Standard Operating Manual

STS ICP-DRIE

Contents

Appendix

STS ICP-DRIE system

1. Picture and Location

Fig.1 STS ICP-DRIE system

The ICP-DRIE etching system is located at NFF Phase II, Room 2240.

2. Process Capabilities

2.1 Cleanliness Standard

The ICP-DRIE etching system is being classified as CLEAN equipment.

2.2 Possible Etching Materials

- Silicon wafer.
- Silicon of SOI wafer.
- Thick poly-silicon film.

2.3 Process Specification

The masking material can be photo-resist or oxide prepared in CLEAN equipment.

2.3.1. What the ICP-DRIE CAN do

- Individual 4 inches single/double side polished full silicon or SOI wafer.

2.3.2. What the ICP-DRIE CANNOT do

- Wafer with metal film is not allowed.
- Defect appearance of the wafer.
- Fragile appearance of the wafer.
- Appearance of the photo-resist is not well baked.
- Appearance of the photo developer on the back side of the wafer.
- No photoresist is allowed on the backside where it can contact the electrode.
- Wafer appears will generate particles during etching process.
- Recipe developed that affects the process repeatability of the machine, i.e. polymerization process, passivation time longer than etch time.
- Wafer that coated with SU8 photo-resist.
- Wafer with heat dissipation grease is not allowed.
- Dummy carrier wafer used must be in CLEAN cleanliness standard.
- Special approval is required for wafer thinner than 400um.
- Special approval is required for incomplete wafer (not full wafer).
- Special approval is required for transparent quartz wafer.

2.4 Etching Process Useful Information

- For less than 10% exposed etching area (we defined as small exposed area), linewidth over 3um, recipe with faster etch rate will be suggested. Typical fast etch rate is around 2um/min.
- For more than 75% exposed etching area, or linewidth is smaller than 2um, recipe with slower etch rate will be suggested. Typical slow etch rate is around 0.5um/min -1um/min.
- For small exposed area etching, typical selectivity of silicon to photo-resist is around

50:1, to LTO is around 75:1, and to thermal oxide is around 85:1.

- For a typical 400um wafer, the minimum holes dimension that can be etched through is 40um in diameter. The aspect ratio for typical etch through process is 10.
- Typical sidewall roughness (scallop) is around 50-150nm.
- When you are using LTO as the masking material, you are recommended to add a photoresist ring mask on the top of the LTO mask. It is because during the LTO deposition, the slot area of the quartz boat deposits less oxide than normal, so the thin oxide area is not enough to mask the deep silicon etch. Please see the ring mask preparation process attachment or consult NFF yellow room staffs for details.
- For deep silicon etch, please do not remove the edge bead of the masking material during mask preparation. Otherwise, the wafer edge will be etched away and damaged, and also leave residue in the chamber.
- If you are going to do the etch-through process or deep silicon etch (200um<), please prepare a 4 inch bare silicon carrier wafer for holding your wafer for the last 150-200um etch. In case of the etch breaking through, the wafer may be caused crack due to the backside Helium flow in the wafer chuck, then helium leaks into the chamber and it raises the pressure and abort the system. However, The carrier wafer will increase the etch-rate due to the thermal conductivity effects and also the selectivity of the mask material will be degraded, so a good process parameter control is required
- Please do not put any patterns in the outermost 8mm circumference area, because the wafer clamp fingers hold the wafer in this area.
- Due to the loading effects, the large open area patterns always etch faster than closely packed patterns.
- During the process, a thin polymer film is deposited and need to be removed after etching. An EKC solution is advised by manufacturer to remove this kind of polymer and you can ask lithography module staffs for details. Be careful the polymer film is one of the contamination sources in a high temperature process.
- Before starting your etch process, please make sure that you have a 5-10 minutes

"condition" run in order to ensure the equipment stability.

For more details information about the DRIE process, please consult NFF etching module staffs.

3. Useful information to work in NFF

3.1 Emergency Responses and Communications

In case of emergency issues, please contact NFF staffs,

- Preason Lee – Deputy Safety office (x7900).
- CK Wong – senior technician (x7226).

In case of technical help, please contact NFF staffs,

- CK Wong – senior technician (x7896).
- Casper Chung –technician (x7896).
- Brial Kwok – technician (x7896).

3.2 Become a Qualified ICP-DRIE User

Please follow the procedures below to become a qualified user of the ICP-DRIE:

- Read all materials provided on the NFF website of the ICP-DRIE.
- Request ICP-DRIE operation training and examination online.

4. Operation Safety and Rules

4.1. Operation Safety

4.1.1 General Safety

NFF user must familiar themselves with the following general safety issues:

- Location of emergency exits and assembly points
- Procedures for obtaining first aid assistance must be known.
- Various alarm sounds and emergency call procedures must be known.

4.1.2 Equipment Safety

ICP-DRIE user must be aware themselves of the following equipment safety issues:

- In emergency when using the equipment, push the red emergency button (Fig. 2) to interrupt the equipment power, and report to the NFF staffs immediately. DO NOT attempt to resume the equipment on before the problem is solved.
- If the equipment fails while being used, never try to fix the problem by your own, please write down the alarm information and report to NFF etching module staffs. Alarm/warning message will be displayed at the bottom of the screen (Fig. 3). DO NOT attempt to resume the equipment on before the alarm/warning message is verified.
- Be careful to the components of the equipment, which involves high magnetic field, RF radiation and high temperature hazard.

Fig 2 Emergency button (ESO)

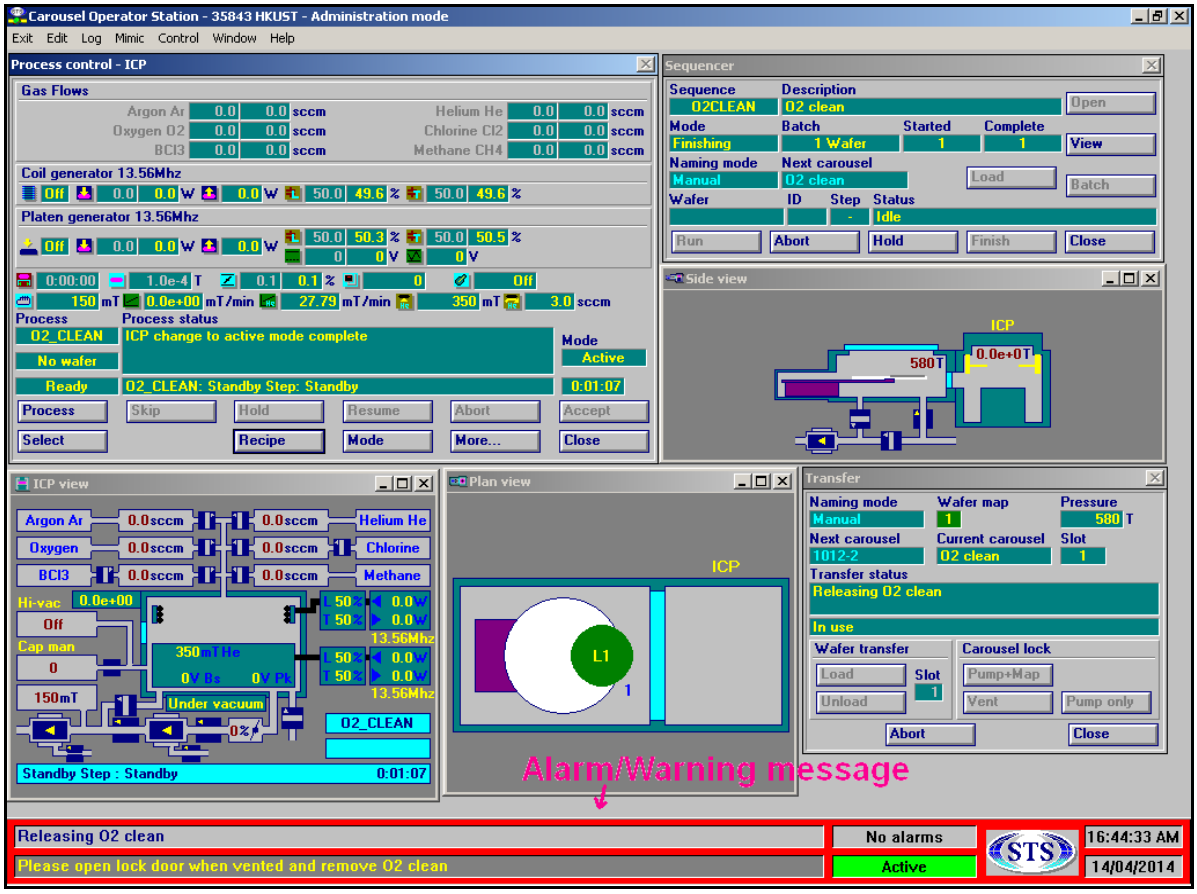


Fig.3 Alarm/Warning message

4.2 Operation Rules

- Do not operate the equipment unless you are properly trained and approved to operate the equipment.
- ICP-DRIE can be reserved in NFF administration office (room 4218) within office hour.
- ICP-DRIE allows ad-hoc reservation on Monday and Thursday in NFF laboratory with the designated computer (Fig.4). Each ad-hoc reservation session is one hour, and user cannot reserve two consecutive ad-hoc sessions.
- Reservation will be forfeited if user does not show up and check-in within half of the session time and it may cause a $200 penalty.
- Please fill all the details of the log-sheet attached, i.e. date, name, project number, email, project details, material …
- Do not leave an on-going etching process unattended.
- Do not skip any purge steps during process running.

- Do not change details of the recipe unless you are authorized to do. If you need to start a new recipe, please consult NFF etching module staffs.

