Karl Suss MA6 Mid/Deep UV Mask Aligner
Operating Manual

Pre-Operation

- **Change gloves.**

WARNING
No solvents are allowed near the machine, change your gloves before operation!!

- **Sign in the Logbook**

Power on Procedure

- The main power, air and vacuum are always on.
  Turn on the NITROGEN gas.

- **Ignition of the exposure lamp (CIC 1200)**
  Switch ON power of 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.

ATTENTION
Nitrogen failure for longer than 5 minutes will turn off the exposure lamp!

- **Starting the machine**

  Shortly turn the *POWER SWITCH ELECTRONIC* on the front panel control clockwise into ON position and release. Machine initializes. And example for the display message is:

  “Ready for Start – press LOAD Button
  MA6-[M] V 4.000 22.07.02 SW:P”

  The meaning of the second displayed line is:
  configuration software version date included options

  Press the flashing LOAD key on the keyboard.
  “Watch out machine is starting!”

  The software is loaded and the machine is in *initial state*, ready for operation:
  “Ready for Load”

  All motorized manipulators (TSA, BSA and alignment stage) are set to the position used before the machine was powered off.

First Mask print mode

The first mask print of a wafer is done without alignment. This software sequence is started by the EXPOSURE key. Starting from the *initial state* of the machine, these steps have to be performed:

- Adjust Parameters:

  Select exposure mode: SELECT PROGRAM key
  Press SELECT PROGRAM key.
  Toggle through the menu and confirm
  your exposure program by pressing SELECT PROGRAM key again

  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 output **40mW/cm^2**

  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.

  Important: Choose program number same as your gowning locker number to prevent conflict and confusions.

- Load Mask

  Watch out for the microscope movement! 

  Start mask loading sequence: CHANGE MASK key
  You have to take out the mask holder, flip it 180º and put it on the tray. If a mask is loaded, press ENTER to toggle the mask vacuum off, retract the mechanical mask clamp and remove the mask.

  Load mask and secure it in place: ENTER 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.

  Slide the mask holder back into machine and secure it: CHANGE MASK key
  Flip the mask holder 180º back and move it into the machine. Lock the mask holder slide by pressing CHANGE MASK key again.

- Load wafer

Fist pull out transport slide and load wafer: EXPOSURE 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 held by vacuum

Move slide in: ENTER key

The machine instructs: move slide into machine and confirm with ENTER

Wedge error compensation (WEC)

WEC starts automatically after the last action is completed.
The wafer is adjusted parallel to the mask.

- Exposure

After WEC the wafer moves automatically in exposure position. Depending on the exposure program selected all program steps will be performed automatically. Exposure takes place. After finishing the wafer chuck moves down to unload the exposed wafer.

- **Unload mask: CHANGE MASK key**

Hit the CHANGE MASK key and the mask holder will be released. Pull the mask holder out, flip it by 180º and store it on the tray to your left. Hit ENTER to switch the mask vacuum off. Retract the mechanical clamping and remove the mask.

- **Turn machine off:**

Toggle *POWER SWITCH ELECTRONIC* to position OFF.
Turn off the CIC by pressing on the OFF button.

Important: Leave nitrogen on for 30 minutes, and then turn it off.

Warning: Do not attempt to ignite the lamp prior to the completion of 45 minute cooldown. This might cause lamp to explode!

Top side alignment

In this mode the wafer is aligned to the mask using the topside alignment microscope (TSA). The following example explains the steps to align and expose with manual mask loading, soft contact print and WEC-type contact. Starting from the *initial state* of the machine these tasks must be performed:

- Adjust Parameters:

Select exposure mode: SELECT PROGRAM key

Press SELECT PROGRAM key.
Toggle through the menu and confirm
your exposure program by pressing SELECT PROGRAM key again

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.

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.

- Load Mask

Watch out for the microscope movement!

Start mask loading sequence: CHANGE MASK key

You have to take out the mask holder, flip it 180º and put it on the tray. If a mask is loaded, press ENTER to toggle the mask vacuum off, retract the mechanical mask clamp and remove the mask.

