

# Standard Operating Manual

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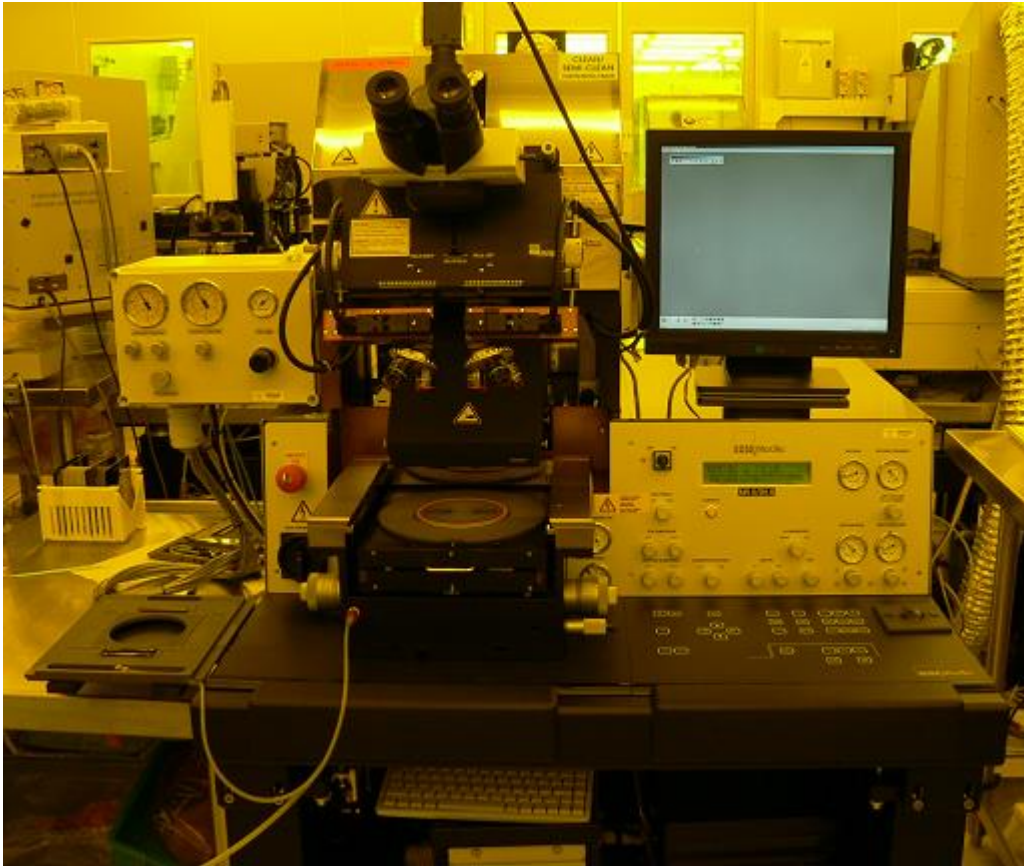
## **Karl Suss MA6 Mask Aligner**

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# Karl Suss MA6 Mask Aligner

## 1. Picture and Location



This tool is located at NFF Room 2240 Cleanroom Class 100.

## 2. Process Capabilities

### 2.1 Cleanliness Standard:

Suss MA6#1 Mask Aligner is classified as a “Non-Standard” equipment;

Suss MA6#2 Mask Aligner is classified as a “Clean/Semi-Clean”.

**2.2 Substrate Size:** TSA is  $>5\text{mm}^2$  to 2”, or 4”; BSA is 2” or 4”

**2.3 Photo mask Size:** 5” Square

**2.4 Alignment Accuracy:** TSA (down to  $0.5\mu\text{m}$ ), BSA (down to  $1\mu\text{m}$ )

**2.5 Resolution:**  $1\mu\text{m}$

### 3. Contact List and How to Become a Qualified User

#### 3.1 Emergency Response and Communications

1. Security Control Center: 2358-8999 (24hr) & 2358-6565 (24hr)
2. Safety Officer: Mr. Wing Leong CHUNG 2358-7211 & 64406238
3. Deputy Safety Officer: Mr. Man Wai LEE 2358-7900 & 9621-7708
4. NFF Senior Technician: Mr. Henry YEUNG 2358-7896
5. NFF Technician: Mr. Charles TANG 23587896

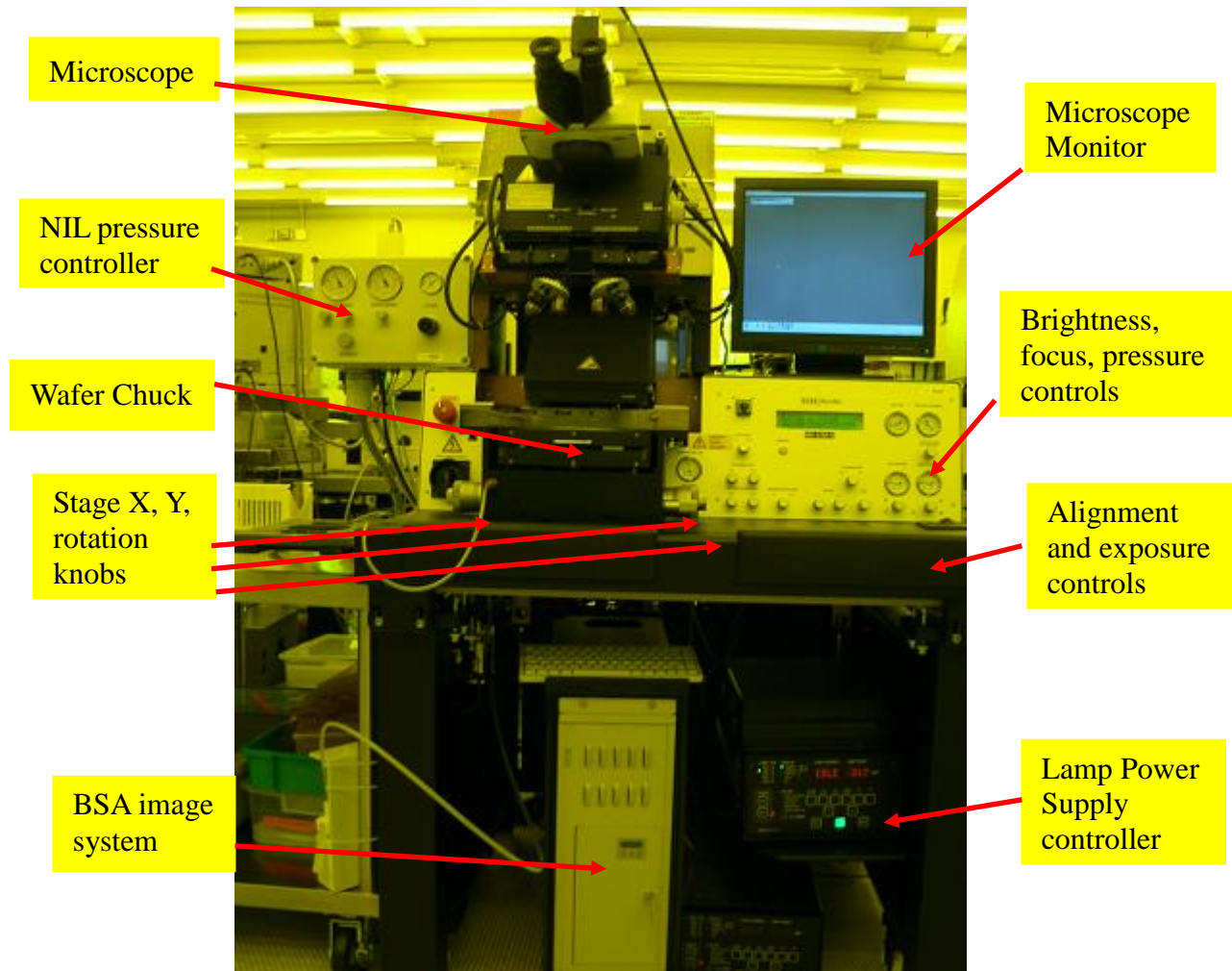
#### 3.2 Training to Become a Qualified MA6 User

Please follow the procedure below to become a qualified user.