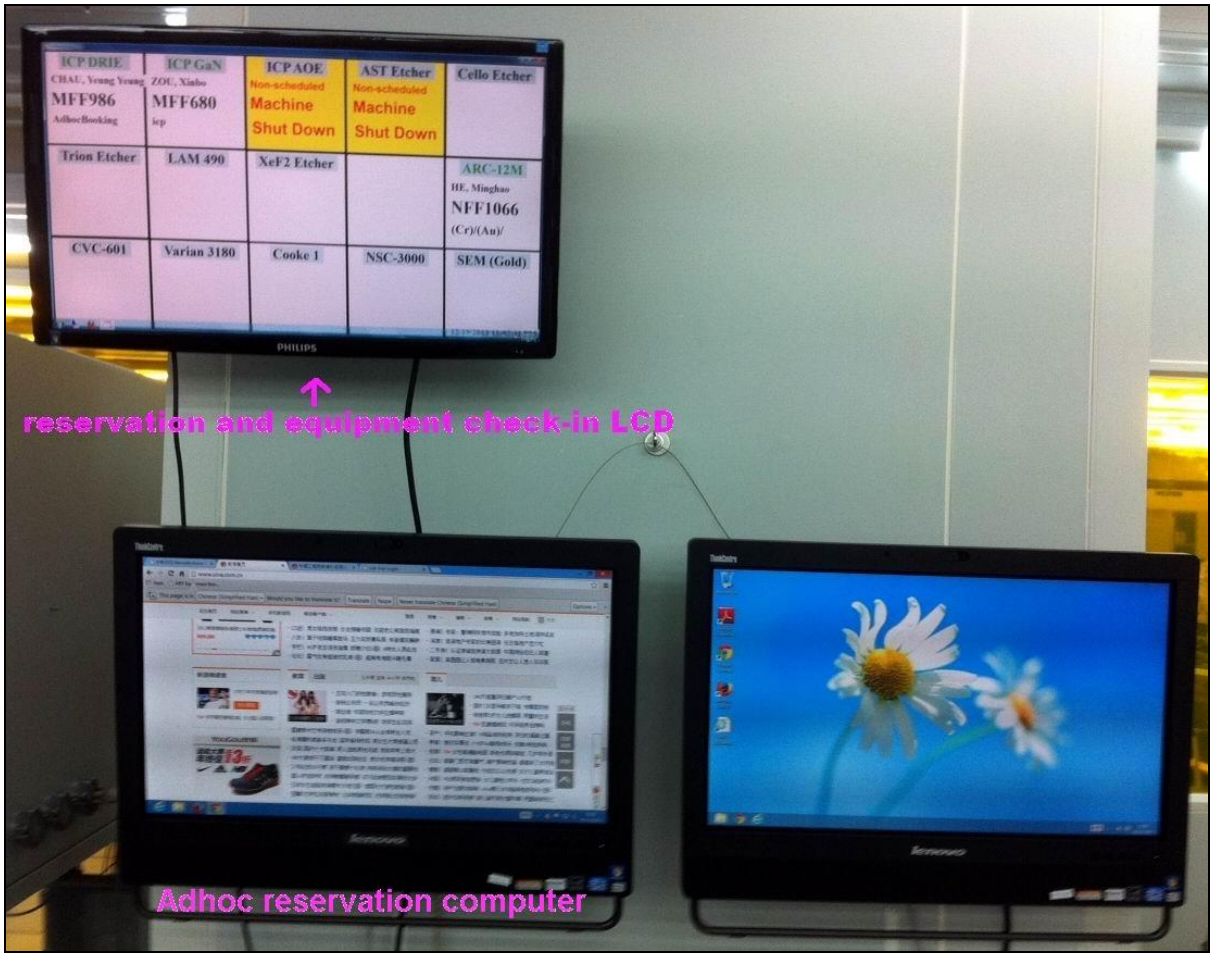


Fig.4 Reservation and Equipment check-in status LCD

5.0 System Operation

5.1 ICP DRIE System Description

The STS ICP-DRIE system (電感藕合電漿深反應離子刻蝕機) is used to etch deep silicon trench by employing alternative passivation/etch(Bosch) & parameter ramping technique, which offer a highly anisotropic etch with low undercut. However, due to the Bosch process, unavoidable scallop phenomena is expected to happen and also a thin layer of polymer will be formed during the passivation step.

The ICP system apply inductive coupled design, so high density plasma can be formed in the process chamber, this in return provide a high Si etch rate. Normally, SF6 and C4F8 gases are

used for the etching and passivation respectively, and He gas is used for backside cooling to ensure better control of the etch rate.

5.2 Initial Status Check

- Please check the equipment status from the shutdown notice board in the NFF reservation website.
- If the equipment has been reserved, please check the name and project number that displayed on the dedicated LCD screen are correct (Fig. 4).
- Please check-in the reserved equipment on your own within half of the session time. To do the check-in, please scan your NFF access card over the card reader attached.
- If you are failed to check in the equipment, there is an interlock, and you cannot operate the equipment normally.
- Before operate the equipment, make sure you have read and fill the details of the log-sheets attached.

5.3 Initial System Check

Normally, there are 5 operation modes, Administration, Development, Standard, Production and Monitor mode. In this manual, all the operation details will be described based on the administration mode operation.

- Check the mode of operation shown in the operation screen (Fig.5). It should be logged in Administration or Production mode in order to make any changes in the process parameters.
- Check there is no alarm/warning message displayed at the bottom of the screen.
- Check there are six operation screens are available, i) Process Control screen, ii) Sequencer screen, iii) Side view screen, iv) ICP View screen, v) Plan view screen and vi) Transfer screen.
- Check the system status must be in “ACTIVE” mode at the lower right corner, it means the system is READY for etching process.
- Check any wafer left in the load lock or process chamber through the view port glass of

the equipment or operation screen.

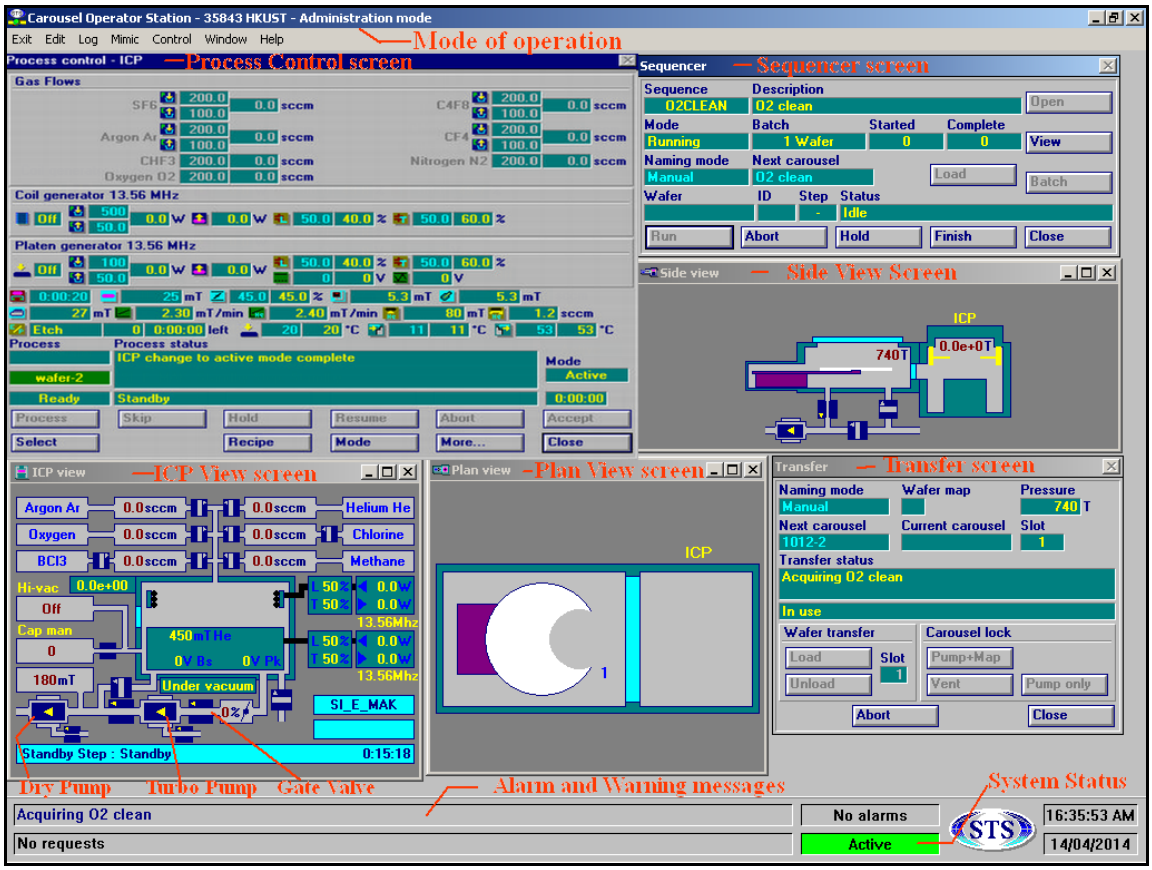


Fig.5 System operation screen

5.4 Preparation before Etching Process

ICP-DRIE users are advised to do the following steps before doing the etching process.

- Make sure the shut-off valve of the C4F8 gas cylinder is open and gas line is pressurized, so that the gas can be delivered to the system (Fig. 6). The gas cylinder was located right side behind the equipment, and the full pressure should be over 40 psi, and can be observed on the gauge attached to the gas cylinder.
- Check the electrode cooling chiller is turned ON and default temperature is 23^{o}C (Fig. 7). The chiller was located right side behind the ICP-Poly equipment.

Fig.6 C4F8 gas cylinder

Fig.7 ICP-DRIE electrode cooling chiller

6. Introduction to ICP operation control system

As mentioned, there are six operation control screens available in the main screen, i) Process Control screen, ii) Sequencer screen, iii) Side view screen, iv) ICP View screen, v) Plan view screen and vi) Transfer screen. In the following section, details description of the screens will be given:

6.1 Process Control screen

The process control screen allows the operator to view the current chamber status, which execute, hold and resume the processing as necessary. It also consists of 1) Gas flows, 2) RF power supplies, and 3) Process Status as shown in (Fig.8).

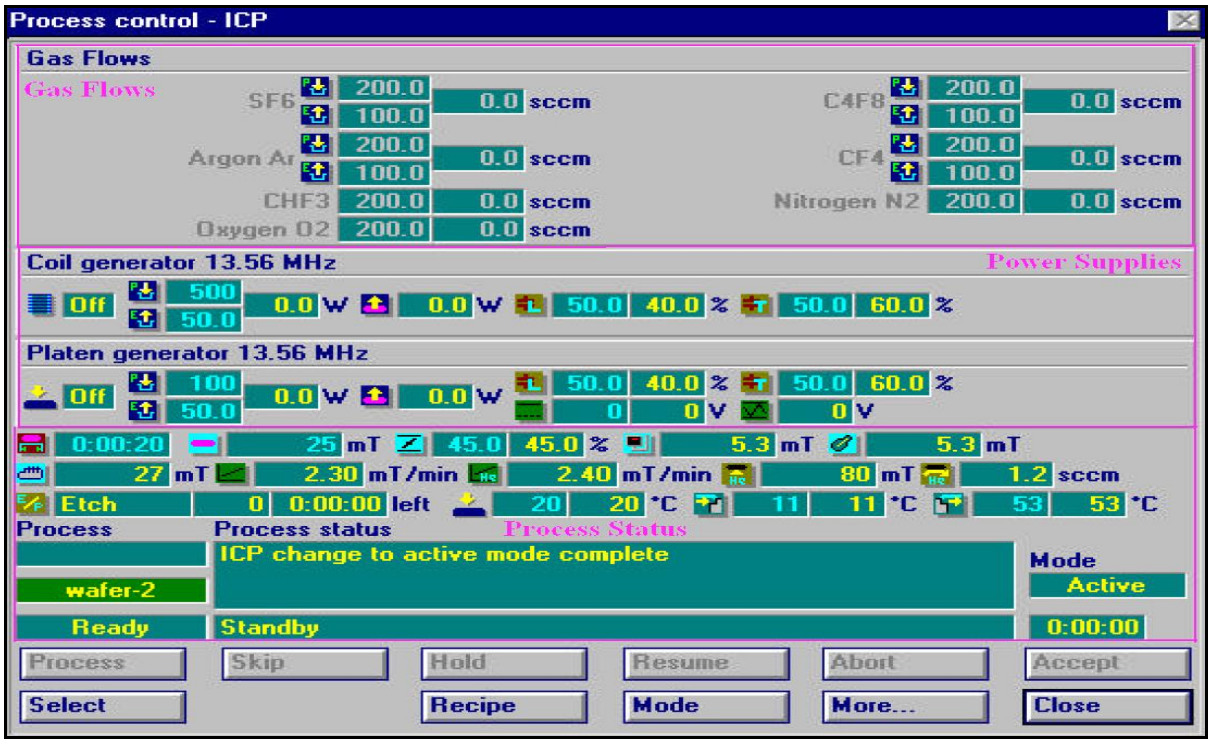


Fig.8 Process Control screen

- **Gas Flow**

The Gas Flow section states the gases name and each gas flow rate in sccm (Fig.9a).

