

KARL SUSS MA8 MASK ALIGNER PROCEDURE

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OVERVIEW:

- UV broad-band, I-line (365 nm) and G-Line (436 nm) wavelength are available. Contact super-user for installing I-line or G-line filters.
- Exposure methods: flood, proximity, soft and hard contacts, low-vacuum and vacuum contacts.
- Mask size: 4"×4", 5"×5", and 7"×7"
- Wafer size for Top-Side Alignment: 3", 4", 6" and 8"
- Note: this tool is not capable of doing Bottom-Side Alignment.
- Maximum wafer thickness: 3 mm

SPECIAL NOTES OR RESTRICTIONS:

- Must be qualified to use the tool by super-user.
- Do not lean on machine during alignment or exposure.
- Most materials are allowed on this machine. Contact super-user for more details.

SAFETY PRECAUTIONS:

- **WATCH OUT FOR THE MICROSCOPE MOVEMENT AT ALL TIMES!!!**
- Nitrogen failure for longer than 5 minutes will turn off the exposure lamp. Do not attempt to turn the lamp on again. Contact super-user or technical support person.

QUICK DEFINITIONS *(see Appendix for more details):*

- WEC – Wedge error compensation (setting the wafer parallel to the mask)
- Al. Gap – Alignment gap (initial gap between the wafer and mask)
- SEP. – Alignment gap separation (control keys to set the alignment gap)
- Exp. – Exposure
- Exp. T. – Exposure time
- Prox – Exposure type: proximity
- Soft-Ct – Exposure type: soft contact
- Hard-Ct – Exposure type: hard contact
- Vac-Ct – Exposure type: vacuum contact
- Lvac-Ct – Exposure type: low-vacuum contact, also Low Vac
- Pre. Vac – Pre-vacuum time with reduced vacuum pressure
- Full Vac – Full vacuum time before exposing in Vacuum contact
- Vac Purge – N₂ purge time into the vacuum chamber after exposing
- TSA – Top side alignment
- BSA – Bottom side alignment
- STG – Stage
- F1 Key – Press **F1** key and **ENTER** to raise or lower the microscope during alignment

EXPOSURE METHODS:

An important parameter for the exposure is the contact method between mask and wafer. The type of exposure program is selectable with the **SELECT PROGRAM** key. After this selection it is possible to edit all corresponding parameters by pressing the **EDIT PARAMETER** key.

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 – the exposure gap. The gap value is adjustable with the **EDIT PARAMETER** key.

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 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, even with large wafers.

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. This chamber is evacuated in steps. Pre vacuum gently pulls vacuum into that mini chamber to enable a smooth contact between mask and wafer. Furthermore it prevents gas bubbles to be trapped between both. Full vacuum will be applied in the next step. The wafer will be brought to the closest contact position. The vacuum securing the wafer on the chuck is replaced by nitrogen. In this mode the best contact between mask and wafer is achieved. After the exposure nitrogen will be purged into the mini chamber to break the vacuum. The larger the wafer the longer the vacuum and purge times. For best results start a test with long times and reduce them gradually. All parameter could be set using the **EDIT PARAMETER** key.

Low-Vacuum contact

In this mode the space between the wafer and mask is partially evacuated. Nitrogen is bled in to prevent complete evacuation. So, the high resolution level of the vacuum contact exposure can be combined with a minimum mechanical stress for wafer and mask. This causes less wear to the mask and wafer than vacuum contact mode.

Flood Exposure

This process does not require a mask. Whole substrate is exposed with UV light (usually done for Image Reversal Technique). Exposure begins once you load a wafer. Contact super-user for more information.

FIRST-LEVEL MASK EXPOSURE

1. LOAD MASK

- Press **CHANGE MASK** key.
- Place the mask onto the mask holder against the stop pins.
- Toggle the mask vacuum on by pressing the **ENTER** key.
- Activate the mechanical mask clamp by pressing on the leaf spring.
- Flip the mask holder 180° and move it into the machine.
- Press **CHANGE MASK** key again to lock the mask holder.

2. ADJUST PARAMETERS

- Edit parameters by pressing **EDIT PARAMETERS** key. Change all necessary parameters: exposure time, alignment gap (200 μm), and exposure type. Leave other parameters unchanged.
- Press **EDIT PARAMETERS** key again to confirm the changes.

3. LOAD WAFER

CAUTION: Watch Out For Microscope Movement!