1. Read through the on-line equipment operating manual of the equipment;  
  
<http://www.nff.ust.hk/equipment-and-process/equipment-operation-manual.html>
2. Attend the equipment hand-on operation training either by peer or NFF staff.
3. If training is provided by NFF staff, user must log in NFF equipment reservation system, and register these trainings.
4. Pass the examination for the equipment operation and the safety.

## 4. Operating Procedures

### 4.1 System Description



1. The Karl Suss MA6 is a top and bottom side mask aligner used for fine lithography down to 1 micron or below.
2. 350 W mercury arc lamp i-line (365nm) with "smart power supply" is capable of operating in constant power mode, or constant intensity mode. The default is constant intensity mode. In this mode, the lamp deteriorates; the power is automatically adjusted to keep the intensity of the wavelength. Also the Intensity of the lamp may be read from the power supply during exposure or during a lamp test.
3. Top side wafer alignment using a conventional microscope, wafer and mask stage

assemblies. Bottom side alignment using bottom viewing optics, CCD imaging with image frame grabber and LCD display. This allows registration of features on the backside of a wafer to the topside of the same wafer.

4. Automatic computer control with LCD status for User prompting and keypad entry. Up to 50 programs may be stored.
5. 5 contact modes may be used for exposure. These include: soft contact, hard contact, vacuum contact, low vacuum contact, and proximity. Each mode is easily selected by keypad and may have certain parameters changed by the user.

#### 6. Exposure Modes

**Proximity:** This is the most careful exposure for the mask. Mask damage is reduced to a minimum. But the structural resolution is not as high as with any contact exposure. Between mask and wafer is a distance left (exposure gap).

**Soft contact:** Mask and wafer are brought in contact. The structural resolution is better than in proximity exposure. The vacuum securing the wafer onto the chuck is maintained during exposure. The only force to press the wafer against the mask is the force applied during WEC.

**Hard contact:** This is similar to soft contact mode. After the wafer has moved into contact the vacuum underneath the wafer is switched off and nitrogen is purged under the wafer instead. So a closer contact between wafer and mask is guaranteed.

**Vacuum contact:** This mode performs the highest resolution levels. After the WEC and alignment the wafer is brought into contact with the mask. The rubber seal of a necessary vacuum chuck is creating a mini chamber between mask and wafer. The rubber seal pressure is adjustable by the VACUUM SEAL regulator.

**Low vacuum contact:** This mode is similar to vacuum contact with one difference: The vacuum level in the wafer chamber can be adjusted by the “LOW VACUUM ADJUSTMENT” regulator. So the high resolution level of the vacuum contact exposure can be combined with a minimum mechanical stress for wafer and mask. Set an appropriate vacuum with the vacuum chamber regulator and test the result using the “ALIGNMENT CHECK” key.



**Flood Exposure:** It is possible to exposure the whole wafer without a mask. After this mode is selected, the exposure can be started from the initial state by pressing the “**EXPOSURE**” key. The exposure takes place as long as the exposure time was set independent if a mask (and mask holder) is loaded or not.

#### 4.2 Safety Warnings

1. Follow NFF General Lab Safety policy.
2. Do not attempt to run the machine unless you are entitled to do so!
3. Do not open the electronics cabinets and any cover.
4. Do not touch the lamp house. It may burn your skins.
5. Do not attempt to ignite the lamp prior to the completion of 45 minute cool down. This might cause lamp to explode.
6. Leave nitrogen on for 30 minutes, and then turn it off (if need)!
7. Adjust the COARSE FOCUS TSA only in microscope down position! You can move the objectives to low and they can crash into the mask, the mask holder, etc.
8. To prevent mask damage, unload the mask before powering off the machine!
9. The high UV light energy produced by the exposure lamp can cause eye damage and skin burns. Don't stare at the light during exposing!
10. If the machine failure while being used, never try to fix the problem by yourself. Please contact NFF staffs.
11. High power UV lamp is used in this machine. It is mercury-based. It pose a chemical risk. If a UV lamp break or explode, do not attempt to clean up. You should isolate the NFF cleanroom and call NFF staffs.
12. The Emergency Off – Button (EMO) red button located in the left on the front

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of the machine. Only use the EMO in emergency situations. Emergency situations are where injury of personnel or serious damages of the system impends immediately.

13. In case of fire, keep calm, sound the alarm. If the machine hasn't shut down, press EMO Button to shut down the machine and notice NFF staff and UST security.
14. After exposure to mercury vapors consult doctor immediately!
15. In case of air pressure failure the damping elements are deflated and your fingers could be jammed.

### **4.3 Operation Precautions and Rules**

1. Please reserve the time slot on your own, and make sure you use your own time slot to do the exposure process.
2. Please check the checklist and fill all the details of the logbook attached.
3. Change your gloves before operation if your gloves contaminate with any resist.
4. Do not operate the machine unless you are properly trained and approved by NFF staff.
5. If mask and wafer are in contact (CONTACT INDICATOR on), don't move the wafer!
6. Watch out for the microscope movement!
7. No solvents are allowed near the machine!
8. The clip may not be strong enough to hold the mask in place when the mask holder is inverted. The vacuum should always be **ON** before the mask holder is inverted; otherwise the mask will drop and possibly break.
9. Remember to invert the pattern 180 Degrees for BSA masks.
10. Nitrogen failure for longer than 5 minutes will turn off the exposure lamp!

### **4.4 Initial Status Checks**

1. Please check the status of shutdown notice posted in the NFF reservation website
2. Please check the reservation status on the website, and reserve the right time



slot by your own.

3. Please check-in the equipment on your own according to the reserved time slot.  
If you haven't check-in, "Loss of wafer vacuum! Confirm with ENTER" error message will be displayed during process.
4. Before operate the machine, please make sure you have read and check the check list, and fill the log sheet.

#### 4.5 Initial System Checks

Before starting, verify the machine is in the correct idle state:

1. If system power is off (LCD display and all control LED off), please contact NFF staff to power on the machine.
2. Mask and wafer trays are on the stage with NO mask or wafer.
3. Pressure = 5-6 bar; Nitrogen = 1-2 bar, Vacuum < -0.8 bar.
4. Check log book that last user had no problem.
5. Move wafer stage to center position (x-axis and y-axis is at 10mm, rotation knob is at 0°).

#### 4.6 Power on Procedure (For Staff ONLY!)

If lamp power is off (no LED readout), turn lamp power on at the power supply under the table.

Note: System power must be OFF to start the lamp.

##### 1. Ignition of the exposure lamp (CIC 1200)



- Switch "ON" button to power on the Constant Intensity Controller (CIC).
- The software version is shown on the display.
- The CIC performs a self calibration test and displays "ready".
- Press CP (constant power) key. Display shows "wait", followed by "Start".

- Press “**START**” key. This will ignite the exposure lamp. **LED LAMP LIFE/POWER** is flashing until lamp warming up is finished.

