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Surface Technology Systems – Advanced Silicon Etching

0. Table of contents

1. Changes compared to previous versions

Date	Page number	New version number	Description
10-04-2011		/01	Combined version of documents RWV-010-040-013/01 (2006) and User Manual (2007)

2. Safety

2.1 General

Emergency Off buttons:
The tool is equiped with a number of *emergency off* buttons **red** **yellow** that can be pressed in case of potentially dangerous situations. These switches will shut off the electrical power supply to the tool. Additionally, local switches **black** **white** are available to shut off the electrical power supplied to the tool AND the local power sockets.

Electricity/Radiation:
The equipment satisfies all usual safety regulations and there is no danger when the tool is used properly. However, unsafe situations are present if metal covers have deliberately been removed or cables disconnected: then there is danger for high-power electrical shock (220/380V) or high-power RF radiation (13.56MHz, 380kHz).

Chemical hazardous gases:
The process gasses SF_6 en C_4F_8 are not really dangerous. These gases decompose into hazardous components when a plasma is ignited inside the process chamber. Safety measures make direct exposure to these hazardous gasses highly improbable. The process chamber is equiped with (over)pressure sensors and processing immediately stops upon sensor excitation.

Maintenance (by qualified people only!!):
Once in a while, the process chamber has to be opened in order to remove and clean the interior of the chamber. This operation is supposed to start after a one hour oxygen plasma clean. Dispite this pre-clean care should be taken at opening of the system, as small quantities of more or less suspicious gasses still may escape from the tool at first contact with the moist room atmosphere. The chamber interior may be covered with flakes and small particles. In serious cases, safety measures have to be taken (wear breath protection, good ventilation).

2.2 Chemicals

The only process gasses are sulfur-hexafluoride (SF_6) and octafluorocyclobutane (Freon C318, C_4F_8). Helium (He) is used for wafer backside cooling.

Detailed information about these chemicals can be found in the corresponding Material Safety Data Sheets (MSDS).

3. User Manual

3.1 General information

The <STS ASE> deep Si etcher, is equipped with a single process chamber. Wafers can be dry-etched using fluorine containing process gasses. The official name *Advanced Silicon Etch* (ASE) indicates that the tool is limited to the etching of silicon only and this is done according to a special procedure (see below). All processing is done in a closed vacuum system and a robots takes care of wafer transportation between a load lock carousel or a cassette station to the process chamber.

The etch tool is an ICP reactor (Inductively Coupled Plasma), in which reactive species (radicals) and ions are generated at high rates by an ICP source and the intensity of ion bombardment on the wafer can be regulated by the application of an RF-bias. Vertical etch profiles can be realized following the so-called Bosch process: alternatingly the wafer is exposed to an SF_6 plasma and a C_4F_8 plasma. In the first short part of the cycle, silicon is etched in a more or less isotropic way, whereas in the second short part the etched profile is covered by a passivation layer. In the etch part of the next cycle this passivation layer is opened preferentially at the bottom, mainly by ion bombardment, and etching starts again. By repetition of the etch/passivation cycle, the etch proceeds layer by layer downwards into the silicon wafer. A single cycles typically takes 8-20s and the etch rate typically is 0.1-2µm/cycle, depending on the selected etch recipe and the etch mask lay-out. Although there are a number of standard etch recipes, each of them aimed at a certain task, it is not uncommon that recipes have to be tweeked in order to get the desired etch result.

➔ **Consult the machine owner about the most suitable recipe for your application.**

3.2 Mimic and control windows

The ***MACS Operator Station*** *(Multiplex Atmospheric Cassette System)* is displayed on the monitor as a composition of windows.

If the *MACS Operator Station* is not visible on desktop, move down to pop-up task bar *(Fig.1)* and click on *MACS Operator Station* or its icon *(left)*.
On the task bar: **NEVER close *Data Exchange*!!**

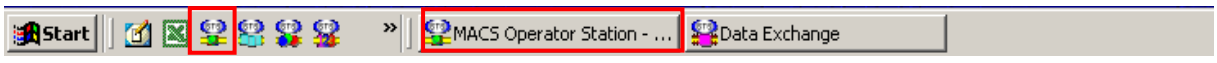


Fig.1: Task bar

There are two kinds of windows *(Fig.2)*:

- ***Mimic*** windows, containing information only, and

- ***Control*** windows, allowing user interaction with the tool by means of command buttons.