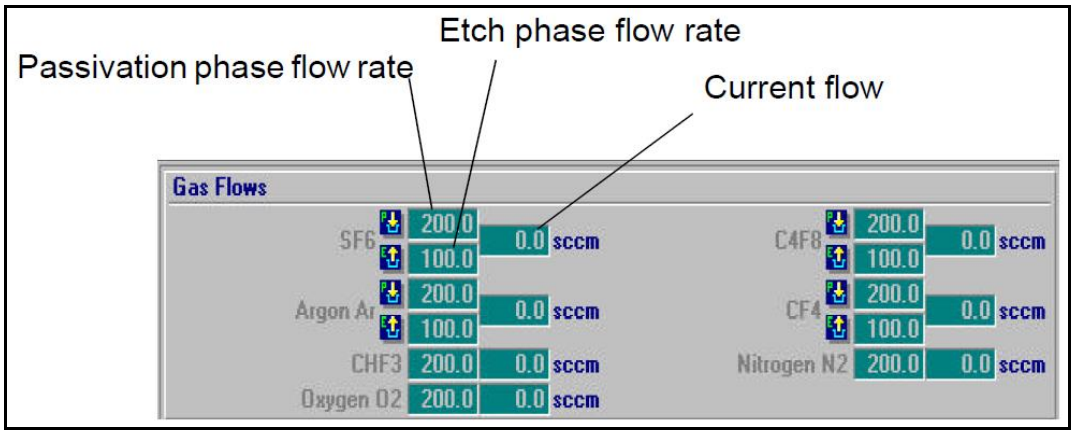


Fig. 9a Gas flow section

- **RF Power Supplies**

The RF Power Supplies section states both RF power set points of coil and platen of both etch/passivation phase, including current forward and reflective power, also status of the matching unit (Fig.9b).

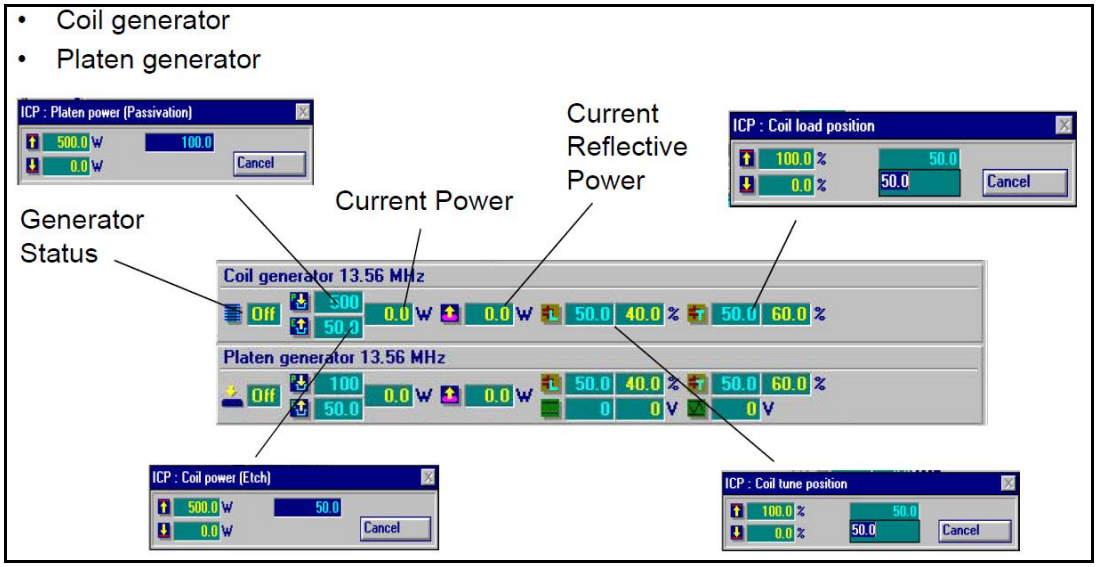


Fig.9b RF Power supplies section

- **Process Status**

The status of the process can be monitored in the chamber process status section (Fig 9c).

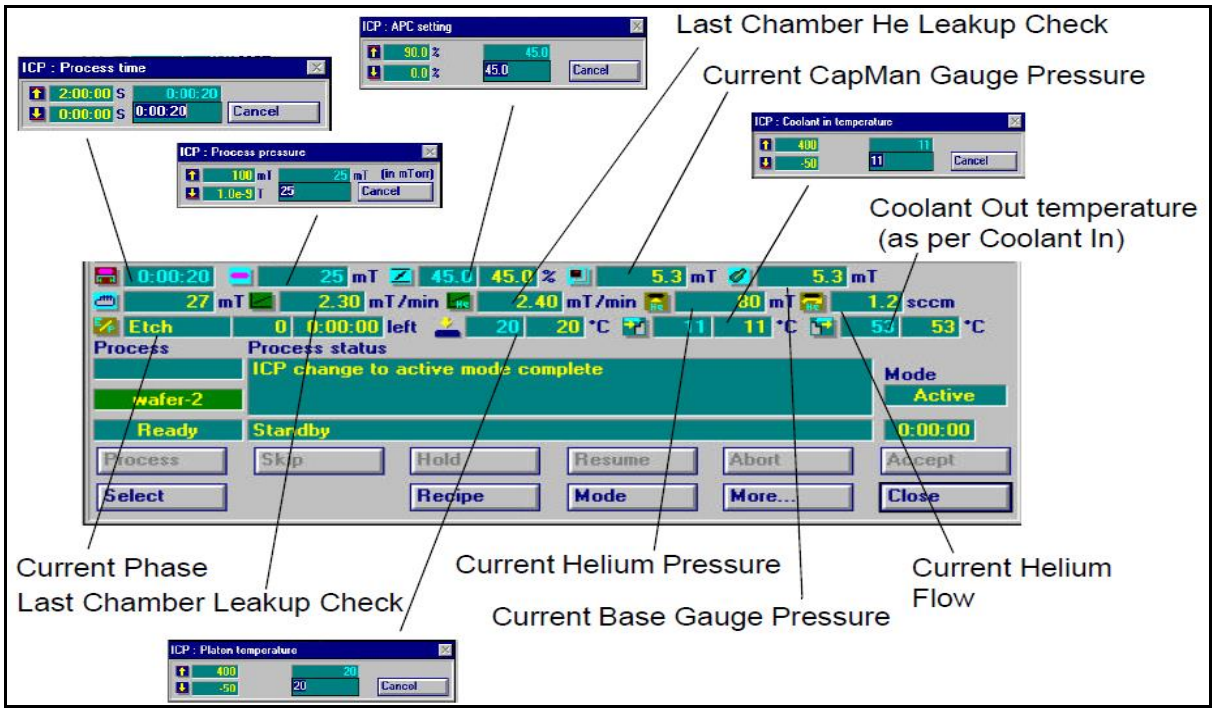


Fig.9c Process Status section

In the following, a brief description of the function keys that helpful to user will be given:

Process: This key can initiate the current selected process.

Select: This key can open the "Run ICP process" dialog (Fig.9d). In this dialog, all the recipes can be selected. If "PROCESS" key is then pressed, the system will load and initiate

running of the highlighted process recipe. Otherwise, if SELECT key is pressed, then the system will load the highlighted process recipe for viewing or editing, and this will not initiate the process.

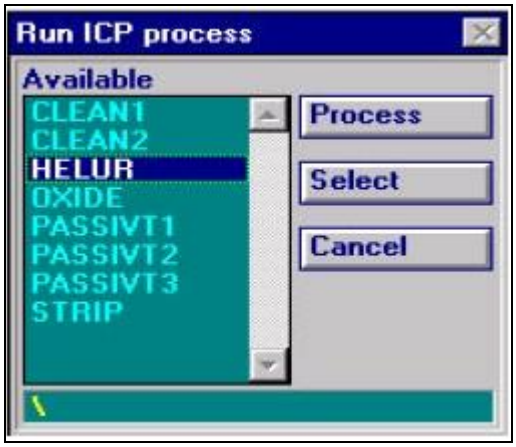


Fig. 9d Recipe Run dialog

Skip: This key can use to skip the current process step.

Hold: This key can place the process that is running in the Hold condition.

Resume: This key can resume the process that is in the Hold condition.

Abort: This key can abort the current running process.

Accept: When there is a fault, alarm or warning, a message will be displayed at the bottom of the display (Fig.3), and this key is use to acknowledge and clear a fault report dialog once the fault, alarm or warning is cleared.

Mode: DRIE user is not allowed to use.

More: DRIE user is not allowed to use.

Recipe: This key can open the Process Recipe editor dialog. In the process recipe editor, user can select their own recipe. The following section will describe the Recipe Editor in details.

6.1.1 Process Recipe

According to the rules of Intellectual Property, ICP-DRIE users must use their own recipe, and do not use the recipe of other's without permission. A heavy penalty will be given to the users if they are found to override the rule. In addition, please be reminded the system cannot write protect user's recipe, and the recipe may has chance to be changed by other user

accidentally. So, all user has own responsibility to backup and check the recipe details themselves. Before saving a recipe, DRIE user must check carefully the recipe name is correct. A heavy penalty will be given to the users if they are found to change other's recipe.

A recipe is consists various "steps" together with various "pages", as shown in figure10.

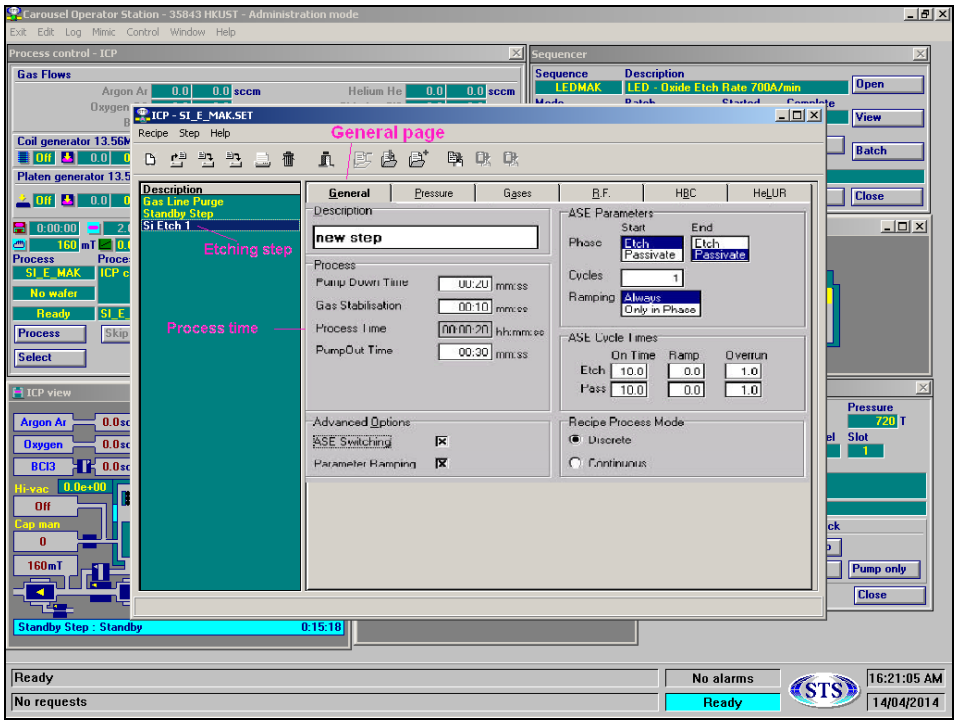
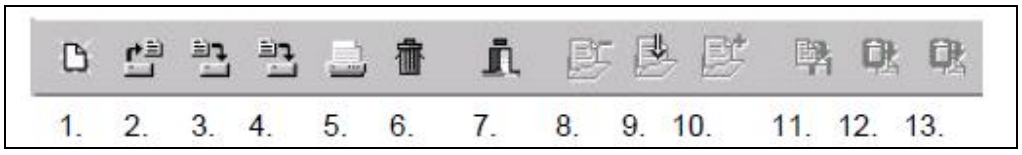


Fig.10 Recipe editor screen

There is a tool bar located on the top of the recipe editor; details of the function will be described in the following:



1. New Recipe: To create a new recipe.
2. Open Recipe: To open an existing recipe for editing or viewing.
3. Save Recipe: Save the current recipe settings under the current file name.
4. Save Recipe as: Save the current recipe settings under a different file name.
5. Print Recipe: Not available
6. Delete Recipe: Deletes recipe.
7. Exit: Exits the recipe editor.
8. Delete Step: Deletes the selected step.