## 2. Powering on the electronic

- Wait for around 10 minutes let the lamp stable.
- Turn the POWER SWITCH ELECTRONIC on the upper panel control clockwise into ON position and release.

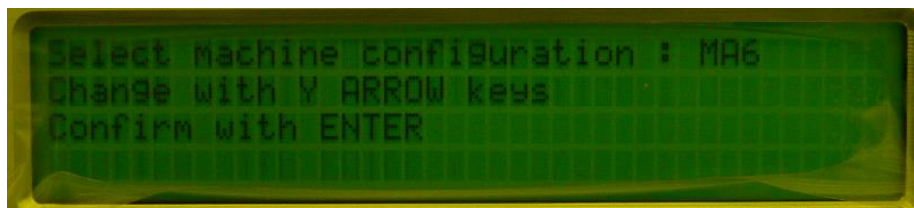
Machine initialize. The display message is:



- Press the flashing **LOAD** key on the keyboard when you are asking to do so.

"Watch out machine is starting!"

- Now you are asked for:



- Press the flashing **ENTER** key on the keyboard when you are ask to do so
- "**ready for Load**"
- The software is loaded and the machine is in initial state, ready for operation:
- All motorized manipulators (TSA, BSA and alignment stage) are set to the position used before the machine was powered off.
- Press “**BSA Microscope**” button to deselect BSA Microscope.



## 4.7 Modify Parameters

### 1. Select Process: “**EDIT PARAMETER**” key

Press “**EDIT PARAMETER**” key to toggle with the “**X-Arrow**” key to **PROCESS**, select with the “**Lithography**” by the “**Y-ARROW**” key.

**2. Select exposure mode: “EDIT PARAMETER” key**

Press “EDIT PARAMETER” key to toggle with the “X-Arrow” key to expose mode, select with the “Vacuum, Low Vacuum, Hard, Soft, Proximity or Flood-E” by the “Y-ARROW” key.

**3. Edit parameters: “EDIT PARAMETER” key**

Press “EDIT PARAMETER” key to edit the parameter.

Change all necessary values and confirm by pressing “EDIT PARAMETER” key again.

Note: 365nm lamp is calibrated to certain intensity; the setting value is shown in front of the machine.

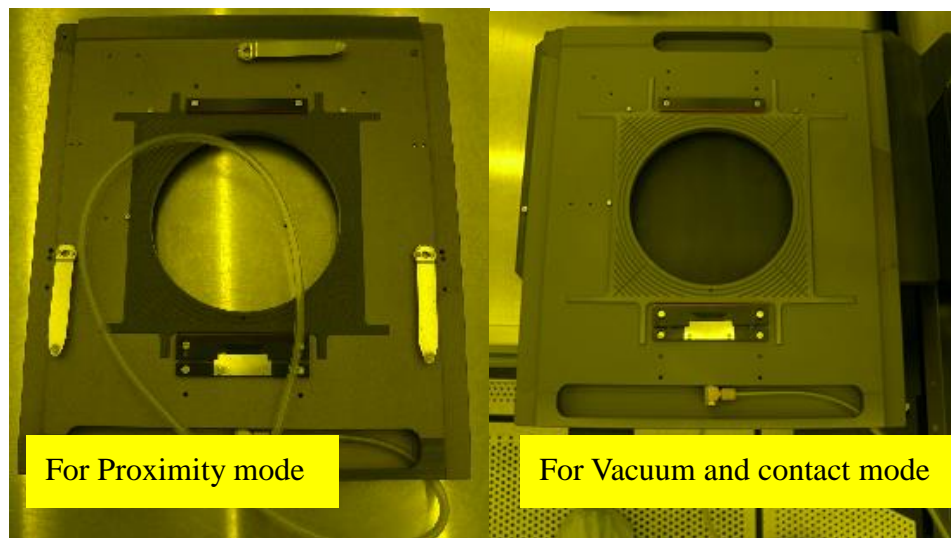
**4. Save all setting: “EDIT PROGRAM” key**

This function is an optional possibility to save this parameter set for the future.

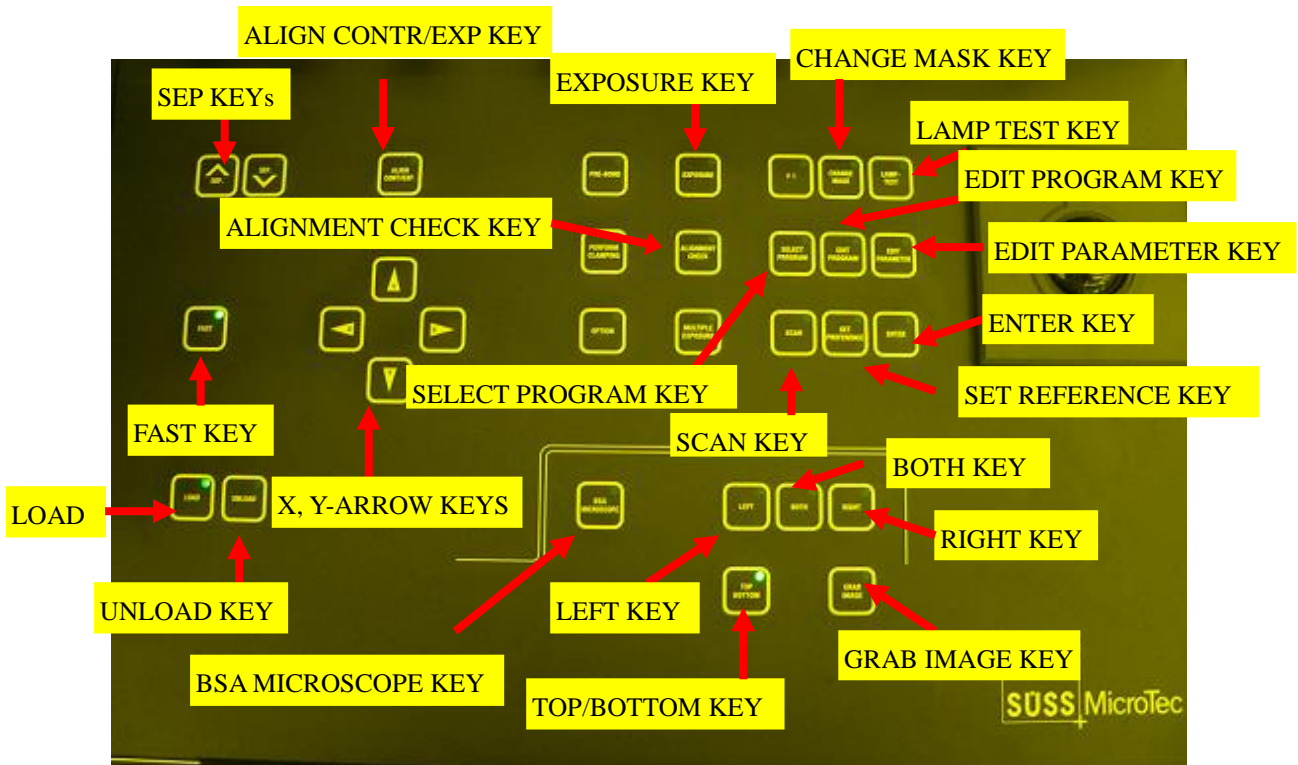
Toggle with the “X-ARROW” keys to “SAVE Pgm.”. Select with the “Y-ARROW” keys a program number. Prior saved programs to the same number will be overwritten without warning. Save the settings by the “EDIT PROGRAM” key. Existing programs can be loaded from here.