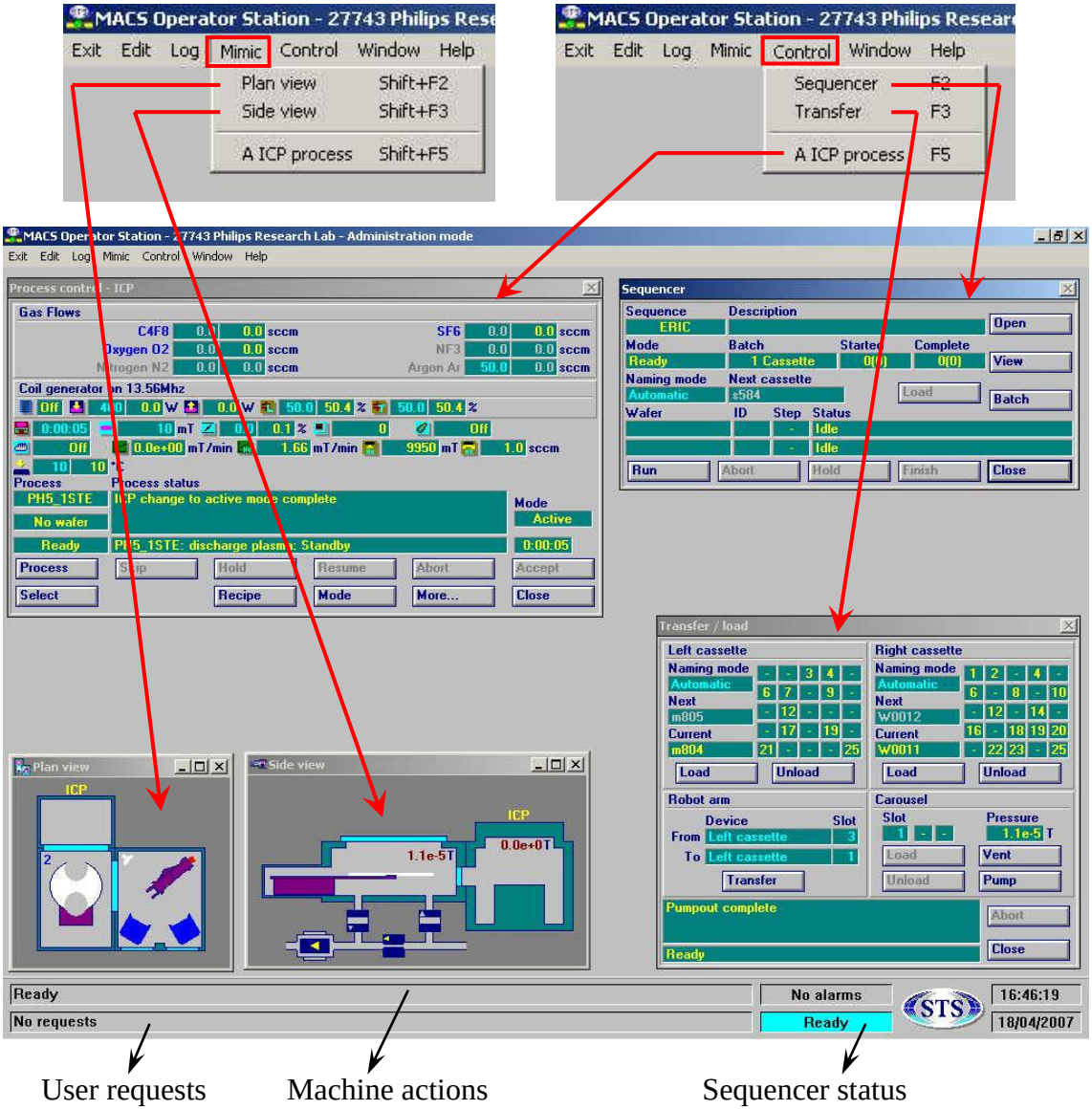


*Fig. 2: Full monitor screen with **Mimic** and **Control** windows.*

With the *Mimic* windows ***Plan view*** and ***Side view*** the user can trace down the position of wafers, follow the actions of the carousel and the MACS robot that transfer wafers between carousel load lock and process chamber, and between cassette deck and carousel. The user may also check pressure readings.

The *Control* window ***Transfer/Load*** allows manual control over the carousel and the cassette load station. The ***Sequencer*** is for automated operation.

Process control is enabled by the *Control* window ***ICP process control***.

Finally, running processes may be viewed by a *Mimic* window ***ICP process view***, although this option has little extra value: all information is already displayed in the *ICP process control* window, albeit in a less graphical way. Usually this mimic window is switched off.

4. User Manual – Part 1: Manual Control mode

In manual control mode it makes little or no sense to use the cassette load stations, as they would only serve as wafer storage places. Instead, the carousel is the place to be for wafer manual loading and unloading.

➔ Before you start loading any wafers, take notice of the wafer constraints mentioned in Sect. 6.

4.1 Wafer loading and transfer

4.1.1 Be sure that the latch of the carousel lid is able to move freely forward and backward, by checking the position of the **black knob** at its base *(Fig.3)*: it should be pulled out to the right and turned by 90 degrees to keep it fixed in the 'out' position.

The black knob is there to secure the latch in the closed position in case of automated operation only: it prevents the carousel lid from opening up after venting.

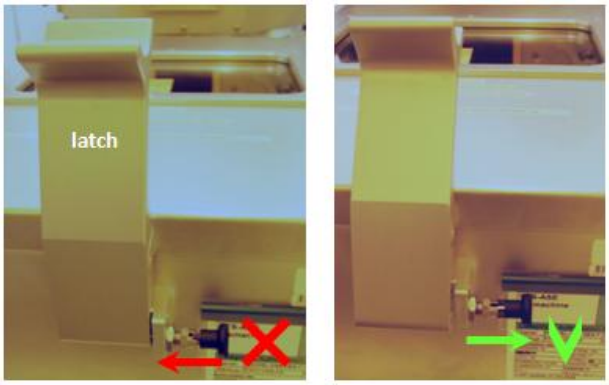


*Fig.3: The correct position (right) of the **black knob***) for manual loading.*
**) at the base of the latch of the carousel lid.*

4.1.2 Use the 'quadrant' at the lower right side *(Fig.4)* of the *Transfer/Load* window called ***'Carousel'*** to load wafers:

4.1.2a ***Vent*** is used to get the carousel to atmospheric pressure. Sometimes high pressure indications are unrealistic, but in the end the lid will open up automatically.

4.1.2b Lift the lid and put one (or two) wafer(s) into the recess(es) in the carousel plate.