9. Insert Step: Inserts a new step immediately before the selected step.
10. Append Step: Adds a new step after the last step.
11. Copy step: Copies all the setting of the selected step.
12. Insert step: Inserts a previously copied process step.
13. Append copy: Appends a previously copied process step.

6.1.2 Steps and Pages description

6.1.2.1 Steps

Typically the recipe consists of at least three steps, gas line purge step, standby step, and one or more recipe steps:

Gas Line Purge step: this step purge the gas lines and chamber before process recipe step. However, user is not allowed to change parameters in this page.

Standby step: this step used at the start and end of a process recipe, to ensure that the process chamber is pumped down to base pressure and ready to start processing. However, user is not allowed to change parameters in this page.

Etching step: this step contains etching parameters in various pages, and will be described in the following

6.1.2.2 Pages

In the etching step, it contains six pages, i) General, ii) Pressure, iii) Gases, iv) RF, v)HBC, and vi) HELUR pages, and will be described in the following (Fig.10):

i) General Page

The general page contains the following components:

Description: A maximum of 16 characters can be inputted as description of the process step.

Process:

- **Pump Down Time:** The maximum time allowed pumping down to base pressure. If the system fails to achieve base pressure within the programmed time, a fault message will be displayed on screen. If a fault message is displayed, the system will continue to pump

down to achieve base pressure. However, DRIE user is **not allowed** to change this parameter.

- **Gas Stabilization:** The time between process gases being introduced to the chamber and the RF being switched ON. However, the default value is 30 seconds, DRIE user is **not allowed** to change this parameter.
- **Process Time:** The time RF power ON, is automatically calculated using cycle time parameters, and DRIE user can input the time or cycles required for the etching process.
- **Pump Out Time:** The time allowed for pumping out the chamber after one process step has finished and another one starts. However, DRIE user is **not allowed** to change this parameter.

Advanced Options:

- **ASE Switching:** This switching permits the operator to switch between an etching process and a passivation process. The primary control of a profile is achieved by changing etch/deposition step times ratio. More deposition time gives less re-entrant, more positive profiles, and more etch time gives more re-entrant, less positive.
- **Parameter Ramping:** This parameter ramping permits the operator to ramp the start/finish of etch and passivation process. The pressure, cycle time, gas flow and the coil/platen power can be ramped to maintain the profile at a satisfactory etch rate and high selectivity. For each parameter, the ramping operation will be defined by a start value and a ramp rate. For example, a gas flow might be set to a start value of 50 sccm and a ramp up rate of 3 sccm/min. In a 10 minutes process step, this would result in a flow rate of 80 sccm. The ramp rate may be set to positive or negative values. However, DRIE user must consult any etching module staffs before changing this parameter ramping option.

ASE parameters:

- **Phase:** If the start and end phases are different, the process will complete a whole number of cycles. If the start and end phases are the same, the process will complete an

addition half cycle. However, default setting is “different” in phase and DRIE user is **not allowed** to change this parameter without permission from etching module staffs.

- **Cycles:** DRIE user can input the number of cycles required for the process.
- **Ramping:** Available to the parameters set on the Gases page when “Parameter Ramping” is selected. Select “Always” if ramping is required throughout the process, i.e. on both etch and passivation phases. Select “Only in Phase” if ramping is required only during the active phase of the process. However, default setting is “Always” ramping and DRIE user is **not allowed** to change this parameter without permission from etching module staffs.

ASE Cycle Times:

- **On Time:** The time DRIE user is required to set for both etch and passivation cycle. However, DRIE user is **strictly prohibited** to set passivation time longer than etch time to prevent polymer deposition.
- **Ramp:** The time increment in seconds/cycle for each phase. However, user is **not allowed** to set such ramping parameter before getting approval from NFF etching module staffs.
- **Overrun:** The time which the process can overrun. The default value set is 0 second; however DRIE user is **not allowed** to set such ramping parameter before getting approval from NFF etching module staffs.

Recipe Process Mode:

- **Discrete:** In this mode, the chamber is pumped down before each process step and pumped out after each process step. The defaults setting for this is “Discrete” mode and DRIE user is **not allowed** to change this parameter before getting approval from NFF etching module staffs.
- **Continuous:** In this mode, the chamber is pumped down before the first process step and is only pumped out after the final process step.

ii) Pressure Page

This page permits user to set the Automatic Pressure Control (APC) valve in either the Automatic mode or Manual mode (Fig.11).

In **Automatic mode**, the valve will move to the optimum position to achieve the required chamber process pressure. The following provides details description of the automatic mode (pressure mode) function:

- **Pressure:** The process pressure at which the process runs. However, we do not encourage DRIE user to change this parameter by your own, please consult NFF etching module staffs when you need to make adjustment to this parameter.
- **Tolerance:** The allowed tolerance as a percentage of the process pressure. The default value is 20%, but for fast switching process up to 50% is understandable. However, DRIE user is **not allowed** to change this parameter before getting approval from NFF etching module staffs.
- **Base Pressure:** The base pressure where the chamber must be pumped to before gas stabilization starts. The default value is 0 mTorr, however, DRIE user is not allowed to change this parameter.
- **Pressure Trip:** The pressure at which the trip should activate to prevents the chamber from over pressurizing. If the trip pressure is exceeded, the process will be aborted. The typical trip pressure for DRIE is 94mTorr, and user is not allowed to change this parameter.

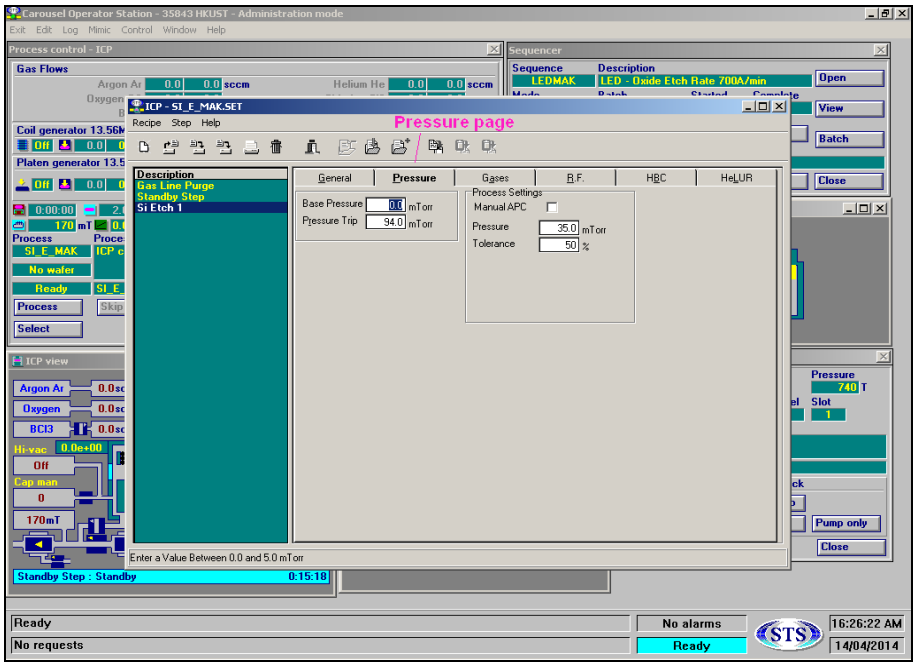


Fig. 11 Pressure page automatic mode screen

In M**anual mode** (fixed APC mode), the valve will move to dedicated position and the process pressure will be stabilized according to the amount of gases flow. The following provides details description of the manual mode function (Fig.12). However, DRIE user is **not allowed** to change this mode of operation before getting approval from NFF etching module staffs.

- **APC setting:** Input a value for the APC angle in the range of 0.1 to 100%
- **Base Pressure:** same as Automatic mode.
- **Pressure Trip:** same as Automatic mode.

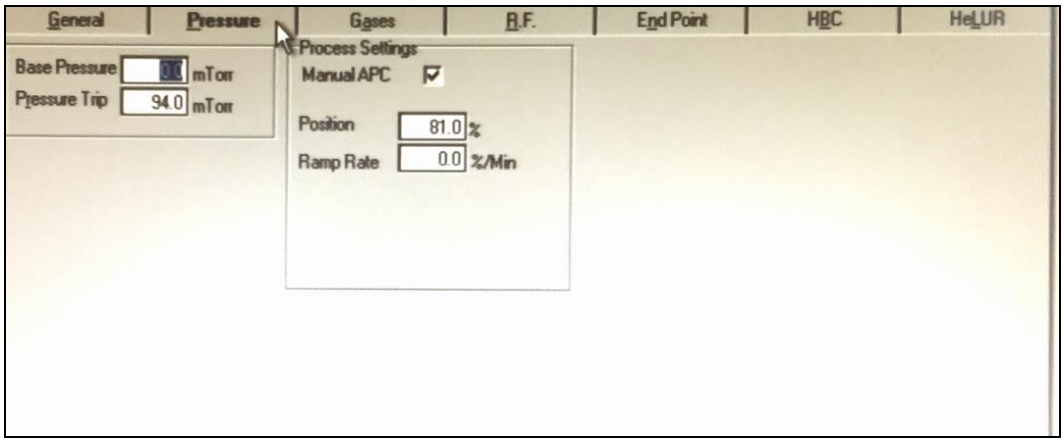


Fig.12 Pressure page manual mode screen

iii) Gases Page

Details in the gases page will be described in the following (Fig.13).