- Press **LOAD** key. The machine instructs: "PULL SLIDE AND LOAD SUBSTRATE ONTO CHUCK"
- Pull out the transport slide completely.
- Insert the proper chuck and place the wafer against the pre-alignment pins.
- Confirm with **ENTER** key. Now the wafer is holding by vacuum. The machine instructs: "MOVE SLIDE INTO MACHINE AND CONFIRM WITH ENTER".
- Gently push in the transport slide and confirm with **ENTER** key. Wedge error compensation (WEC) will automatically adjust the wafer parallel to the mask.
- If desirable to move the chuck/wafer to the center of the mask, set micrometer screws to:
 $X = 10$, $Y = 10$, and $\theta = 0$

4. EXPOSURE

- Press **EXPOSURE** key to expose the wafer. This will move the wafer into exposure position. Shutter will open and expose the wafer. Depending on the exposure program selected all program steps will be performed automatically. After finishing, the wafer chuck will move down to unload the exposed wafer.

5. UNLOAD WAFER

CAUTION: Watch Out For Microscope Movement!

- Wait till the message on LCD screen appears: "UNLOAD SUBSTRATE FROM SLIDE".
- Pull out transport slide completely; otherwise the vacuum will be on.
- Unload wafer and move the transport slide into the machine.
- If you would like to expose additional wafers, perform steps 3-5

6. UNLOAD MASK

CAUTION: Watch Out For Microscope Movement!

- Hit the **CHANGE MASK** key to release the mask holder.
- Pull the mask holder out, flip it 180° and place it on the tray to your left.
- Hit **ENTER** to switch the mask vacuum off.
- Retract the mechanical clamping and remove the mask.

7. STAND-BY MODE

- Turn off the monitor.
- Turn **ILLUMINATION** knob to BSA/IR position.
- Set micrometer screws to: $X = 10$, $Y = 10$, and $\theta = 0$.

TOP SIDE ALIGNMENT

In this mode the wafer is aligned to the mask using the topside alignment microscope (TSA). Make sure you are familiar with following: computer software, **SPLITFIELD** switch, **ILLUMINATION** switch, **TOP/BOTTOM** key, **TOP/BOTTOM SUBSTRATE** fine focus knobs, **OBJECTIVE X-SEPARATION** knobs, **θ -MOVEMENT** knob, **X/Y-ARROW** keys, **FAST** key, **SET REFERENCE** key, **SCAN** key, **ALIGNMENT CHECK** key, **ALIGN CONT/EXP** key, and **SEP.** keys. See Appendix for more detail or contact super-user.

1. LOAD MASK

- Press **CHANGE MASK** key
- Place the mask onto the mask holder against the stop pins.
- Toggle the mask vacuum on by pressing the **ENTER** key.
- Activate the mechanical mask clamp by pressing on the leaf spring.
- Flip the mask holder 180° back and move it into the machine .
- Press **CHANGE MASK** key again to lock the mask holder.

2. ADJUST PARAMETERS

- Deactivate **BSA MICROSCOPE** key (LED off), if it hasn't been done already.
- Edit parameters by pressing **EDIT PARAMETERS** key. Change all necessary parameters: exposure time, alignment gap (100 μm), and exposure type. Leave other parameters unchanged.
- Press **EDIT PARAMETERS** key again to confirm the changes.

3. LOAD WAFER

CAUTION: Watch Out For Microscope Movement!

- Press **LOAD** key. The machine instructs: "PULL SLIDE AND LOAD SUBSTRATE ONTO CHUCK"
- Pull out the transport slide completely.
- Insert the proper chuck and place the wafer against the pre-alignment pins.
- Confirm with **ENTER** key. Now the wafer is holding by vacuum. The machine instructs: "MOVE SLIDE INTO MACHINE AND CONFIRM WITH ENTER".
- Gently push in the transport slide and confirm with **ENTER** key. Wedge error compensation (WEC) will automatically adjust the wafer parallel to the mask.

4. ALIGN SUBSTRATE

- Turn on the computer (located on the left side of aligner) and monitor
- Make sure the **BSA MICROSCOPE** LED key is off to operate the top side microscope.
- Use the lowest magnification (5 \times objective) to find the mask alignment marks.
- If microscope head is in upward position, press **F1** key and **ENTER**, to put the microscope down. To raise microscope up at any time during alignment press **F1** key and **ENTER** again.
- If necessary, use the **OBJECTIVE X-SEPARATION** and **θ -MOVEMENT** knobs to bring both left and right mask alignment marks into their respective splitfields.
- Once the mask alignment marks are found, use **X**, **Y**, and **θ** knobs at the stage to align the wafer alignment marks with the mask alignment marks. **NOTE:** It is critical to have alignment gap of 200 μm or more while moving substrate stage over long distances. It could damage mask, sample and mask aligner. To check or change the alignment gap, use **SEP.** keys.
- If necessary, check the alignment by pressing **ALIGNMENT CHECK** key or **ALIGN CONT/EXP** key (see Appendix for more detail).