➔ **Take notice of the wafer orientations: wafer flats should face the centre of the carousel plate, like indicated by the black lines engraved into the plate.**

4.1.2c Close the lid and keep it closed: shortly after closure the carousel plate will turn until a wafer sensor has mapped the position(s) of the wafer(s). After some time the wafer information in the *Plan view* and *Side view* windows will be updated.

4.1.2d Optionally, the carousel may be pumped down by activating ***Pump***, but this step may be skipped as it will automatically be carried out upon loading wafers to the process chamber.

4.1.2e Activate the sub-window ***Slot*** and you will get the choice to select a wafer in slot 1 or slot 2. Enter the preferred slot number and press *Enter*. Slot numbers are engraved in the top-right corner (visible) and the low-left corner (invisible) of the carousel plate.

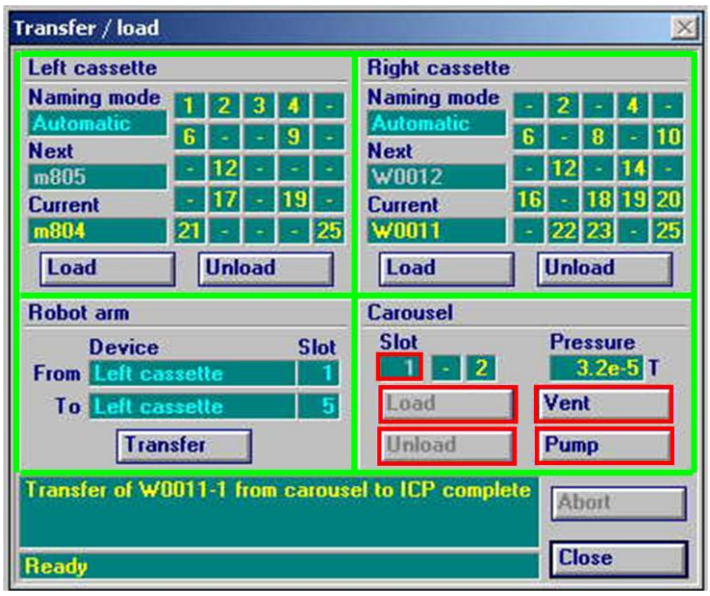


*Fig. 4: The lower right 'quadrant' of the **Transfer/Load** window called 'Carousel' for manual loading of wafers.*

4.1.2f Press ***Load*** to transfer the selected wafer to the process chamber. The carousel will be pumped down to a setpoint of ~300 mTorr, a turbo pump then speeds up the pumping process and at 4.0E-4 Torr the carousel is ready for loading. The wafer will then be transferred to the process chamber and automatically clamped down onto the electrostatic chuck.

4.2 Select recipe and check/change process time

4.2.1 Press the ***Select*** button in the ***Process Control*** window *(Fig.5)* and select the right recipe from the pop-up menu.

4.2.2 Confirm your selection with ***Select*** in the pop-up menu. The system will prepare the chamber for processing (purge and pump, chamber coloured in blue) and then will wait for further commands.

If you accidentally press *Process* in the pop-up menu, the selected process will start. If you don't like this to happen, immediately press *Abort* in the process control window and the process will stop and switch to stand-by.

4.2.3 Press ***Recipe*** to enter the *Recipe Editor (Fig.6)*, or alternatively *Edit/Process Editor*.

4.2.4 In the recipe, ignore *Gas line Purge* and *Standby Step* and only select process step(s). Ignore all tabs except for the one called ***General*** and check the process time in that tab. If necessary change the process time, or – in case of a Bosch process – the number of cycles.

➔ **No other parameters than these two may be changed by users!**

Most recipes are Bosch processes with parameter cycling, each cycle including an etch step and a deposition/passivation step. The editor is smart and automatically rounds off the process time to a full number of cycles.

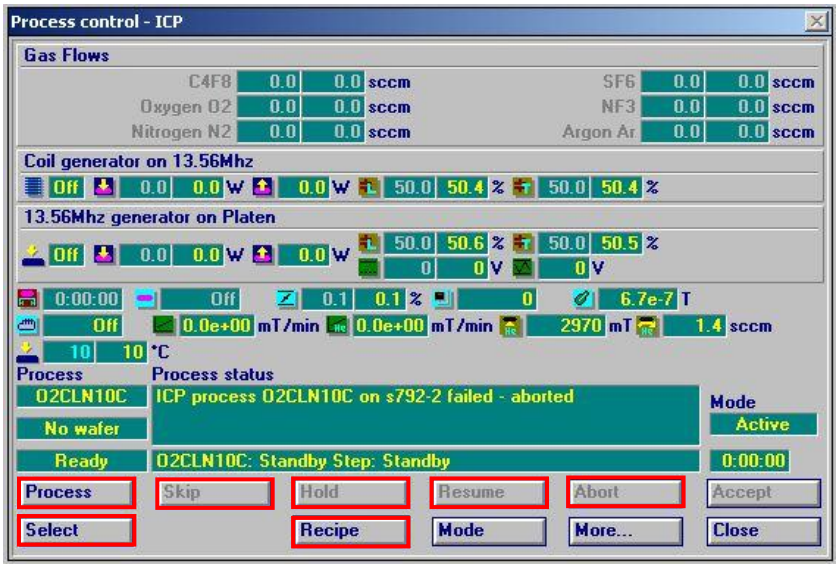


Fig.5: ***Process control*** *window in stand-by mode*

In case of a *multiple-step recipe*, it is better not to change the individual process times, as they are matched by design, especially in the case of activated parameter *ramping*.