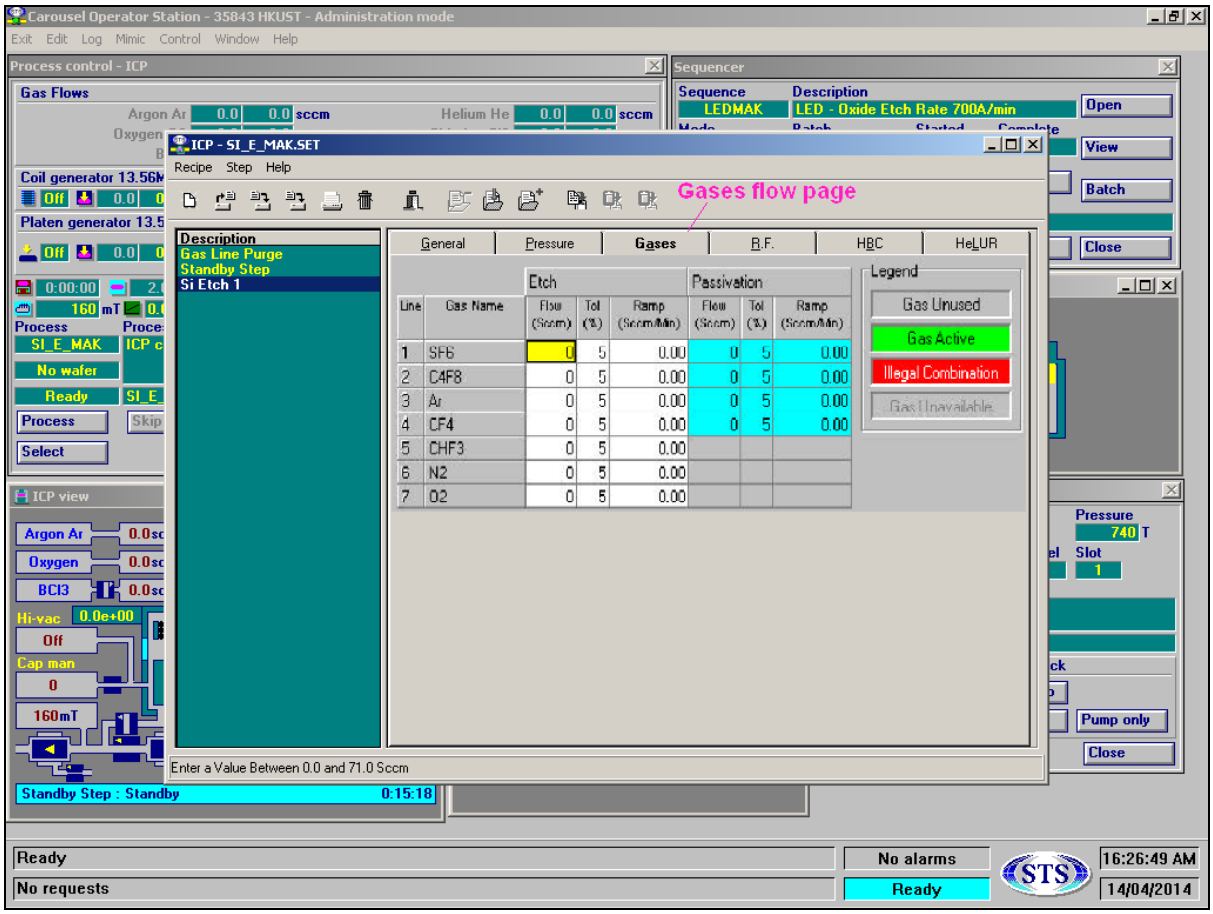


Fig.13 Gases page screen

- **Etch:** Flow, Tolerance and Ramp parameters in the etch phase can be input for each gas in the process. Typically SF6 and O2 gases will be introduced in the etch phase, but sometimes C4F8 will also be introduced depends on the process. However, if you are not sure how to set these parameters, please consult NFF etching module staffs.
- **Passivation:** Flow, Tolerance and Ramp parameters in the passivation phase can be input for each gas in the process. Typically, C4F8 will be introduced in the passivation phase to do the sidewall passivation. However, if you are not sure how to set these parameters, please consult NFF etching module staffs.
- **Flow:** The gas flow rate in sccm.
- **Tolerance:** The allowable flow rate variation as a percentage of required flow.
- **Ramp:** The gas ramp rate in sccm/minute if parameter ramping function is selected.

However, the system does not allow ***illegal gas combinations***. Once a gas has been used in a process, any illegal gases are automatically excluded for the rest of the process. For example, when O2 is selected, then CH4 and BCl3 will be excluded for selection (Fig.14).

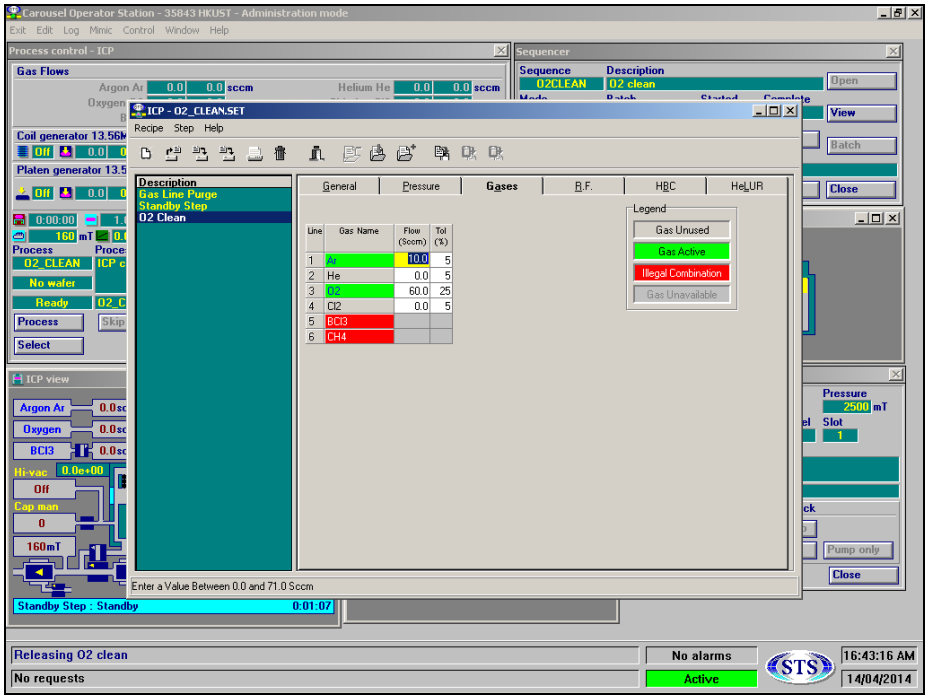


Fig.14 Illegal gases combination

iv) RF Page

Power, Tolerance and Matching parameters in etch/passivation phase can be input in this page. However, please consult NFF etching module staffs if you are not sure how to set these parameters. DRIE user who failed to set the RF page will cause serious damage to the equipment. The following provides details description of the RF page (Fig.15).

RF Mode, DRIE user is **not allowed** to change these setting.

- **Platen Only:** Select the RF platen generator required for the process recipe.
- **Coil Only:** Select the RF coil generator required for the process recipe.
- **Simultaneously:** Enables both RF generators to be viewed. This is the default setting of the RF mode in DRIE system.
- **Etch/Passivation Power:** Power in etch/passivation phase of the process can be input in this page. However, please consult NFF etching module staffs if you are not sure how to set these parameters.

- **Tolerance:** The allowed tolerance as a percentage of the RF power. The default value is 20%, but for fast switching process up to 50% is understandable. However, DRIE user is **not allowed** to change this parameter before getting approval from NFF etching module staffs.
- **Matching:** Select the mode of operation, MANUAL or AUTO. The default setting is AUTO mode; however DRIE user is **not allowed** to change this setting.
- **Match Load/Tune:** The preset starting position of the load/tune capacitor, defined as percentage of 0 to 90%. However DRIE user is **not allowed** to change these parameters.

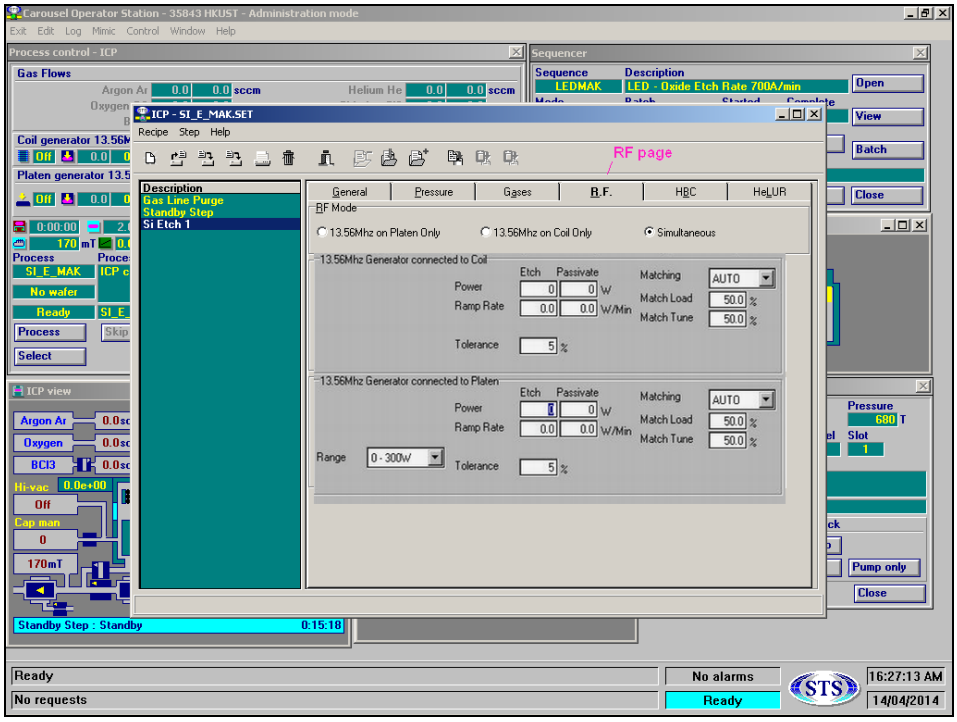


Fig.15 RF Page screen

v) Helium Backside Cooling (HBC) Page

This page controls helium backside cooling of the wafer, and details will be described in the following (Fig.16). However, HBC must perform for every etching process, DRIE user is **not allowed** to change these setting.