#### **4.8 Mask Loading**

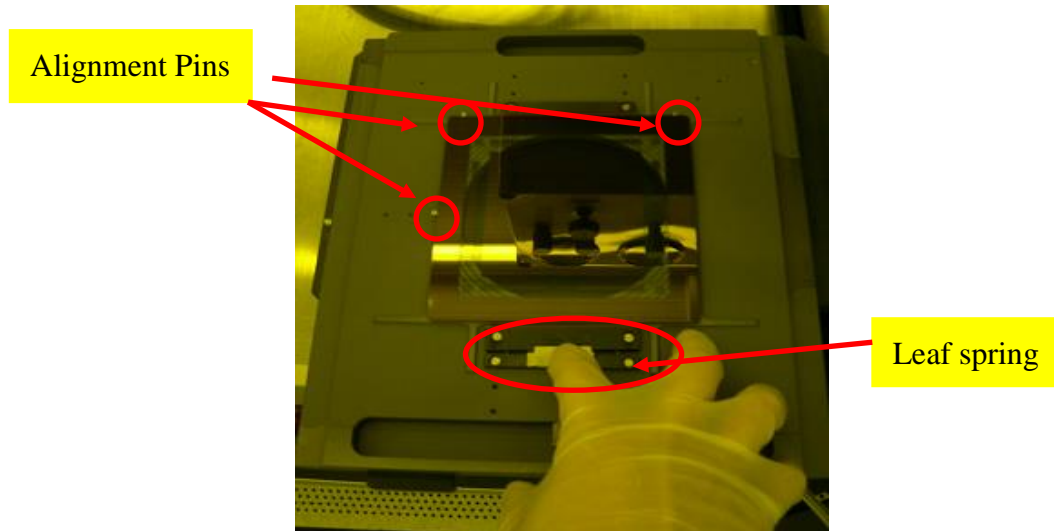
There are two mask holder; one for vacuum or contact mode, and the other one for proximity.



1. If MA6 is not already in the “**CHANGE MASK**” mode. “**CHANGE MASK**” and “**ENTER**” keys do not flash. Press “**CHANGE MASK**” key.
2. Take out the mask holder, flip it 180° and put it on the left compartment. If a mask is loaded, verify on LCD display that vacuum is still on before pulling out tray. If not, press “**ENTER**” key to turn mask vacuum on. Press “**ENTER**” key to toggle the mask vacuum off, retract the mechanical mask clamp and remove the mask after put it on the left compartment.



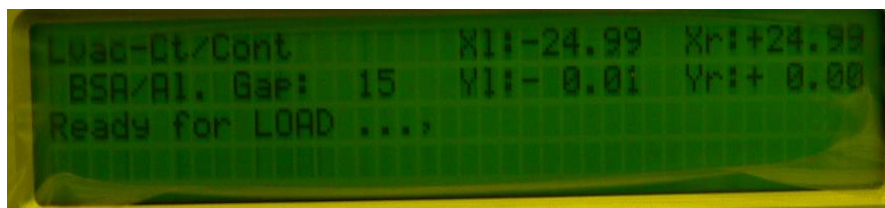
3. If need a different mask holder, disconnect vacuum hose at machine by pushing in on red knurled knob and gently pull on the hose. Store unwanted mask holder at Mask holder Storage area and choose the appropriate mask holder. Place the new mask holder upside down on the left compartment. Reconnect vacuum hose by pressing connector firmly into red knob's opening.
4. Put the mask, chrome side up onto the mask holder against the 3 alignment pins. The machine instructs: “Change mask – Press ENTER to toggle mask vacuum is: OFF”.



5. Toggle the mask vacuum on by press flashing “**ENTER**” key. Activate the mechanical mask clamp by pressing the leaf spring down. Verify vacuum is on before turning mask plate over. (Use hand should unable to move the mask).



6. Flip the mask holder 180 ° that your mask is on the bottom and slide mask holder back into the guides of the machine. Put your hand under the mask holder to avoid the drop down of the mask.
7. Lock the mask holder slide by press “**CHANGE MASK**” key again. “Ready for Load” message appears on the LCD display.



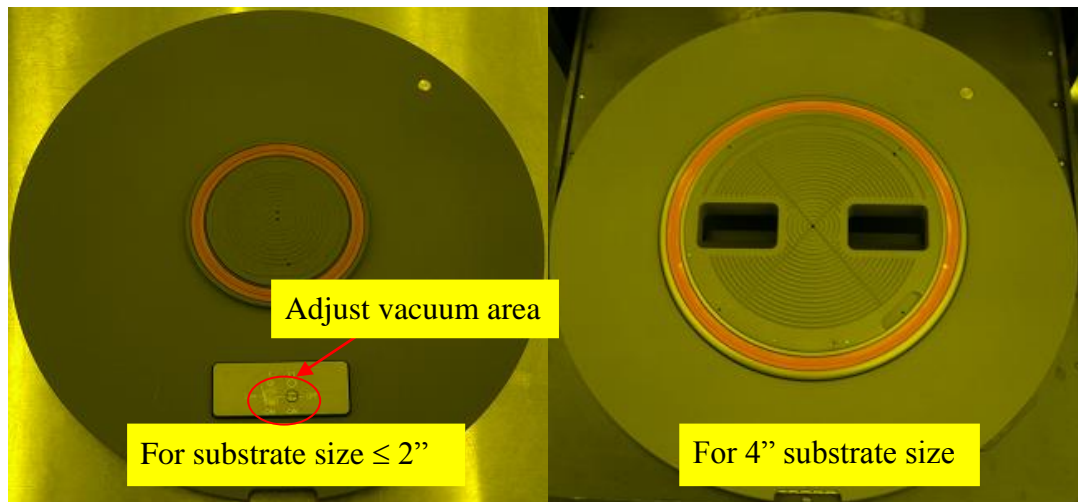
**CAUTION:** The clip may not be strong enough to hold the mask in place when the



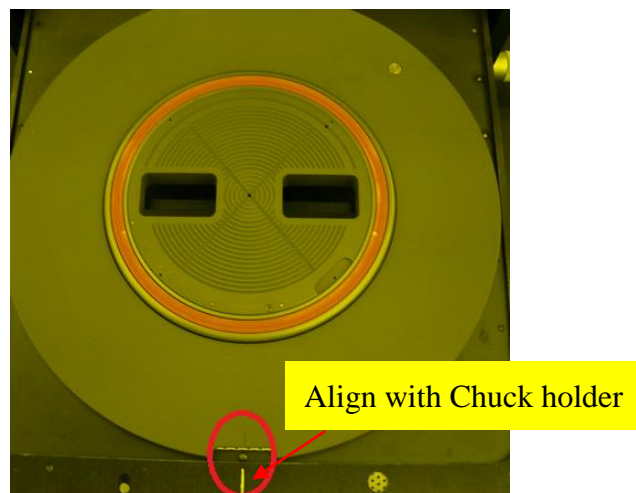
mask holder is inverted. The vacuum should always be **ON** before the mask holder is inverted; otherwise the mask will drop and possibly break.

#### 4.9 Wafer Loading

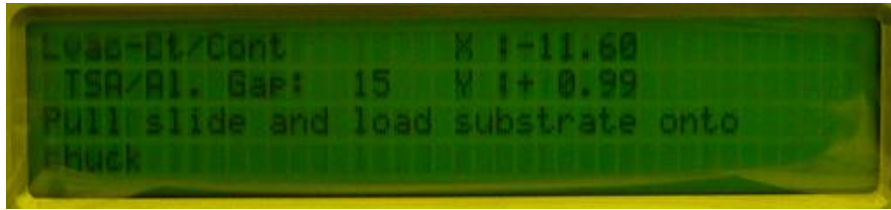
There are two wafer chucks, one for 4 inch substrates and the other one for pieces (1.5cm to 2 inch). **CAUTION:** Do not drop, scratch or otherwise damage the chuck. Store an unused chuck at its proper location.