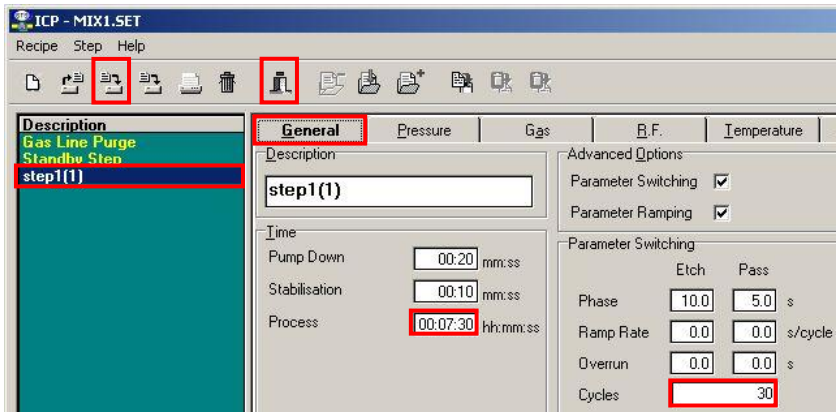


Fig.6: ***Recipe Editor****, setting process time or number of cycles*

➔ Also be aware that recipes with active parameter *ramping* start and end with different parameter settings, such that it is not wise to use one and the same recipe twice for the same wafer: the result of *one* long etch run probably will not be the same as the result of *two* short etch runs with the same total etch time. After the first run an etch extension recipe should be set up for the second run. That extension recipe will start with well-adapted parameters. In that case consult the equipment owner.

➔ **Always consult the machine owner if you like to change more than just the process time, or if you like to make a new recipe !!**

4.2.5 Save the recipe before closing the editor, either by ***Recipe/save*** and ***Recipe/close*** or by the using the corresponding icons.

4.3 Run an etch process

After loading a wafer (Sect. 4.1), and selection of the right recipe and adjustment of the process time or number of cycles (Sect. 4.2), an etch run can be carried out from the *Process Control* window.

4.3.1 Start the process by pressing ***Process*** *(Fig.5).*

The *Process Control* window will expand and change its lay-out now *(Fig.7)* in order to display all details about the process parameters (**blue** = set values, **yellow** = actual values).

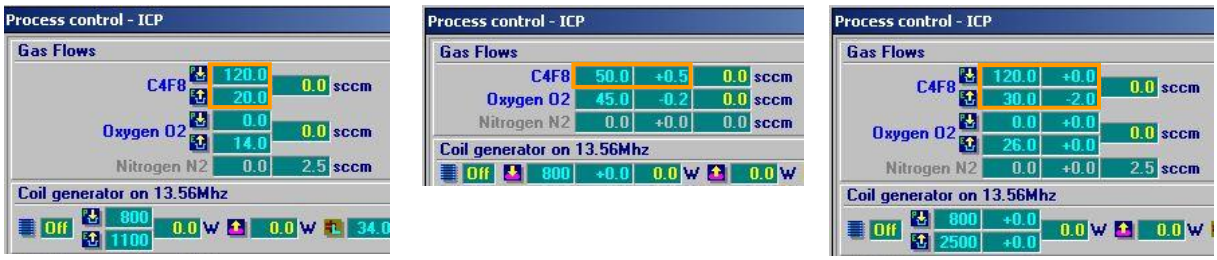


Fig.7: Detail of the left upper-corner of the expanded ***Process Control*** *window, when process is started in switching mode (left), in ramping mode (middle), and in switching+ramping mode (right). If switching and ramping are absent, the lay-out looks like Fig.5.*

Each process run starts with a *Standby step* in which the process chamber is prepared for processing, the process chamber colours blue on screen then.

Before processing the ***helium leak-up rate*** is checked (pump line closes, check takes 10-30s, pump line opens). If the leak-up rate is too high (>5 or 6 sccm/min, *Fig.8*), the wafer is not accepted for processing (alarm). The wafer may be dirty on the back-side or its flatness may be poor (e.g. curvature / bow caused by stress). In that case always abort the process by pressing ***Abort*** and remove the wafer from the chamber.

Fig.8: Helium Leak-up rate

4.3.2 As soon as the plasma ignites, the process chamber colours purple on screen. If really necessary, the process may be interrupted by pressing ***Hold*** (plasma *off*) and continued later by pressing ***Resume*** (plasma *on* again), but that procedure is exceptional and it is not recommendable to do so.

It is also possible to end a step by pressing ***Skip***. The process will continue with the next process step (if present in the recipe) or return to *Standby step*. Again, there must be a good reason to do so.

4.3.3 When process time is up, the process will automatically end with the *Standby step*, preparing the process chamber for wafer transfer.

4.4 Wafer unloading

4.4.1 After processing the first wafer press the ***Unload*** button in the ***Carousel*** quadrant of the ***Transfer/Load*** window.

A 'background' recipe called ***Dechuck*** will be activated automatically. It will take some time to unclamp the wafer. Subsequently, a short (5s) argon plasma will be applied to discharge the wafer. After that the wafer will be returned to the *Carousel* load lock.

4.4.2 If a second wafer is awaiting processing in the carousel: load that wafer and start the process run before venting the carousel.

Actually, the ***wafer logistics*** are free to the user. Either the load lock is vented after processing two wafers, or vented after loading the second one into the process chamber. The latter procedure is time saving when many wafers have to be processed, as the first processed wafer can be exchanged for a fresh third one while the second one is being processed. The process chamber is processing almost continuously then, without time waisted for load lock vent and pump down.

4.4.3 To open up the carousel, press ***Vent*** in the *Transfer/Load* window. The latch will allow the lid to open up upon reaching atmospheric pressure.