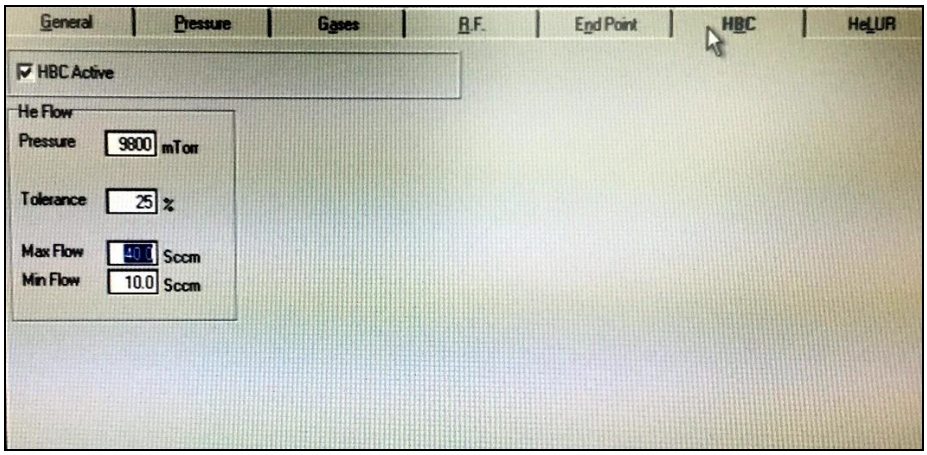


Fig.16 Helium backside cooling (HBC) screen

- Pressure: The helium backside cooling controlled pressure. The typical helium backside cooling pressure was controlled in 9800mTorr.
- Tolerance: Pressure tolerance as a percentage. Typical tolerance set is 25%.
- Max Flow: The maximum flow value should be set 40 sccm.
- Min flow: The minimum flow value should be set 10 sccm.

vi) HeLUR (Helium leak-up rate) Page

Details in the Helium leak up rate (HeLUR) page will be described in the follows (Fig.17):

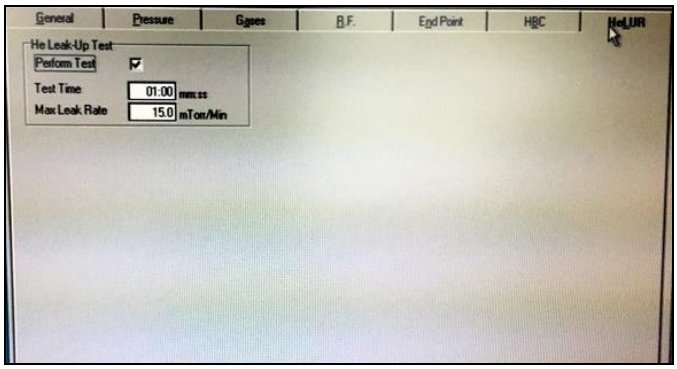


Fig.17 Helium leak up rate screen (HeLUR)

- **Perform Test:** Helium leak up rate test is always performing for etching process. DRIE user is **not allowed** to change this setting.
- **Test Time:** The helium leak up test time period. Typical test time should be 1 minute.
- **Max Leak Rate:** The maximum allowed He leak up rate. Typically, the maximum leak up rate should not exceed 15mTorr/min.

If there is any problem to set a recipe, please consult NFF staff for help. However, user has

their own responsibility to tune a recipe, and we cannot provide a recipe that fits the requirement of all users.

6.2 Sequence screen

The process sequencer provides the means to run a process automatically. It monitors and controls wafer movement through the system as defined by the selected sequence (Fig.18). The sequence includes wafer transportation, processing, and loadlock chamber venting phase. In the following, sequencer's function keys that useful to the user will be described:

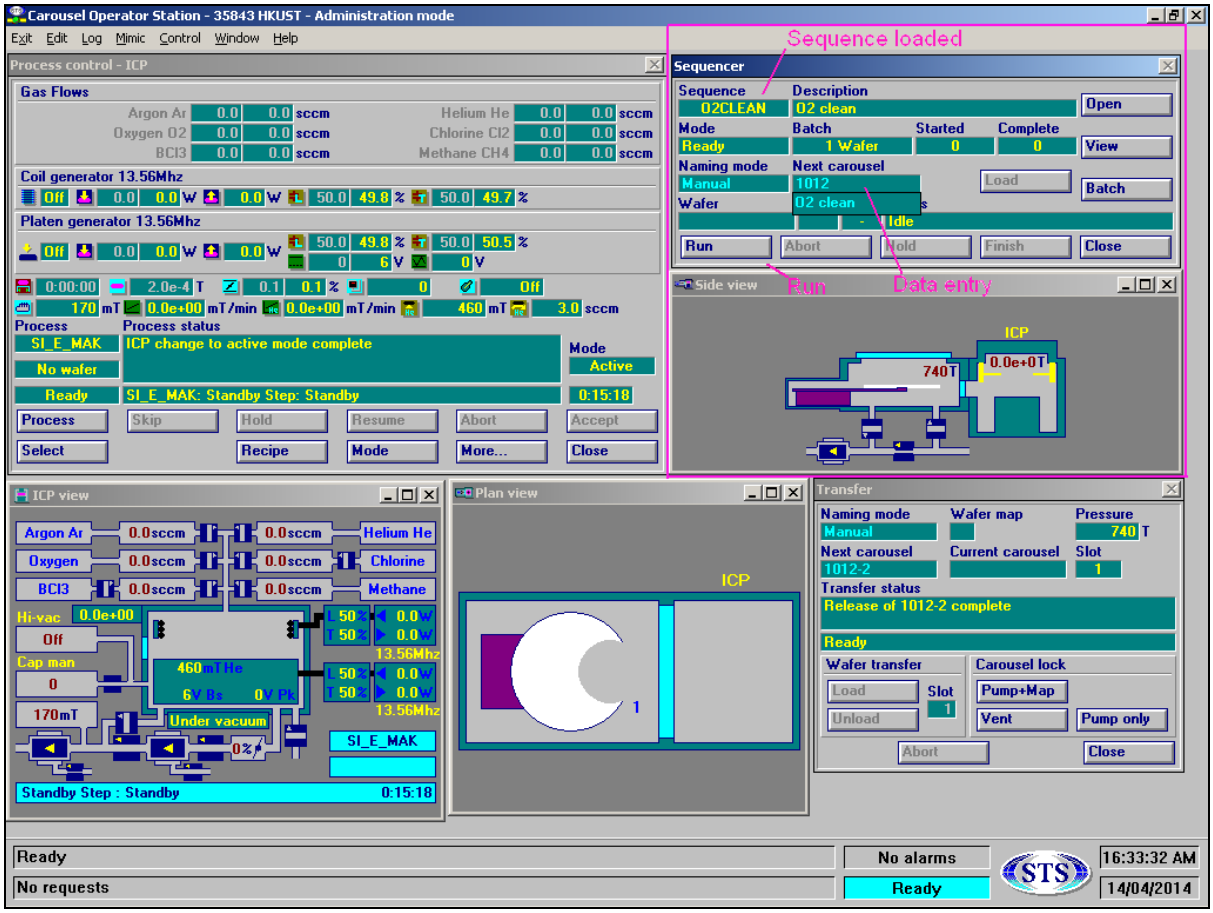


Fig.18 Process sequencer

- **Run:** The "Run" key is use to activates the selected sequence.
- **Abort:** The "Abort" key is use to aborts all current operations (including processing)
- **Hold:** The "Hold" key is use to activates a hold condition. Note, the system allows current processes, loads, unloads or transfer to complete their cycle before the system is held.

- **Stop/Finish:** The “Stop” key is use to stop the sequence at the end of the current action.
- **Naming mode:** Manual naming mode is set as default**;** please allocate a name in the “Next Carousel” field. Please be reminded, DRIE user must fill the name correctly, as it is a log file name for data logging.
- **Load:** If the last log file name did not change, then a load key must be press in order to initiate the selected process sequence.
- **Open:** The “Open” key is used to open the sequence loader pull down menu (fig.19), and the sequence can be selected.

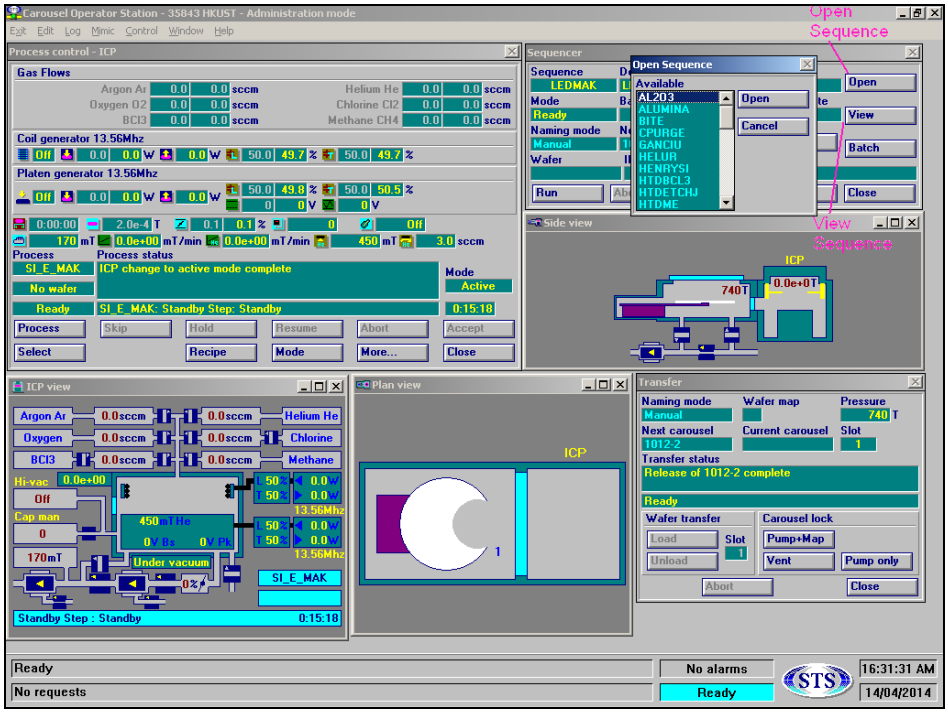


Fig. 19 Sequence selection menu

- **View:** The “View” key is use to open the sequence editor, in which details of the required sequence can be viewed or edited (Fig.20a). To insert a recipe step into a sequence, click “Edit“ key in the sequence editor, and then “Select” key to select the right recipe from the recipe database (Fig.20b), finally click “Insert” key to insert a recipe. After the recipe inserted, a sequence description can be input in the Description field. At the end, click the “validate” key to verify the sequence created is valid for recipe running and save the sequence.

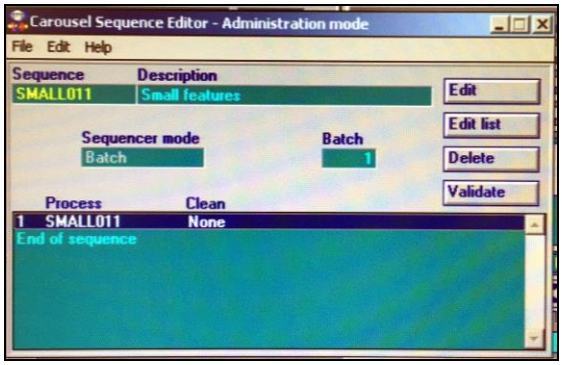


Fig. 20a Sequence editor

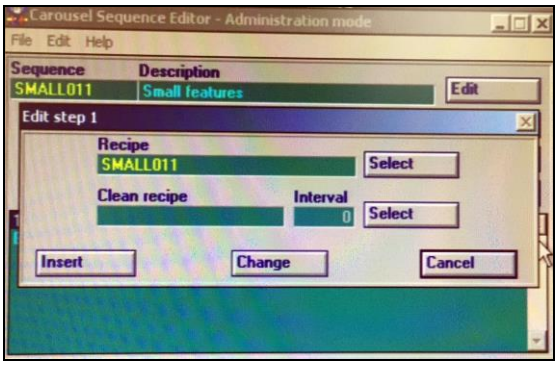


Fig. 20b Recipe insertion screen

However, if you cannot find a sequence that contains the recipe you want to use, or you do not know how to setup a sequence, please consult NFF staff. Be careful, running a sequence contains wrong recipe will get unexpected result. Therefore, user must confirm the selected sequence name in the screen (Fig.18) before running a sequence.

6.3 ICP view screen

In this screen, parameters of MFCs flow, pumping line pressure, chamber pressure, process pressure, APC throttle valve opening angle, RF power and matching can be observed (Fig.5).