5. EXPOSURE

- Press EXPOSURE key to expose the wafer. This will move the wafer into exposure position. Shutter will open and expose the wafer. Depending on the exposure program selected all program steps will be performed automatically. After finishing, the wafer chuck will move down to unload the exposed wafer.

6. UNLOAD WAFER

CAUTION: Watch Out For Microscope Movement!

- Wait till the message says: "UNLOAD SUBSTRATE FROM SLIDE".
- Pull out transport slide completely; otherwise the vacuum will be on.
- Unload wafer and move the transport slide into the machine.
- If you would like to expose additional wafers, perform steps 3-6.

7. UNLOAD MASK

CAUTION: Watch Out For Microscope Movement!

- Hit the **CHANGE MASK** key to release the mask holder.
- Pull the mask holder out, flip it 180° and place it on the tray to your left.
- Hit **ENTER** to turn the mask vacuum off.
- Retract the mechanical clamping and remove the mask.

8. STAND-BY MODE

- Turn off the computer and monitor.
- Turn ILLUMINATION knob to BSA/IR position.
- Set micrometer screws to: X = 10, Y = 10, and $\theta = 0$.

APPENDIX

DEFINITIONS

I. ALIGNMENT STAGE CONTROLS:

- **X-MOVEMENT micrometer screw** – This is located at the right side of the alignment stage and moves the wafer in x-direction. Maximal travel ± 10 mm.
- **Y-MOVEMENT micrometer screw** – This is located at the left side of the alignment stage and moves the wafer in y-direction. Maximal travel ± 5 mm.
- **θ -MOVEMENT micrometer screw** – This is the small knob at the right side of the alignment stage. Maximal travel $\pm 5^\circ$.

II. FRONT PANEL CONTROLS:

- **CONTACT indicator** – This lamp lights whenever mask and wafer are in contact. If you move the wafer manually further up, this indicator starts flashing.
- **ILLUMINATION switch** – The illumination is supplied wither to the TSA or BSA microscope by fiber optics light cables from a light source. BSA illumination is selected in the BSA/IR position.
- **BSA/IR microscope illumination** – The potentiometers labeled LEFT and RIGHT achieve the fine illumination adjustment for the two objectives of the BSA microscope (BSA/IR is selected).
- **TSA microscope illumination** – The fine illumination adjustment is performed with the TSA adjustment knob.
- **MAGNIFICATION BSA switch** – Select between low and high magnification.
- **SPLITFIELD switch** – With the rotary switch in middle position, the left/right objective image is shown on the left/right half side of the video monitor simultaneously. With the switch in the right or left position, the right/left objective image is displayed on the whole video monitor.
- **TOP SUBSTRATE LEFT/RIGHT focus** – In order to improve the image of the mask structures displayed on the video monitor only minor focus adjustments are necessary. The two potentiometers individually control the fine focus of the BSA and TSA microscope objectives at the upper focus plane.
- **BOTTOM SUBSTRATE LEFT/RIGHT focus** - In order to improve the image of the mask structures displayed on the video monitor only minor focus adjustments are necessary. The two potentiometers individually control the fine focus of the BSA and TSA microscope objectives at the upper focus plane.

III. KEYBOARD CONTROLS:

- **X, Y-ARROW keys** – The function of these keys depend on the task performed:
 - Movement of the upper microscope (TSA)
 - Movement of the lower microscope (BSA)
 - X-ARROW key: selection of the next/last parameter in the control software
 - X-ARROW key: change of parameter values

Arrow keys marked with X are labeled with an triangle pointing to the right/left. To move the manipulators along the X-axis press one of these keys. Arrow keys marked with Y are labeled with triangle pointing upward/downward. To move the manipulator along the Y-axis press one of this keys. In case the manipulator reaches the limit positions along X- or Y-axis, the message on the monitor indicates: “HW OR SW LIMITS ACTIVE – USE ARROW KEYS”. To move back into regular range use the key in the opposite direction.

- **FAST key** – Activating this key (LED is ON) enables the movement of the microscope manipulator into the desired direction with the fast speed (otherwise the movement is performed with the slow speed).
- **SEP keys** – The keys are labeled with arrow pointing upward and downward and marked with SEP (separation). With these keys the alignment position of the wafer can be changed in steps of 1 μm along the z-axis. The keys are active after WEC. If the substrate makes a contact with mask, the CONTACT indicator turns on. Moving the wafer further up, the indicator starts flashing.

NOTE: Never align the wafer if the mask and wafer are in contact with each other. This will damage the wafer and the mask.

- **ALIGN CONT/EXP key** – Acts as a toggle switch. You can quickly change the position of the wafer between alignment and exposure position relative to the mask.

NOTE: Never align the wafer if the mask and wafer are in contact with each other. This will damage the wafer and the mask.