4.4.4 At the very end - with all wafers removed from the system – close the lid, wait for carousel mapping and leave the carousel under vacuum condition by pressing the ***Pump*** button in the *carousel* quadrant.

➔ **Please don't forget to fill in the log book on the desk near the etch tool!**

5. User Manual – Part 2: Automated Control mode

The *Sequencer* is for **automated** process runs. The *sequencer* takes over from the user almost all of the manual actions described in the previous sections! The sequence will take care of wafer transfer, and selects and runs the programmed etch recipe(s).
The user puts all information required by the etch tool into a procedure called *Sequence*, saves the sequence under some name (for later use) and sets the process times in the recipes that are involved in the that specific sequence.

➔ Before you start loading any wafers, take notice of the wafer constraints mentioned in Sect. 6. Ensure there are no wafers present in process chamber and carousel.

5.1 Wafer loading

5.1.1 Ensure that the carousel lid is closed and the latch of the lid is fixed and secured by the **black knob** at its base *(Fig.9)*. The black knob should be turned and pushed in to the left.

The black knob is there to secure the latch in the 'closed' position: it prevents the carousel lid from opening up after venting.

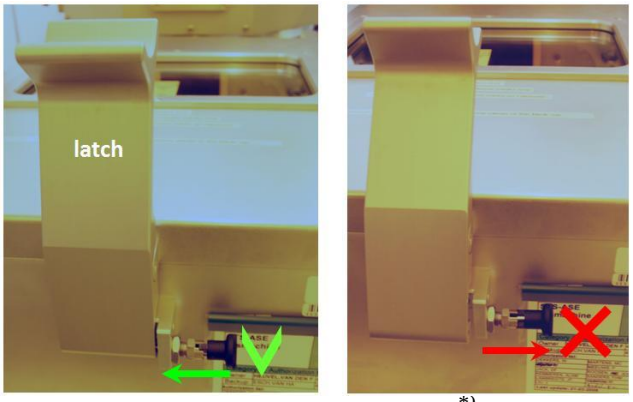
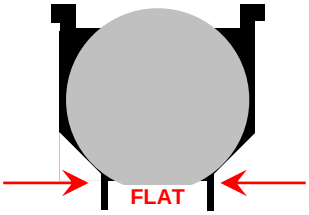


*Fig.9: The correct position (left) of the **black knob***) for automated processing.*
**) at the base of the latch of the carousel lid*

5.1.2 Take the left cassette out of the cassette station, put in your wafer(s) and place the cassette back into position (dock **IN**).

➔ **Take care of the right wafer orientation, wrong or bad wafer orientation will result in damage to the wafer chuck inside the etch chamber (electrostatic chuck has a flat as well)!!!**



The main flat should be oriented as indicated in the sketch: horizontal flat at the bottom of the cassette.

Separate from the etch tool, a **wafer flat aligner** (*Fig.10*, 'rotating spindle') is available to orient all wafers present in a cassette in one single action:
- with the ***position*** switch choose the *'down'* orientation,
- press ***run*** and wait.

Always check the wafer orientation after using this device: the aligner is not perfect and sometimes fails, especially with short flats or thin wafers!! If necessary, repeat the procedure or make corrections manually.

*Fig.10: Wafer flat aligner; for the STS ASE tool select the **down position**.*

5.1.3 Ensure that an empty cassette is positioned on the right side of the cassette station (dock **OUT**).

5.1.4 Close the cassette doors.

5.2 Sequence operation

5.2.1 In the *Sequencer* control window *(Fig.11)* press the ***Open*** button, and **select your sequence** from the pop-up list. This sequence will then appear in the text box in the upper left-hand corner of the sequencer control window.
*If you don't have a sequence set up yet, go to Sect. 5.3 or 5.4 first to make a **new sequence**.*

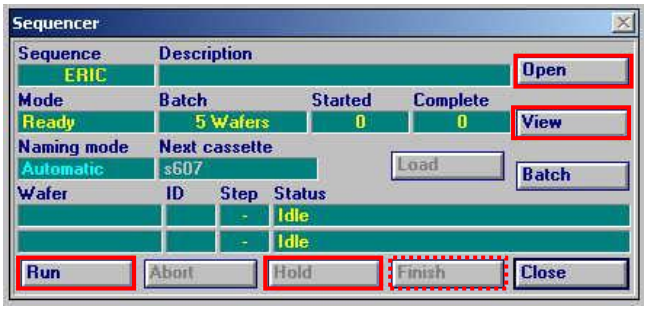


*Fig.11: **Sequencer** control window.*

5.2.2 Check the sequence by pressing ***View***. Alternatively, you may press ***Edit / Sequence editor*** in the main menu bar, press *File / Open* and select the right sequence.

5.2.3 In the *Sequence Editor* window *(Fig.12)* check or adjust the batch size, the number of wafers to be processed: it should correspond to the number of wafers present in the left cassette. Note that empty slots in the cassette, even between wafers, will be ignored.

5.2.4 Save your settings via *File/save* and leave the *Sequence Editor* window via *File/exit*.

5.2.5 Set the right **process time(s) in the recipe(s)** invoked in the selected sequence. The simplest way is to open the recipe editor by pressing ***Edit / Recipe editor*** in the main menu bar, open the recipe(s), set and save the recipe(s) following the steps in Sect.4.2.