6.4 Side view screen

In this screen, loadlock pressure, wafer status and RF On/Off status can be observed.

6.5 Plan view screen

In this screen, wafer and RF On/Off status can be observed.

6.6 Transfer screen

In order to load/unload wafer manually, wafer transfer screen can be used (Fig.21). Details of the screen will be described in the following:

Naming mode: Can be set manual/automatic mode, default setting is in Manual mode.

- **Manual** naming mode: User must input a name in “Next Carousel” field. Please be reminded, DRIE user must fill the name correctly, as it is a log file for data logging.
- **Automatic** naming mode: Wafer name is generated by incrementing previous wafer

name by “1”.

Pressure: indicates the actual pressure of the loadlock chamber.

Transfer Status: In this field, transfer status can be observed, and function keys are available. Details of the keys will be described in the following:

- **Load**, initiates the wafer loading sequence. The wafer is transferred from the loadlock to the process chamber.
- **Unload**, initiates the wafer unloading sequence. The wafer is transferred from the process chamber to the loadlock.
- **Pump+Map**, initiates the sequence of the loadlock chamber pump down, wafer scanning and naming procedures.
- **Pump**, initiates the pump down sequence of the loadlock chamber without a wafer.
- **Vent**, user can vent the loadlock chamber with the key. However, please make sure the machine has been checked-in; otherwise, the loadlock chamber will not be vent.
- **Abort**, user can abort the transfer operation in case of transfer problem.

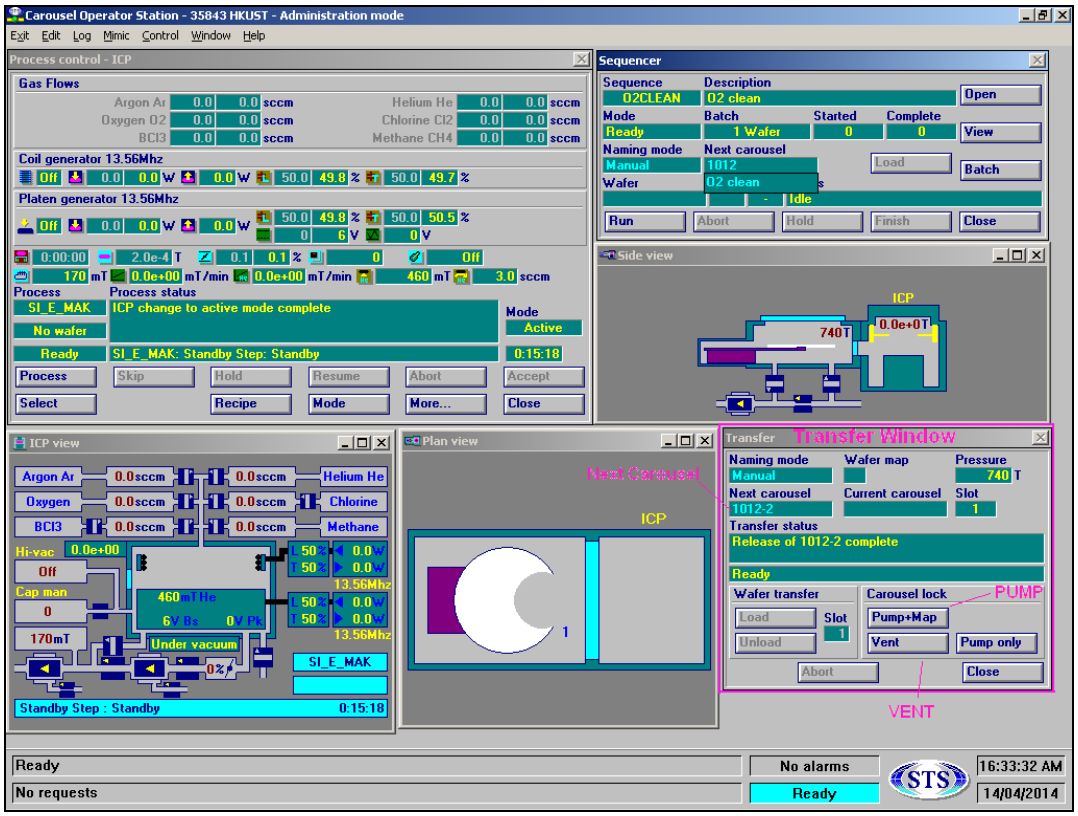


Fig.21 Transfer Screen

7. Process run

There are two methods to run a process, 1) manually, and 2) automatically.

7.1 Manual Operation

To run a recipe manually, the operation involves the following steps:

i) Load lock chamber vent

ii) Set wafer

iii) Pump down and wafer loading

iv) Run etching recipe

v) Wafer unloading and load lock vent

7.1.1 Load lock chamber vent

Verify the load-lock chamber is in vacuum or not. If the chamber is in vacuum, and the load lock lift door cannot be opened, then click the VENT button in Transfer screen (Fig.21). During venting, a chamber releasing warning message will be display at the bottom of the screen (Fig 22). The chamber lift door will be released in around 1 minute.

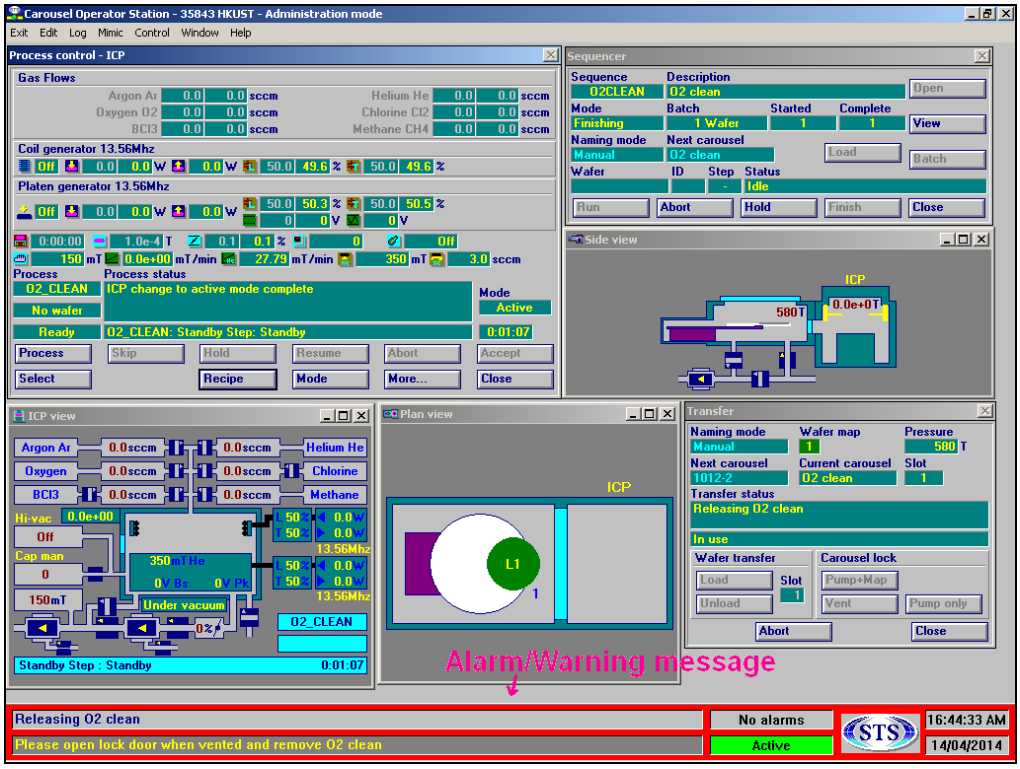


Fig.22 chamber releasing message

7.1.2 Set Wafer

Set and align wafer on the load lock arm (Fig. 23).

Fig.23 Set and align wafer

7.1.3 Pump down and wafer loading

Close the load lock lift door gently. In the Transfer screen, click the **NEXT CAROUSEL** text bar (Fig.21), and type a log file name, i.e. project no. Make sure the chamber door was correctly closed; otherwise the load lock chamber cannot be pump down. Then, press the **PUMP+MAP** button (Fig. 21). Wait a minute for the load lock chamber evacuation. When the crossover pressure reached, the **LOAD** button will appear, click on it to initiate wafer sending procedures.

Finally, the wafer will sit on the electrode lip-seal and the wafer clamp will slide down. Then, load lock gate valve will be closed, and the process chamber will pump down to base pressure.

7.1.4 Run etching recipe

Select a recipe and then click “Process” key to start the process according to the recipe parameter set (please refer to section 6.1). Once, the recipe starts, it simply goes through the following steps:

1) Waiting for base pressure: chamber pressure must be pump down to 0mTorr before proceeding to the next step, readout can be observed from the VAT controller display (Fig. 24) or the **Cap Man** reading from the process status screen (Fig.9c)

Fig.24 VAT chamber pressure readout

2) Helium leak up rate check: In order to control the wafer temperature during etching, helium gas is introduced to the backside of the wafer. Then a 1-2kg mechanical wafer clamp will slide down to hold the wafer onto a lip-seal mounted on the electrode, so the temperature controlled helium can be keep at specific pressure designed in recipe. Typically, a helium leak up rate should not exceed 15mTorr/min for DRIE; otherwise the process will be halted at this step (Fig. 25). For details setting of the helium back side cooling, please refer to section 6.1.2.

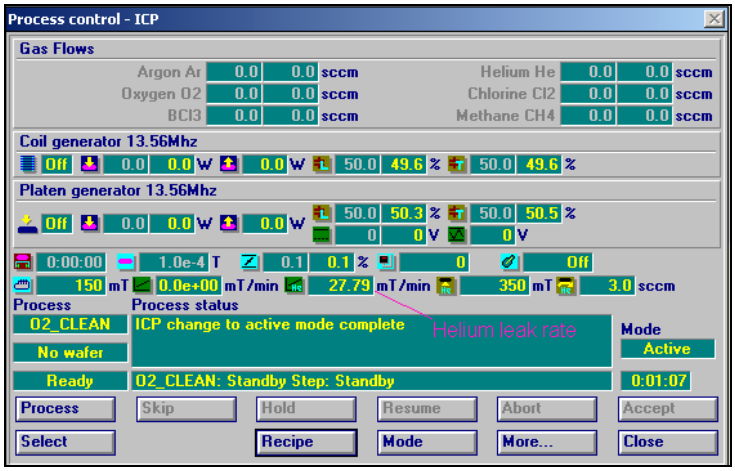


Fig.25 Helium leak up rate display

3) Waiting for Match: the load/tune capacitors of the matching unit will move to the pre-set position designed in recipe. For details setting of the RF and matching parameters, please refer to section 6.1 (Fig.9b & Fig.15).

4) Gas Stabilization: different gas channels will deliver gases to the chamber, and flow will be stabilizing (Fig.8 & 9a).

5) Etching: RF power will be given out, and RF matching unit start to match the impedance inside the chamber. Effective RF matching can minimize the reflected power, and increase the forward power until it reached the set point, then plasma ignite, and you can observe the plasma light through the side viewports of the equipment or in the screen (Fig. 26).