Load mask and secure it in place: ENTER 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.

Slide the mask holder back into machine and secure it: CHANGE MASK key

Flip the mask holder 180º back and move it into the machine. Lock the mask holder slide by pressing CHANGE MASK key again.

- Load wafer

Fist pull out transport slide and load wafer: LOAD key

If the chuck is not centered, move it with the micrometer screws to the middle position. 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 held by vacuum.

Move slide in: ENTER key

The machine instructs: move slide into machine and confirm with ENTER

Wedge error compensation (WEC)

WEC starts automatically after the last action is completed.
The wafer is adjusted parallel to the mask.

Lower microscope: F1 key

If the microscope is not lowered automatically press F1 key, confirm with ENTER.

Watch out for the microscope movement!

- Microscope alignment

Set up the TSA: SPLITFIELD switch

An actual TSA-microscope image on the monitor is enabled by turning the SPLITFIELD switch to LEFT. Toggle **BSA MICROSCOPE key off**. This key also switches the controlled manipulator motors from BSA to TSA.

Microscope illumination: *ILLUMINATION* to TSA

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.

Focus on the mask plane: TOP/BOTTOM key

Coarse focus is possible by using the *TSA Z-MOVEMENT knob* placed behind the TSA-microscope. Make sure the TOP/BOTTOM key LED is on and adjust the fine focus separately using the TOP SUBSTRATE LEFT/RIGHT regulators.

Adjust microscope to the mask alignment marks

Move the left/right objective to the left/right mask alignment marks using the *OBJECTIVE X-SEPARATION knobs*.

Grab image: **GRAB IMAGE key (option)**

First keystroke grabs the image. The objectives move the focal plane to the wafer and the TOP/BOTTOM key LED goes off. The motor control of the microscope manipulator is disabled at this time. Second keystroke deletes the stored image and enables the manipulator again.

- Wafer alignment

Focus on the wafer plane

Adjust the left/right microscope image with the *BOTTOM SUBSTRATE LEFT/RIGHT regulator.*

Alignment

Use the micrometer screws of the alignment stage for *STG-X-Y-Θ-MOVEMENT*.

If mask and wafer are in contact (*CONTACT INDICATOR* on), don't align the wafer!

Alignment check

Depending on your requirements, an alignment check could be helpful using the SEP keys, ALIGN CONT/EXP key or the ALIGNMENT CHECK key.

- Exposure

EXPOSURE key

Pressing this key the wafer will move into exposure position. Exposure takes place. [Despite the exposure was initiated hitting the UNLOAD key before the light shutter has opened the program will continue it's exposure sequence without wafer exposure.] After finishing the wafer chuck moves down to unload the exposed wafer.

Watch out for the microscope movement!

- **Unload mask: CHANGE MASK key**

Hit the CHANGE MASK key and the mask holder will be released. Pull the mask holder out, flip it by 180° and store it on the tray to your left. Hit ENTER to switch the mask vacuum off. Retract the mechanical clamping and remove the mask.

- **Turn machine off:**

Toggle *POWER SWITCH ELECTRONIC* to position OFF.
Turn off the CIC by pressing on the OFF button.

Important: **Leave nitrogen on for 30 minutes**, and then turn it off.

Warning: Do not attempt to ignite the lamp prior to the completion of **45 minute cooldown**. This might cause lamp to explode!

Bottom side alignment

The wafer is aligned to the mask using the bottom side alignment microscope (BSA). The following example explains the steps to align and expose with manual mask loading, vacuum contact and WEC-type proximity. Starting from the *initial state* of the machine these steps have to be performed:

- Adjust Parameters:

  Select exposure mode: SELECT PROGRAM key
  Press SELECT PROGRAM key.
  Toggle through the menu and confirm your exposure program by pressing SELECT PROGRAM key again

  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.

  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.

- Load Mask

  Start mask loading sequence: CHANGE MASK key
  You have to take out the mask holder, flip it 180º and put it on the tray. If a mask is loaded, press ENTER to toggle the mask vacuum off, retract the mechanical mask clamp and remove the mask.