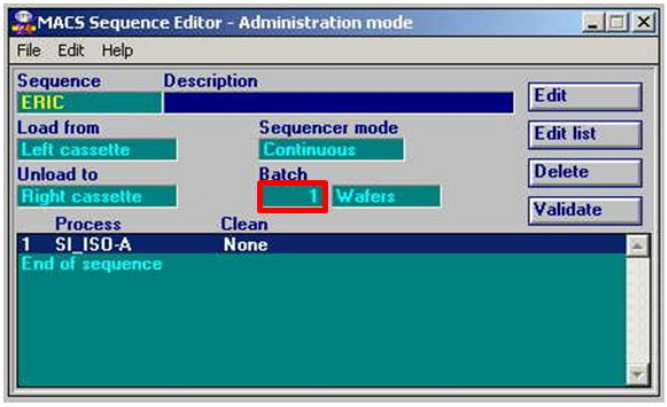


Fig.12: ***Sequence Editor*** *window.*

5.2.6 Ensure that the machine doesn't contain wafers in carousel and process chamber and is idle (for example, not busy with carousel mapping after lid closure!).
Press the ***Run*** button in the sequencer to **run a sequence**. Confirm that you like to use cassettes already loaded in the cassette station.

At any time, do NOT open the doors, wait until the sequence has ended !!

One by one the robot will map the left and right cassette first. After that the sequencer will guide all wafers from the *left* cassette through the etch tool and bring them back to the *right* cassette after processing.

A sequence consists of a automated line-by-line command structure. ***However, manual intervention is still possible at every moment!!!*** The button ***Hold*** in the *Sequencer control* window will interrupt a sequence in that sense that a running action (transfer or process) will be finished before the actual interruption will take place. The user is then asked what to do with the next command line: ***Continue*** (sequence proceeds), or ***Stop*** (take over command by manual control). Likewise, all control buttons in the *Process control* window are available for use (just in case...).
Finish will skip all wafers that are still positioned in the left cassette. The sequence will finish all wafers it started with and bring them back to the right cassette.
Any *abort* command will obstruct sequence progress. In that case, the user should stop the sequence and proceed by manual control to remove all wafers from the etch tool.

When the sequencer is used, **automated wafer numbering** produces 's'-numbers, for example: s006-5 means 'wafer from cassette number 006, slot number 5'. This number is useful for data retrieval in the data logging system.

5.2.7 At the very end, leave the carousel under vacuum by pressing ***Pump*** in the carousel quadrant of the *Transfer / Load* window.

➔ **Please don't forget to fill in the log book on the desk near the etch tool!!**

5.3 Set up a simple sequence

The simplest sequence is composed of one (or more) line(s) with the name(s) of the recipe(s) that the tool will automatically select to process the wafers. All wafers will be processed in the same way: for each wafer the sequence starts with the process in the first line, then – if present – it takes the process in the second line, and so on, until the process in the last line has been finished, next wafer, etcetera. The most common sequences have just one line with one recipe only.

5.3.1 The easiest way to make a new sequence is to take an existing sequence, save it under a new name, and edit the new sequence. Press ***Open*** in the Sequencer window *(Fig.13)* and select any existing sequence. In the same window press ***View*** to activate the Sequence Editor *(Fig.14).* Via ***File/Save*** save the existing sequence with a new name (8 characters maximum).

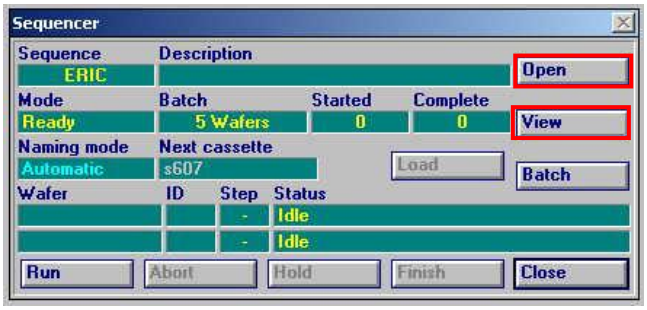


Fig.13: ***Sequencer*** *window*

5.3.2 Select the step(s) present in the *Sequence Editor* and delete them one by one using the ***Delete*** button.

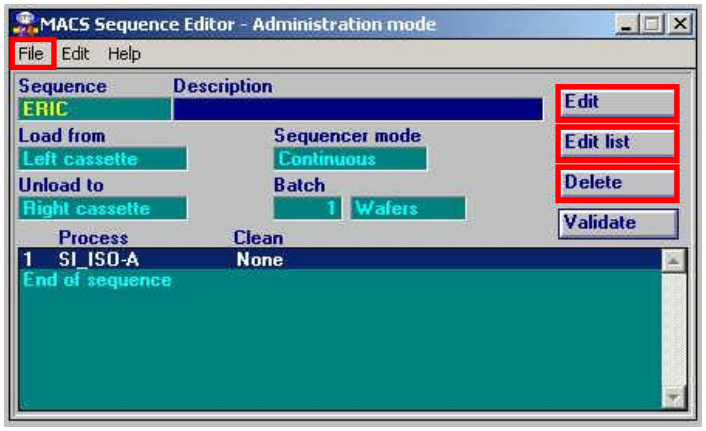


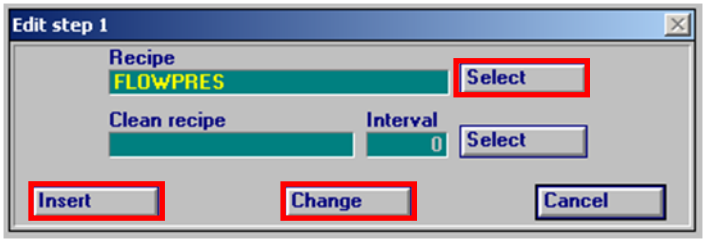
Fig.14: ***Sequence Editor***

5.3.3 Press the ***Edit*** button. In the *Edit step* window *(Fig.15a)* press the ***Select*** button, a *Step recipe* window will appear *(Fig.15b).*

5.3.4 Select your recipe and press ***Select*** in the *Step recipe* window. Your recipe will appear in the *Edit step* window. Press ***Insert*** to enter the recipe into the *Sequence editor* window, it will appear *above* the line selected in that window.