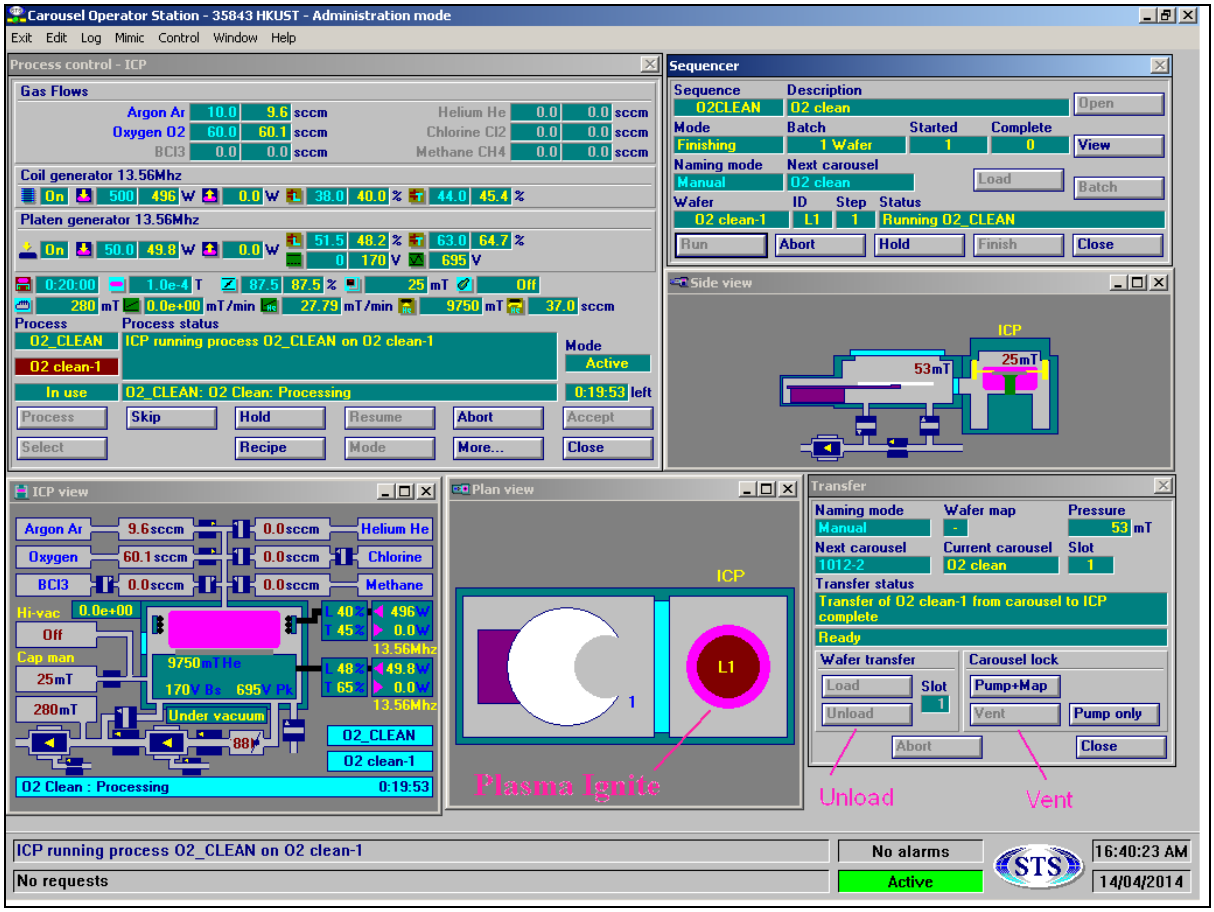


Fig. 26 Plasma ignite

6) Pump out and Cycle purges: after etching process, chamber must be pump down to base pressure, and then a series of cycle purge steps will be carry out in order to remove the residue gas/hazard gas remain in the chamber.

However, during the etching process, the **SKIP/ABORT** function keys can be used to skip or terminate the process (Fig.9c).

7.1.5 Wafer Unloading and Load lock Vent

Once the cycle purges completed, click the UNLOAD button to unload the wafer back to the load lock chamber. Then the wafer is unloaded and the gate valve will be closed. Click the VENT button to vent the chamber. The load lock lift door will be release around 1minute (Fig.22).

7.2 Automatic Operation

Automatic operation involves the following steps:

i) Load lock chamber vent

ii) Set wafer

iii) Select process sequence

7.2.1 Load lock chamber vent

As in manual operation, verify the Load-lock chamber is in vacuum or not. If the chamber is in vacuum, click the VENT button in Transfer screen (Fig.21). During venting, a chamber releasing warning message will be displayed at the bottom of the screen (Fig 22). The lift door will be released in around 1 minute.

7.2.2 Set wafer

As in manual operation, set and align wafer on the load lock arm (Fig. 23).

7.2.3 Select process sequence

Refer to section 6.2, in Sequencer screen, click **OPEN** to open the sequence files, and select the right sequence to be use (Fig. 19). To check details of the loaded sequence, click **VIEW** to open the sequence editor, which provide you the information of the recipe inserted. If you cannot find a sequence that contains the recipe you want to use or don’t know how to create your own recipe sequence, please consult NFF staff. Please be reminded running a sequence contains wrong recipe will get unexpected result. Therefore, user must confirm the selected sequence in the screen (Fig.18) before running a sequence.

In sequencer screen, click on the text bar of the **Next Carousel**, and type a log file name, i.e. project no. Then, click **RUN** button to initiate the process sequence. Finally, all the steps will be executed automatically, and you just need to collect back the wafer when the sequence completed. If there is any problem during process, click **ABORT** button to stop the pump down sequences, wafer transfer or process recipe running steps. However, once the sequence was aborted, and then the remaining steps must be run manually, including recipe running, wafer transfer or venting step.

8. Process Recording

1. Please be reminded you are required to fill all the details of the log sheets. If users fail to do this, a heavy punishment will be given.
2. Write down the problems happened or any comments in the log sheets.

9. Clean up

1. Clean up the area.
2. Return items to their proper locations.
3. Put back the dummy wafer on the arm, and pump down the load lock chamber after use.

10. Check out

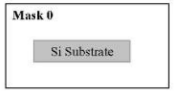
Check out the equipment immediately after use.

Appendix

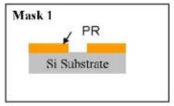
Mask preparation process

Reference 1: Process Flow for ASE DRIE PR4620 mask

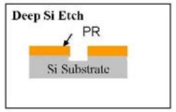
Cross Section — **Process Flow 1 for ASE DRIE PR4620 mask**



Wafer Status		Step No.	Equipment	Cleanliness	Compatibility	Processes	Requirements
Clean	Non-CMOS	0.1	B1:Standard Clean	Clean	Non-CMOS	Initial Clean	10min, 120C
Clean	Non-CMOS	0.2	B2:HF:H2O (1:100)	Clean	Non-CMOS	HF Dip	1min



Wafer Status		Step No.	Equipment	Cleanliness	Compatibility	Processes	Requirements
Clean	Non-CMOS	1.1	Binder oven A	Clean/Semi	CMOS/Non-CMOS	Dehydration bake	10min, 180C
Clean	Non-CMOS	1.2	SVG Coater	Clean/Semi	CMOS/Non-CMOS	Photoresist coating	Program 6 for manual PR4620 coating, without edge rinse. Set spin speed to 2300rpm
Clean	Non-CMOS	1.3	Binder oven B	Clean/Semi	CMOS/Non-CMOS	Soft Bake	10min, 105C
Clean	Non-CMOS	1.4	K Suss MA6 #2	Clean/Semi	CMOS/Non-CMOS	Definition of pattern	Exp. 20s ~ 40s
Clean	Non-CMOS	1.5	Wet Station X1	Clean/Semi	CMOS/Non-CMOS	Developing	Develop 5~6min
Clean	Non-CMOS	1.6	Binder oven C	Clean/Semi	CMOS/Non-CMOS	Hard Bake	10min, 120C
Clean	Non-CMOS	1.7	Telpa 210	Clean	CMOS/Non-CMOS	O2 Descum	If necessary

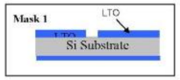


Wafer Status		Step No.	Equipment	Cleanliness	Compatibility	Processes	Requirements
Clean	Non-CMOS	1.8	ICP for Deep Silicon	Clean	CMOS/Non-CMOS	Deep Si Etch	

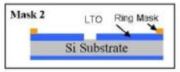
Reference 2: Process Flow 2 for ASE DRIE oxide with ring mask

Cross Section — **Process Flow 2 for ASE DRIE oxide with ring mask**

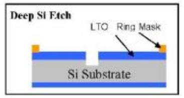
Substrate: Pre-deposited 4" LTO wafers bought from etching module



Wafer Status		Step No.	Equipment	Cleanliness	Compatibility	Processes	Requirements
Clean	Non-CMOS	1.1	Binder oven A	Clean/Semi	CMOS/Non-CMOS	Dehydration Bake	10min, 180C
Clean	Non-CMOS	1.2	SVG Coater	Clean/Semi	CMOS/Non-CMOS	Photoresist coating	Program 2 for manual PR204 coating, without edge rinse.
Clean	Non-CMOS	1.3	Binder oven B	Clean/Semi	CMOS/Non-CMOS	Soft Bake	10min, 105C
Clean	Non-CMOS	1.4	K Suss MA6 #2	Clean	CMOS/Non-CMOS	Definition of designed mask pattern	Exp. 3s ~ 5s
Clean	Non-CMOS	1.5	SVG Developer Track	Clean/Semi	CMOS/Non-CMOS	Developing	Develop time 1min
Clean	Non-CMOS	1.6	Binder oven C	Clean/Semi	CMOS/Non-CMOS	Hard Bake	10min, 120C
Clean	Non-CMOS	1.7	Telpa 210	Clean	CMOS/Non-CMOS	O2 Descum	If necessary
Clean	Non-CMOS	1.8	ICP-AOE	Clean/Semi	CMOS/Non-CMOS	Oxide Etching	~ 2500A/min
Clean	Non-CMOS	1.9	E4:Sulfuric Resist Strip	Clean/Semi	CMOS/Non-CMOS	Resist Stripping (wet)	10min, 120C



Wafer Status		Step No.	Equipment	Cleanliness	Compatibility	Processes	Requirements
Clean	Non-CMOS	2.1	SVG Coater	Clean/Semi	CMOS/Non-CMOS	Photoresist coating	Program 6 for manual PR4620 coating, without edge rinse. Set spin speed to 2300rpm
Clean	Non-CMOS	2.2	Binder oven B	Clean/Semi	CMOS/Non-CMOS	Soft Bake	10min, 105C
Clean	Non-CMOS	2.3	K Suss MA6 #2	Clean	CMOS/Non-CMOS	Definition of ring mask pattern	Exp. 20s ~ 40s, or a bit longer exposure time than normal due to thick LTO
Clean	Non-CMOS	2.4	Wet Station X1	Clean/Semi	CMOS/Non-CMOS	Developing	Develop 5~6min
Clean	Non-CMOS	2.5	Imperial V	Clean/Semi	CMOS/Non-CMOS	Hard Bake	10min, 120C
Clean	Non-CMOS	2.6	Telpa 210	Clean	CMOS/Non-CMOS	O2 Descum	If necessary



Wafer Status		Step No.	Equipment	Cleanliness	Compatibility	Processes	Requirements
Clean	Non-CMOS	2.7	ICP for Deep Silicon	Clean	CMOS/Non-CMOS	Deep Si Etch	

P.S.: Please consult the NFF process staffs before you start the mask preparation process.