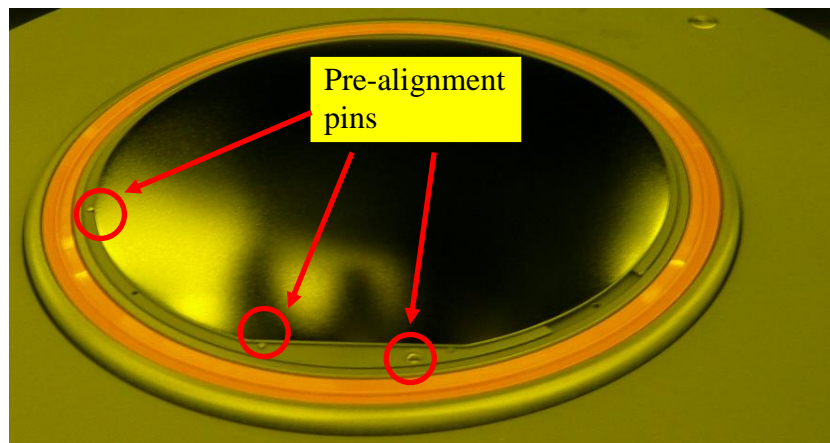
1. Choose the expose mode at first, please follow step 4.7.
2. If the chuck is not centered, rotate the chuck to align with chuck holder, and then move it with micrometer screws to the middle position (x-axis to 10mm, y-axis to 10mm) and adjust the stage rotation knob to 0 (“+”).



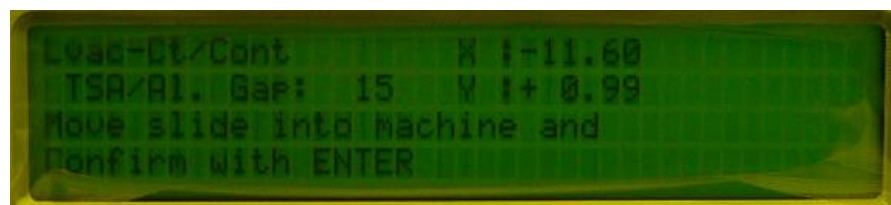
3. Press “**LOAD**” key, pull out the transport slide completely. The machine instructs: "pull slide and load substrate onto chuck". (“**ENTER**” and “**UNLOAD**” key flashing.)



4. Verify the chuck and check red vacuum seal are clean from stains or particles. Use Nitrogen blow gun to remove particles or IPA (Isopropyl Alcohol) with a clean wiper to remove stains if needed.
5. Change the chuck if needed, gently lift the chuck from the bottom side of the slide and remove. Place proper chuck into circular opening within the slide (Seal faces up). Align white line on chuck to steel pin on tray. Always handle wafer chuck by the metal rim, DO NOT touch the center of the chuck directly.
6. Place the substrate on the center of the chuck with the major flat facing you, make sure all open vacuum holes are covered and the wafer against the three pre-alignment pins.

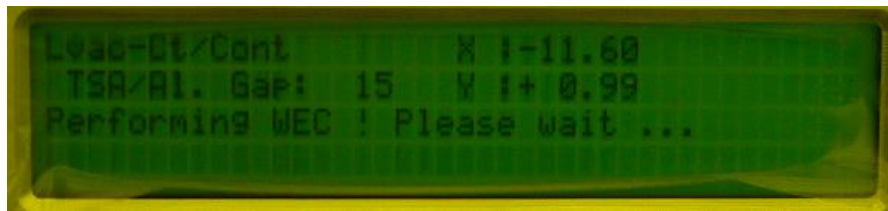


7. Press “ENTER” key to turn on the vacuum.
8. The machine instructs: “move slide into machine and confirm with Enter”. Slowly move the transport slide into the machine.



9. Press “ENTER” key again to confirm. WEC starts automatically. The machine instructs: “Performing WEC, please wait...” The wafer is adjusted parallel to the mask and moves to the setting alignment gap. The microscope moves down to

start the alignment (if it is not already down).