If you made a mistake, or like to replace an existing step, select that line in the *Sequence editor*, select a recipe in the *Edit step* and *Step recipe* windows again and use ***Change*** instead of *Insert*.

If you like wafers to be processed by two or more recipes sequentially, add more steps to the *Sequence Editor* window. All process steps will then be carried out on each individual wafer before the next one is loaded to the process chamber.



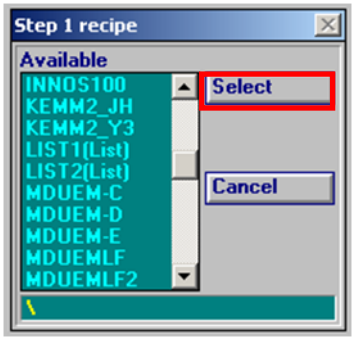


Fig. 15a (left): ***Edit step*** *window*
Fig.15b (right): ***Step recipe*** *window*

5.3.5 In the *Sequence Editor* window *(Fig.14)* check or adjust the batch size, the number of wafers to be processed It should correspond to the number of wafers present in the left cassette. Note that empty slots in the cassette, even between wafers, will be ignored.

5.3.6 In the *Sequence editor* window, select the most convenient *Sequencer mode*:
- *Continuous* mode means that wafers will be loaded to the carousel one at a time, such that a processed wafer, say #5, is exchanged for a fresh one #7, while #6 is being processed.
- *Batch* mode means that two wafers are loaded to the carousel, both of them are processed and returned to the carousel. There is no processing during the exchange of the processed wafers for a set of two fresh ones.

Batch mode is a good option for short etch runs (couple of minutes) only.

5.3.7 Save your settings via ***File/save*** and leave the *Sequence Editor* window via ***File/exit***.

Recommendation: default settings*) shouldn't be changed!

*) Obligatory default settings in the *Sequence editor* are:
- 'Load from' *Left cassette*
- 'Unload to' *Right cassette*
- 'Batch' size is expressed in number of *wafers*, not in number of *batches*

5.4 Set up an advanced sequence

Individual wafer addressing is possible using *Lists*. A list is a simple table of lines, instructing the etch tool to process the 1st wafer with the recipe in line #1 at the top of the list, the 2nd wafer with the recipe in line #2, and so on, until the last wafer with the recipe in the last line in the table.

5.4.1 Follow the procedure described in 5.3.1 and 5.3.2 to obtain an empty sequence.

5.4.2 In the *Sequence editor* window *(Fig.14)* press the ***Edit list*** button, a *Select ICP list* window *(Fig.16a)* will show up.

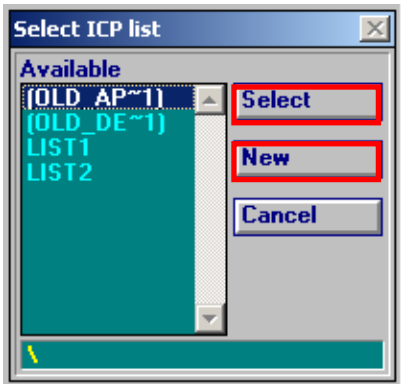


Fig.16a: ***Select ICP list*** *window*

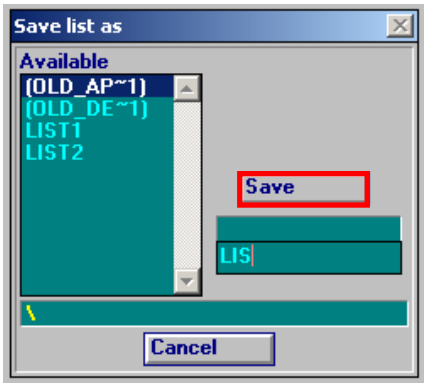


Fig.16b: ***Save list as*** *window*

5.4.3 Make a choice to ***Select*** and edit one of your own lists, or to make a ***New*** one. In both cases the ***Edit process list*** window *(Fig.17)* will show up, with all available recipes listed on the right-hand side.

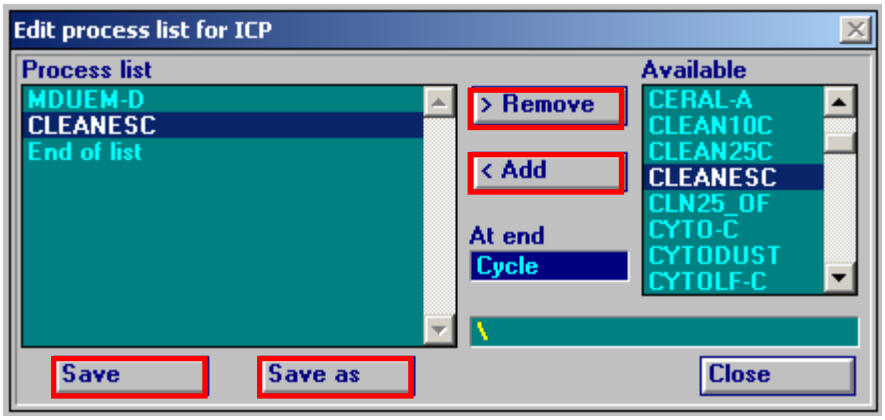


Fig.17: ***Edit process list*** *window*

5.4.4 With the ***Add*** and ***Remove*** buttons, compose the list for your wafers. The number of lines in the list should be identical to the number of wafers to be processed.
For wafers with identical processing, use the same recipe more than once in the list.