- **ALIGNMENT CHECK key** – With this key one can check the alignment prior exposure. Particles between mask and wafer or the edge bead can affect the alignment of the wafer to the mask. To test that the alignment remains stable while moving to exposure position, all parameters of the exposure program are triggered except the exposure itself. This key is active for the exposure programs: Vacuum Contact, Low Vacuum Contact, and Hard Contact. For example: starting the exposure program “Vacuum Contact” triggers the pneumatic procedure (Pre Vac and Full Vac). To check the possible influence of unpredictable factors before exposure, press the ALIGNMENT CHECK key. Press this key again to release the wafer back into alignment gap or press EXPOSURE key if the alignment is acceptable.

- **F1 key** - The different functions of F1 keys are:

- **Microscope up/down** – During loading, aligning and exposure the microscope does all necessary up and down movements automatically. For a better view of mask and wafer, it is possible manually move the microscope up and down.
- **Change align speed** (*do not change*)
- **Single step config** (*not applicable for this model*)
- **Centering stage** (*not applicable for this model*)
- **Select maskloading** (*not applicable for this model*)
- **Scope synchron.** (*not applicable for this model*)
- **Single BSA AI.** – Use this special function to align substrates with alignment mark distance smaller than the minimum distance of the BSA objectives.
- **WEC-delay** – A large wafer needs longer time to set itself exactly parallel to the mask. This is necessary to get high resolution of small structures over the whole wafer. The necessary time must be tested and set by operator. Note: the longer time than required will not hurt, so do not use less than 20 sec.

If you wish to leave the variable unchanged, simply press the flashing F1 key.

- **LOAD key** – After the machine has been powered on, the LED of the LOAD key is flashing. Press the LOAD key to start the wafer loading procedure.
- **UNLOAD key** – If one wishes to unload the wafer, press this key. This key also terminates some working sequences. Pressing UNLOAD after starting the exposure cycle, the exposure sequence will be completed without exposure itself.
- **CHANGE MASK key** – Starting from the initial screen, the operator initiates the procedure for changing (loading/unloading) the mask.
- **SELECT PROGRAM key** – Select one of the six exposure programs of the machine.
- **EDIT PARAMETER key** – After the desired exposure program has been selected, press the EDIT PARAMETER key. Edit the parameter of the exposure program. The parameter is changed with the

corresponding y-directional arrow keys. The next parameter is selected by the x-directional arrow keys. The number of parameters depends on the selected exposure program.

- **EDIT PROGRAM key** – This key enables the operator to assign all parameter settings and the microscope position to a program number ranging from [0] to [99]. This number helps to keep all settings in the nonvolatile memory. (**Save, Load, Delete, and Exit** options)
- **ENTER key** – Press the ENTER key to confirm an action whenever the program prompts you to do so.
- **SET REFERENCE key** – This key enables the operator to store the actual microscope position of the TSA or BSA microscope as reference position. This is necessary for the SCAN key to function.
- **SCAN key** – This key can be used only after a reference position for the selected microscope with the SET REFERENCE key is stored (i.e. the position for the first alignment mark). Then the microscope can be moved to a new position (i.e. the position for the second alignment mark). Activating the SCAN key toggles the position of the microscope between the current position and the reference position.
- **EXPOSURE key** – This key starts the active exposure program after an alignment or in first mask print mode.
- **MULTIPLE EXPOSURE key** – an advanced option to expose the substrate in several intervals
- **LAMP TEST key** – Pressing this key moves the mirror house forward and opens the light shutter. Exposure intensity and uniformity adjustment is possible. Deactivating this key finishes this task.
- **PRE-BOND key** – (not applicable for this model)
- **PERFORM CLAMPING key** – (not applicable for this model)
- **OPTION key** – (not applicable for this model)
- **BSA MICROSCOPE key** – Toggles the motor control and image processing between TSA (LED is off) and BSA (LED is on) microscopes.
- **LEFT key** – For BSA alignment only, the movement of the left objective is possible.
- **BOTH key** – For BSA alignment only, the simultaneous movement of both BSA-objectives is possible.
- **RIGHT key** – For BSA alignment only, the movement of the right objective is possible.
- **TOP/BOTTOM key** – Toggles the focus plane between mask plane (LED is on) and wafer plane.
- **GRAB IMAGE key** – For BSA alignment only. By activating this key, the current monitor image is stored as background image to be superimposed with the wafer image later on.

IV. TSA MICROSCOPE CONTROLS:

- **Z -MOVEMENT knob** – Coarse focus for the microscope
- **θ -MOVEMENT knob** – Rotates the microscope around the z-axis by turning the knob located in the upper right side of the TSA microscope body.
- **OBJECTIVE X-SEPARATION knob** – The right/left objective can be moved independently in x-direction by the big knobs located in the right/left side of the TSA microscope body.