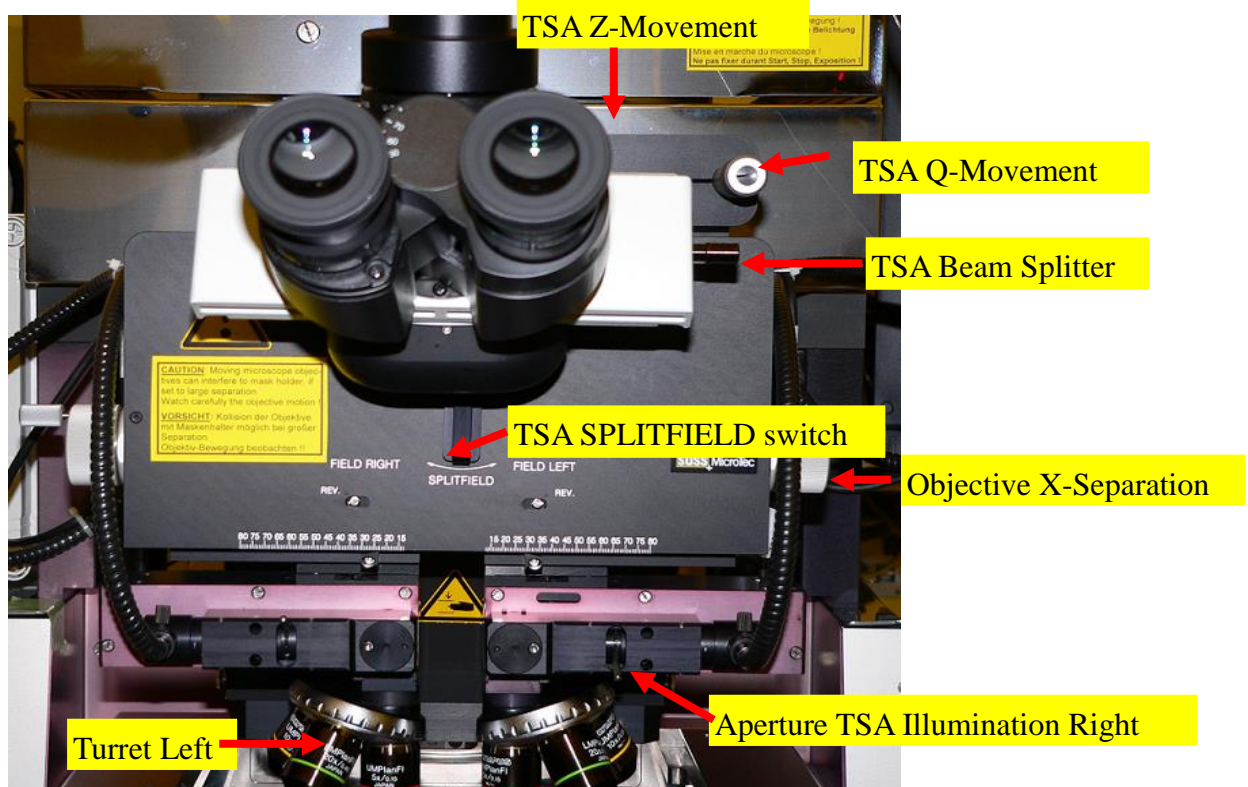


10. The machine instructs: "Align Substrate".



#### 4.10 Top Side Alignment (TSA)

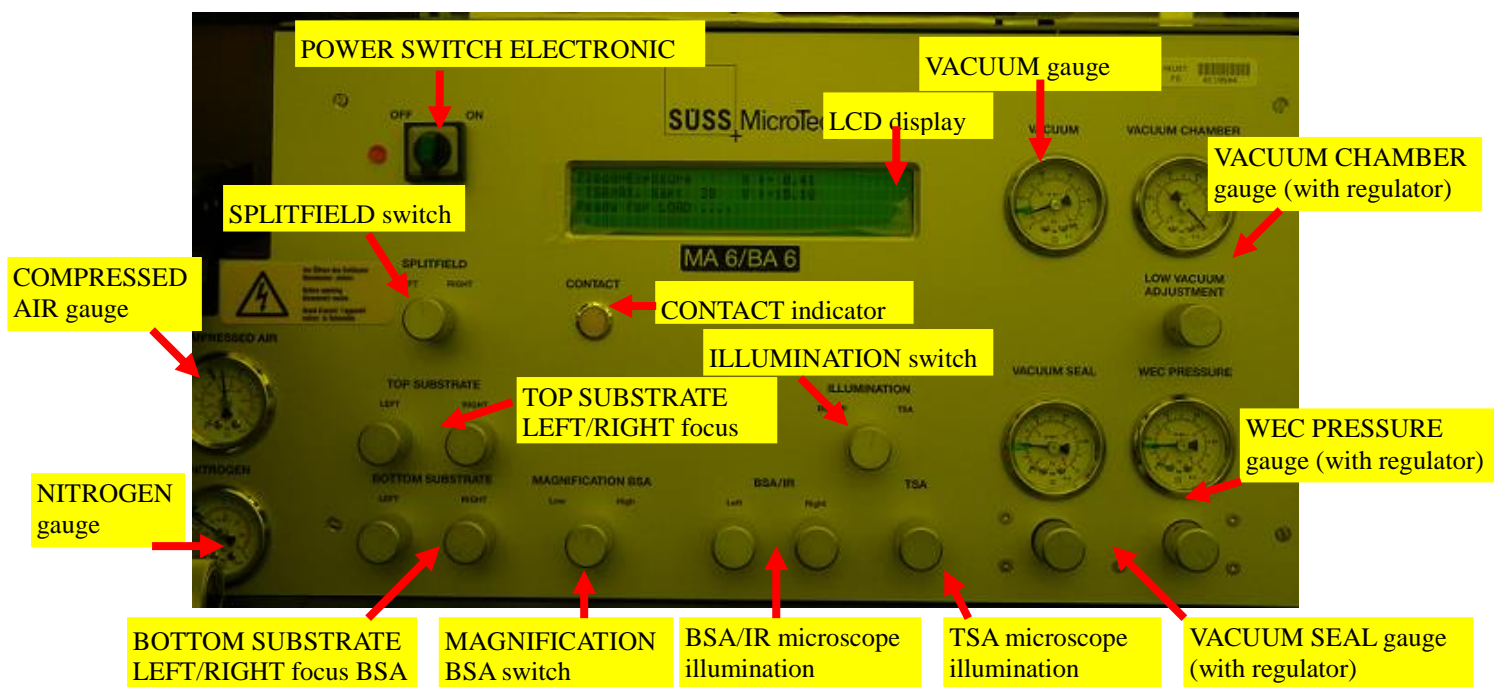
The wafer is aligned to the mask using the topside alignment microscope (TSA). If the microscope is not lowered automatically press “F1” key, confirm with “ENTER” key.





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1. The objectives position over the mask using the “X-Y” arrow keys. The fast speed movement of the microscope may be obtained by pressing “Fast” Key LED on.
2. An actual TSA-microscope image on the monitor is enabled by turning the “SPLITFIELD” switch to LEFT. Deactivate “BSA Microscope” key LED off. This key also switches the controlled manipulator motors from BSA to TSA.
3. This slide on right side of the microscope tube guides the beam to the eyepieces, the monitor or both.
4. Turn “**ILLUMINATION**” switch to TSA and select the light intensity with the potentiometer underneath this switch. Separate intensity selection for the left/right objective is possible with the aperture located at the left/right microscope front.
5. Coarse focus is possible by using the “**TSA Z-MOVEMENT**” knob placed behind the TSA-microscope. This is used to bring the objective’s depth of focus into the fine focus range. The fine focus knobs labeled “**TOP SUBSTRATE**” should be used to focus on the mask. The fine focus knobs labeled “**BOTTOM SUBSTRATE**” should be used to focus on the substrate. Make sure the “**TOP/BOTTOM**” key LED is on and adjust the fine focus separately using the “**TOP SUBSTRATE LEFT/RIGHT**” regulators. When the “**TOP/BOTTOM**” key LED is off, focus control is assigned to the Bottom Substrate knobs.