For wafers to be processed with the same recipe, but different etch times, make a copy or copies of that recipe first, before you create a list. Each copy should get a different name and a different process time.

Although possible, it is not recommended to make very complex sequences composed of a mix of lists and recipes together: one line containing one list should do.

5.4.5 Save your list using the buttons ***Save*** or ***Save as***. In case of a new list, the ***Save list as*** window *(Fig.16b)* will show up. Give your list a name (8 characters maximum).

5.4.6 In the empty sequence *(Sequence editor* window, *Fig.14)*, press the ***Edit*** button now. In the *Edit step* window *(Fig.15a)* that shows up, press the ***Select*** button to select your list in the *Step recipe* window *(Fig.15b)*. It shows recipes and lists together, lists can be identified by name and extension *[List]* following the name.

5.4.7 Follow the procedure described in 5.3.5 to 5.3.7 to finish the sequence.

6. Rules & Regulations

➔ Consult the machine owner about the most suitable recipe for your application.

➔ Parameters in the etch recipes are not to be changed, the only exception being the total process time or – in case of Bosch-type recipes – the number of cycles.

Please take notice of the following remarks about (6.1) substrates and handling, (6.2) cleaning and conditioning.

6.1 Substrates and handling

6.1.1 The ASE tool is for **silicon** etching only, no other materials!

6.1.2 Standard wafer size is 150mm diameter, thickness 670µm; 200mm diameter is optional, but internal machine parts have to be swapped for that purpose. The cassette robot (for automated processing!!) can handle 150mm wafers only.

6.1.3 **Check wafer flat orientation**, if not oriented properly the wafer chuck will be attacked chemically and get damaged or even destroyed!

6.1.4 Never start a conditioning run (Sect.6.2) without a (dummy) wafer in the etch chamber.

6.1.5 Use **resist** and/or **silicon oxide** as mask materials only, metals are not allowed.

6.1.6 At the end of the etch process, avoid long exposure of metal stop layers to the plasma as much as possible, it will degrade the process chamber performance.

6.1.7 For very deep etching **silicon oxide** is the prescribed mask materials, if necessary backed up by resist: at the wafer edge it gives superior protection, suppresses edge disintegration and the generation of particles on the chuck.

6.1.8 In case of double-sided processing, realize that it is very well possible that wafers may not be handled by the robot arm in the atmospheric cassette station: structures on the wafer backside may be a problem for the vacuum clamping system on the arm. If so, automated processing is impossible, manual loading via the carousel the only alternative.

6.1.9 In case of double-sided processing and/or through-wafer etch runs, realize that the wafer is lifted by 3 pins in the process chamber *(Fig.18)*: wafer handling shouldn't be hampered by backside structures or weak spots on the wafer after deep etching (e.g. holes). The wafer and/or the handling mechanism will get damaged. Although the lift pins are slender (~2mm diameter), take at least 5mm diameter structure-free areas around the pin positions (based on an estimated tolerance on wafer placement accuracy).

➔ 6.1.10 **Always consult the machine owner in case of 'specialties':**
Through-wafer etch runs
Thin wafers
Wafer pieces on top of carrier wafers
Silicon on glass or on other non-conductive materials

6.2 Conditioning

Before processing your wafers, conditioning of the process chamber is an option: run your selected process with a dummy wafer for a certain period of time. Conditioning of the tool is not a real necessity, but recommended for better stability and reproducibility of the given recipe. Dummy wafers should preferentially be coated with a (thick) layer of resist or silicon oxide.

Note that in general the amount of material exposed to the plasma influences etch rates. Etch rates tend to go down as 'open' surface area increases. Therefore, it is recommended to do a depth calibration run in advance using an identical dummy wafer.

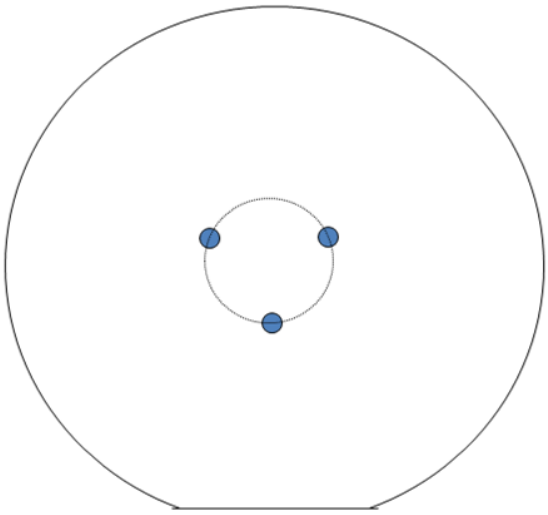


Fig.18: Lift pin positions in the process chamber: 3 spots at 120 degrees on a 30mm diameter circle.

7. Instruction and test

An introduction to the tool is given by the machine owner. Normally the instruction will take about one hour. First the major parts and possibilities of the machine will be explained. After this the operating instructions will be given. Subsequently the potential user will independently operate the system as a test. If successful, the user is authorized to use the tool and his/her name will be added to the users list in the equipment reservation tool.

If it turns out that users operate the etch tool with very large time intervals, it becomes questionable whether those users still know well enough how to operate the system properly. In that case, the tool owner may consider to contact those persons and withdraw their authorizations.