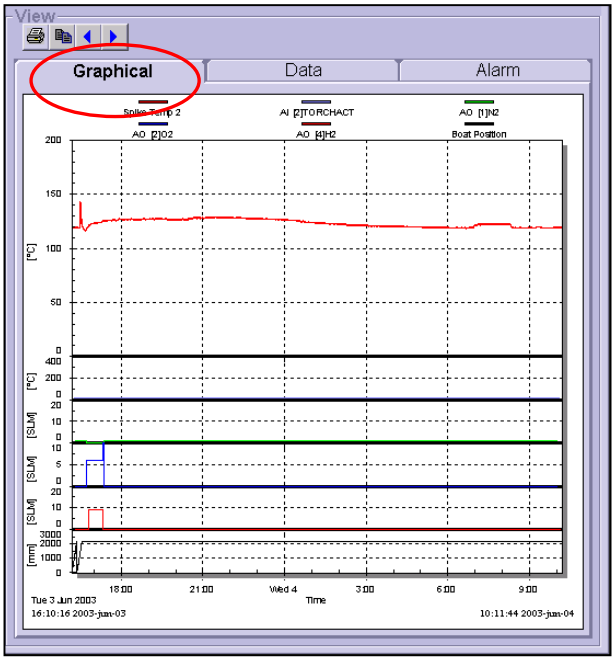
Note: use wildcards to extend the search



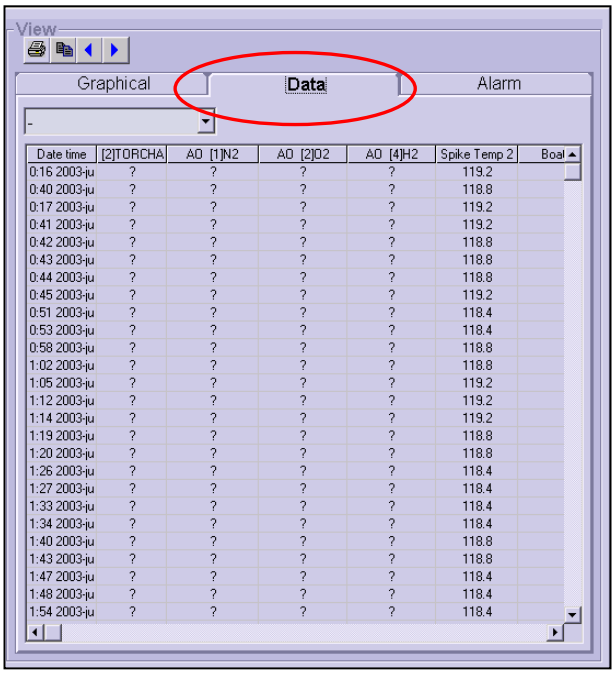
9) Select History Actual for real time logging



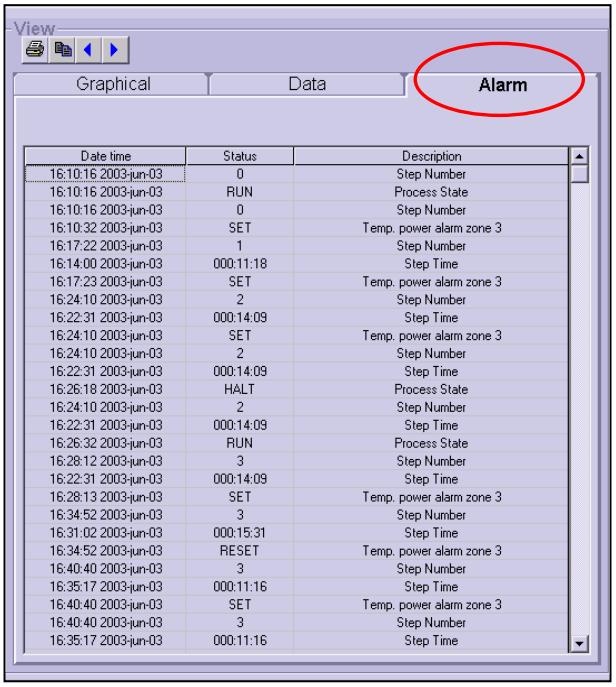
10) Select the Graphical tab page for a graphical presentation of the logging data found by the search criteria above



11) Select the Data tab page for the raw data presentation of the logging data found by the search criteria above



12) Select the Alarm tab page for all alarm messages of the logging data found by the search criteria above



13) Use the Right Mouse Button (RMB) in the Graphical tab page to gain access to the customization dialog. Titles and fonts can be added and/or modified here