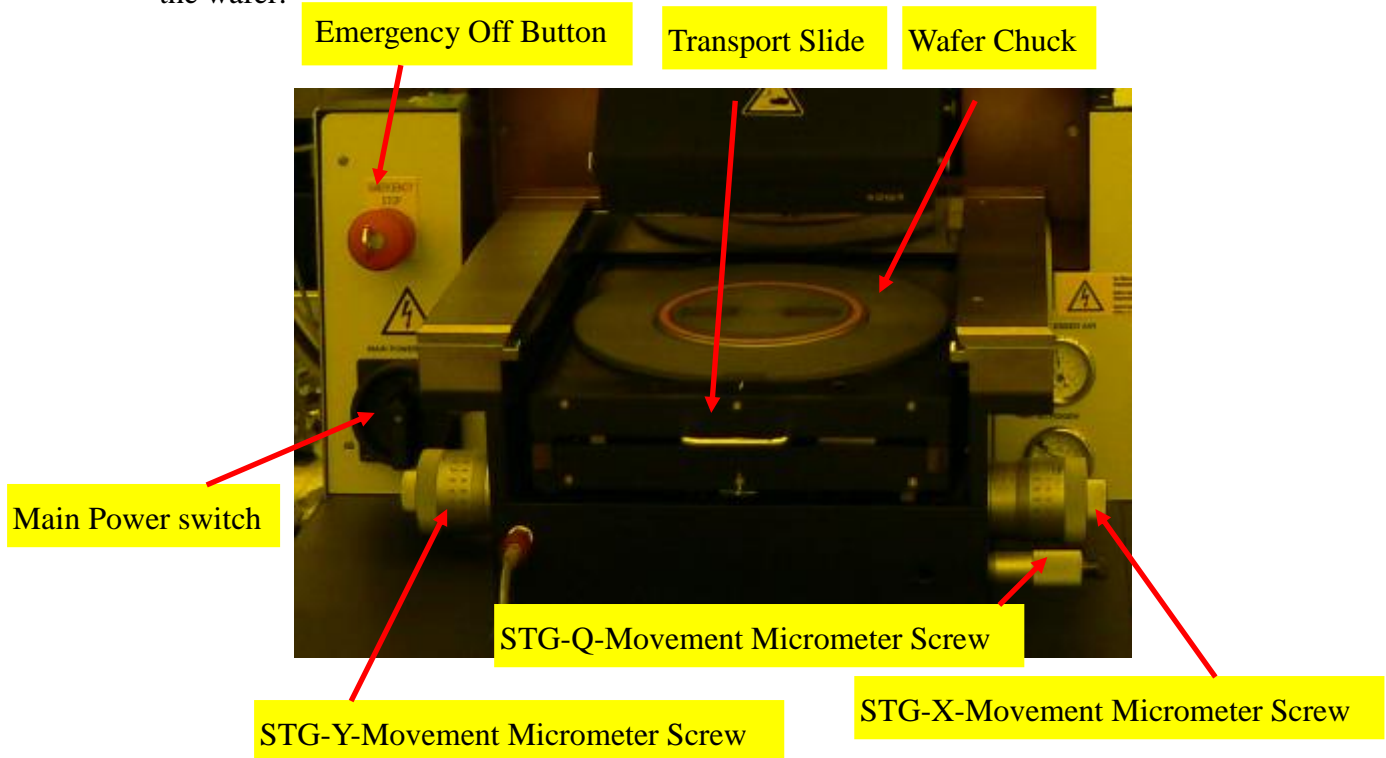


6. Coarse focus is possible by using the “**TSA Z-MOVEMENT**” *knob* placed behind the TSA-microscope. This is used to bring the objective’s depth of focus into the fine focus range. The fine focus knobs labeled “**TOP SUBSTRATE**” should be used to focus on the mask. The fine focus knobs labeled “**BOTTOM SUBSTRATE**” should be used to focus on the substrate. Make sure the “**TOP/BOTTOM**” key LED is on and adjust the fine focus separately using the “**TOP SUBSTRATE LEFT/RIGHT**” regulators. When the “**TOP/BOTTOM**” key LED is off, focus control is assigned to the Bottom Substrate knobs.
7. The right/left objective can be moved independently in x-direction to right/left mask alignment marks using the Objective X-Separation knobs located in the right/left side of the TSA microscope body. To rotate the microscopes around the z-axis by turning the knob located in the upper right TSA microscope front (**TSA-Q-MOVEMENT**).
8. The MA6 has the ability to remember microscope position via the “**Set reference**” key. Simply use x-y arrow keys (fast mode may be used if desired) to position microscope. Press “**SET REFERENCE**” key LED comes on. Reposition microscope with arrow keys to 2<sup>nd</sup> position, Now Press “**SCAN**” Key. Microscope moves back to previous reference position. Press “**SCAN**” again and microscope moves back to 2<sup>nd</sup> position. This method offers easy alignment of small pieces using a single objective or even a single field TSA micro-scope. This feature may be used for bottom side microscope also.

#### 4.11 Wafer Alignment

There are 3 adjustment knobs located near the bottom of the stage to move wafer relative to the mask, X, Y and R (rotation).

**CAUTION:** If mask and wafer are in contact mode (Contact indicator on), don't align the wafer.



1. With MA6 in alignment mode, and view in split field mode (if wafers already have a pattern), straighten wafer by turning rotation R knob.
2. Rotate X and Y alignment knobs to align substrate alignment mark central symmetrical to the mask alignment mark.
3. If too much resistance is felt during wafer movement, or alignment gap needs to be changed, press “SEP ^” key to decrease separation (z value on display become less negative) or “SEP v” key to increase separation (z value becomes more negative).
4. When properly aligned, pressing “ALIGNMENT CHECK” key LED on to bring the substrate into contact mode. If wafer has patterned, alignment shift due to contact may be observed through microscope. If unacceptable shift is observed, substrate or mask may need to be re-cleaned.

Note: The “ALIGNMENT CHECK” key is not available for proximity or soft

contact modes. Use the “**Alignment/Cont**” key instead.

5. Press “**ALIGNMENT CHECK**” key again to exit this mode, and if alignment is acceptable, proceed to expose wafer section.

#### 4.12 Wafer Exposure

Lamp power supply should be in CH1 (Constant Intensity @365nm) mode. The current system intensity setting value is shown in front of the machine. Check process information or expose test wafer to determine proper exposure time for your needs.

1. If exposure time, as displayed needs to be changed, press “**EDIT PARAMETER**” key. Toggle with “**X-ARROW**” key to EXP. TIME, and use “**Y-ARROW**” keys to change exposure time and then press the “**EDIT PARAMETER**” key again. The LCD readout should reflect the changed exposure time.
2. Press “**EXPOSURE**” key, Watch out as Top Side alignment Microscope move up and exposure assembly slide out to expose wafer. (Despite the exposure was initiated pressing the “**UNLOAD**” key before the light shutter has opened will continue its exposure program sequence without wafer exposure).
3. Verify exposure power (270-400W) during exposure on lamp readout.
4. After exposure, microscope drops down and wafer chuck moves down to unload the exposed wafer.
5. The machine instructs: “Pull Slide and unload exposed substrate”. Load another substrate if desired. Otherwise, move the transport slide back into the machine.



6. Press flashing “**ENTER**” key followed by “**LOAD**” key and “**ENTER**” key again.
7. Repeat wafer alignment and exposure procedure as describe above.

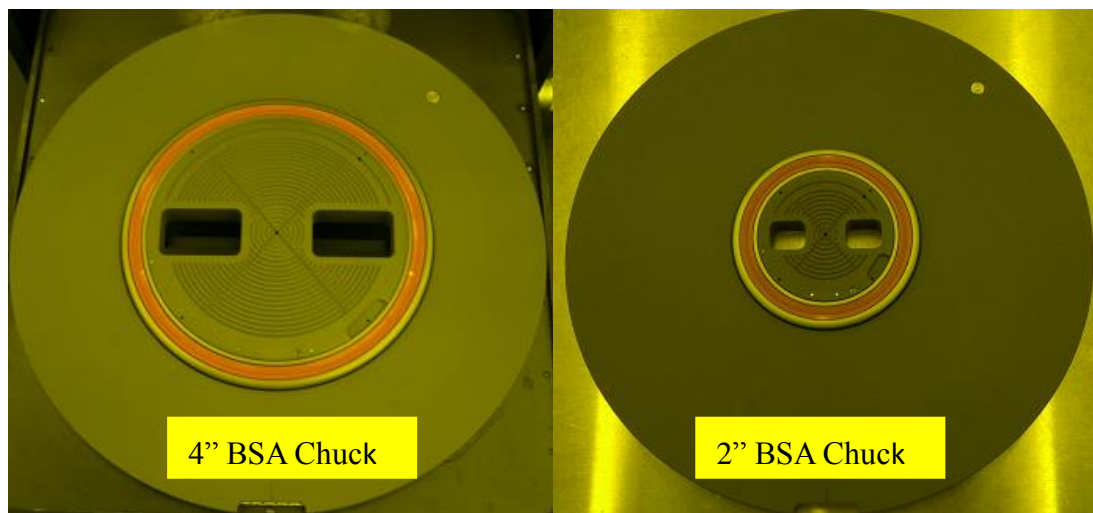
Note: You should develop and inspect the first wafer before you expose the second wafer, you might need to adjust the exposure time.

#### 4.13 Mask Unloading

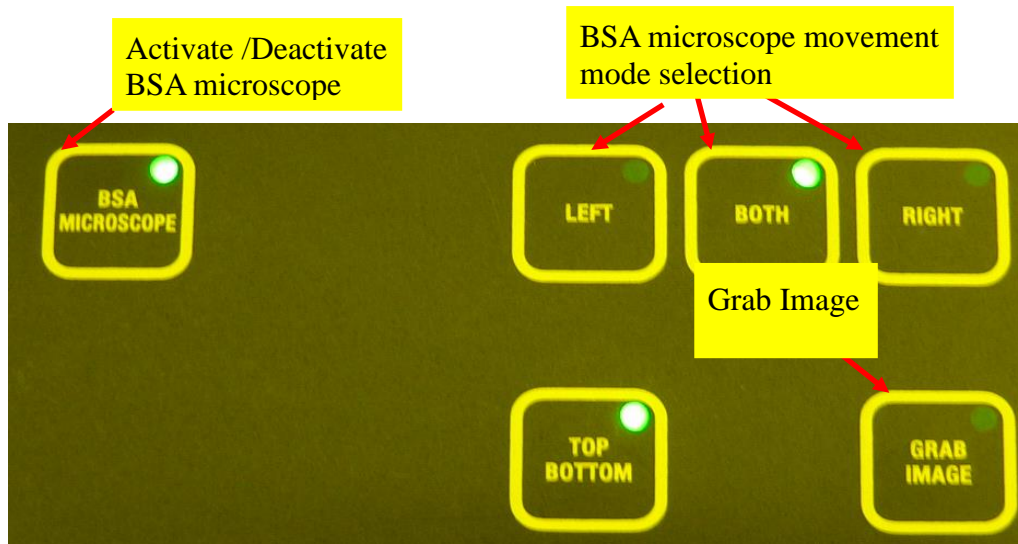
1. Press **“CHANGE MASK”** key, this key and **“ENTER”** key will flash, mask holder will be released.
2. If the microscope is not lifted automatically press **“F1”** key, confirm with **“ENTER”** key to raise it to up position.
3. Verify on LCD display that vacuum is still on. Pull mask holder out, flip it 180 ° and put it on the left compartment. Press **“ENTER”** key to switch mask vacuum off, retract the mechanical clamping and remove the mask.

#### 4.14 Bottom Side Alignment (BSA)

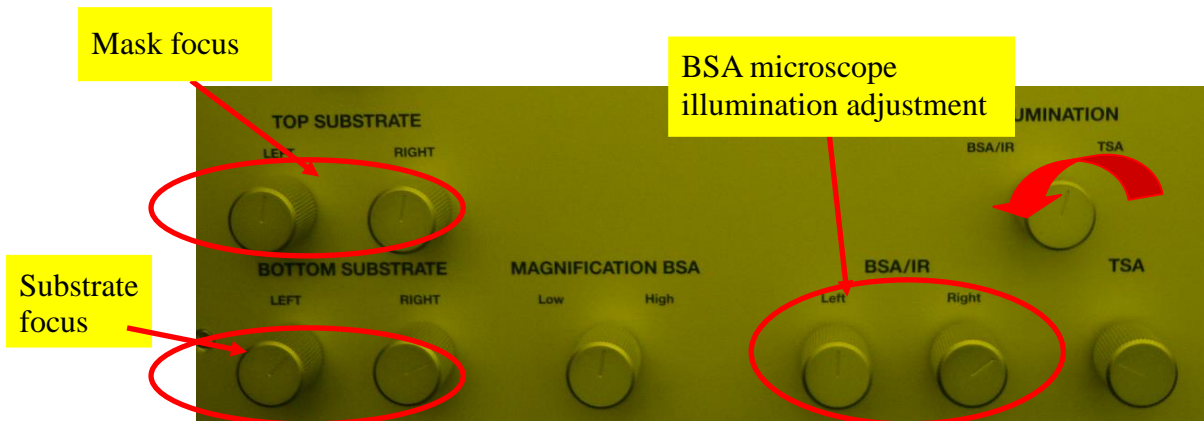
The bottom microscope is used to print a pattern on the backside of a substrate that is aligned to a pattern on the front side of the substrate. It accomplishes this by using a screen grabs or stored an image of the mask prior to loading the substrate. The mask and microscope then lock into place while the substrate is loaded patterned side down, resist side up. The patterned wafer may then be viewed by the bottom side alignment microscope (BSA), and alignment may be accomplished by moving the wafer **ONLY**. Both the mask's stored image and the real time wafer image are viewed on the LCD monitor during this procedure.



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1. Verify MA6 idle mode and start up machine as describe above.
2. Select desired contact mode and parameter setting as described above.
3. Make sure no wafer is on the wafer chuck. Use “UNLOAD” key as previously described if necessary.
4. Turn the “**SPLITFIELD**” switch to middle position and toggle “**BSA MICROSCOPE**” key LED on. This key enables the microscope manipulators accordingly.
5. Turn the illumination switch to “**BSA/IR**” on the front panel’s illumination switch. Adjust the light intensity by the potentiometers labeled “**BSA/IR**” microscope illumination left/right.



6. There are 3 keypads “**LEFT**, **BOTH**, and **RIGHT**” which determine mode of movement; “**LEFT**” for left objective movement, “**BOTH**” for both objective movement. Select one of these keys to move the left/right bottom objective with the “**X-Y ARROW**” keys. If necessary uses fast speed (“**FAST**” key LED on).
7. Load Mask as described previously.
8. Press “**TOP/BOTTOM**” key to activate mask focus (key LED on), adjust the



fine focus separately with the “**TOP SUBSTRATE LEFT/RIGHT**” regulators get a sharp image on LCD monitor.

9. Bottom microscope position may be read from the LCD. Xl= left objective x position; Xr = right objective x position, Yl= left objective Y position, etc. Rotation is accomplished by moving one objective relative to the other. The “**SET REFERENCE**” key may be used as described before.
10. Find the alignment marks or feature on the mask you wish to align to (use split field view).
11. First keystroke “**GRAB IMAGE**” key to grab the mask image. The objectives move to the wafer focus plane (“**TOP/BOTTOM**” key LED off). Note: This must be done every time you load a new substrate. The mask and microscope are now locked down and may not be moved. Second keystroke “**GRAB IMAGE**” key deletes stored image and enables the manipulator again.
12. Press “**LOAD**” key, pull transport slide out and load substrate patterned-side down which is also resist side up. Press “**ENTER**” key to turn vacuum on.
13. The machine instructs: “Push slide into the machine and Press “**ENTER**” key”. Substrate goes into WEC mode and a fuzzy image may appear on the monitor.
14. “**TOP/BOTTOM**” key should be in bottom mode (LED not on).
15. Adjust the left/right microscope image with the “**BOTTOM SUBSTRATE LEFT/RIGHT**” regulator. Adjust illumination if necessary.
16. Use the micrometer screws of the alignment stage for **STG-X-Y-Θ-MOVEMENT**. Align the wafer alignment marks central symmetrical to the mask alignment marks on the grabbed image.
17. Press “**EXPOSURE**” key. Exposure takes place, UV illuminator slides out and substrate is exposed.
18. After finishing the wafer chuck moves down to unload the exposed wafer.
19. The machine instructs: “Pull the transport slide out and unload your substrate”. Move the transport slide back into the machine.  
Repeat through Step 11-19 if need expose another substrate.

#### 4.15 Process Recording during the process

1. Please be reminded you are required to fill all the details of the log sheets. If you fail to do this, a punishment will be given.

2. Write down any problems or comments in the log sheets.

#### **4.16 Clean up**

Clean the chuck and make sure everything is back to the original place.

#### **4.17 Check out**

Check out the equipment in the NFF equipment reservation website or Card Reader after use.

#### **4.18 Machine Shutdown (For Staff ONLY!)**

1. Press “**CHANGE MASK**” key and the mask holder will be released. With the mask vacuum ON, pull the mask holder out, flip it 180° and store it on the tray to the left compartment. Press “**ENTER**” key to switch the mask vacuum OFF.  
Retract the mechanical clamping and remove the mask.
2. Toggle Power Switch Electronic to position OFF.
3. Turn off the CIC by pressing on the OFF button.
  - Leave nitrogen on for 30minutes, and then turn it off.