  Load mask and secure it in place: ENTER 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.

  Slide the mask holder back into machine and secure it: CHANGE MASK key
  Flip the mask holder 180º back and move it into the machine. Lock the mask holder slide by pressing CHANGE MASK key again.

- **Load wafer chuck for BSA**
  If the chuck is not centered, move it with the micrometer screws to the middle position. Insert a proper chuck without wafer onto the transport slide. Move the BSA-chuck (placed onto the transport slide) into the machine. Don't press a key.

- Microscope alignment

Set the monitor image: SPLITFIELD switch

Turn the SPLITFIELD switch to middle position and toggle BSA MICROSCOPE key on (LED on). This key enables the microscope manipulators accordingly.

Microscope illumination: ILLUMINATION to BSA/IR

Turn the illumination switch to BSA/IR and adjust the light intensity by the potentiometers labeled BSA/IR microscope illumination left/right.

Focus on the top focal plane: TOP/BOTTOM key

Make sure the TOP/BOTTOM key LED is on and adjust the fine focus separately with the *TOPS SUBSTRATE LEFT/RIGHT* regulators.

Move objectives to the chuck opening: LEFT, BOTH, RIGHT keys

Select one of these keys to move the left/right objective with the *ARROW* keys. If necessary use fast speed (FAST key LED on).

Grab image: GRAB IMAGE key (option)

First keystroke grabs the mask image. The objectives move to the wafer focus plane (*TOP/BOTTOM key* LED off). The motor control of the microscope manipulator is disabled. Second keystroke GRAB IMAGE key deletes stored image and enables the manipulator again.

- Load wafer

Fist pull out transport slide and load wafer: LOAD key

After grabbing image the machine informs: “ready for load. BSA image stored”. Press LOAD key to start this procedure. Load wafer onto chuck and push slide into the machine as prompted on the display. Press ENTER key.

Wedge error compensation (WEC)

WEC starts automatically. After WEC the wafer will move to the alignment gap.

- Wafer alignment

Focus on the wafer plane

Adjust the left/right microscope image with the *BOTTOM SUBSTRATE LEFT/RIGHT regulator.* Correct illumination if necessary.

Alignment

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.

If mask and wafer are in contact (*CONTACT INDICATOR* on), don’t align the wafer!

Alignment check

Depending on your requirements, an alignment check could be helpful using the SEP keys, ALIGN CONT/EXP key or the ALIGNMENT CHECK key.

- Exposure

EXPOSURE key

Pressing this key the wafer will move into exposure position. Exposure takes place. [Despite the exposure was initiated hitting the UNLOAD key before the light shutter has opened the program will continue it's exposure sequence without wafer exposure.] After finishing the wafer chuck moves down to unload the exposed wafer.

Watch out for the microscope movement!

- **Unload mask: CHANGE MASK key**

Hit the CHANGE MASK key and the mask holder will be released. Pull the mask holder out, flip it by 180º and store it on the tray to your left. Hit ENTER to switch the mask vacuum off. Retract the mechanical clamping and remove the mask.

- **Turn machine off:**

Toggle *POWER SWITCH ELECTRONIC* to position OFF.
Turn off the CIC by pressing on the OFF button.

Important: **Leave nitrogen on for 30 minutes**, and then turn it off.

Warning: Do not attempt to ignite the lamp prior to the completion of **45 minute cooldown**. This might cause lamp to explode!

Single Bottom side alignment

This procedure describes the adjustment of small substrates to a mask using only one BSA microscope. Therefore we recommend a transparent wafer chuck. Starting from the *initial state* of the machine these steps have to be performed:

- Adjust Parameters:

  Select exposure mode: SELECT PROGRAM key
  Press SELECT PROGRAM key.
  Toggle through the menu and confirm
  your exposure program by pressing SELECT PROGRAM key again

  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.

  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.

- Load Mask

  Start mask loading sequence: CHANGE MASK key
  You have to take out the mask holder, flip it 180º and put it on the tray. If a mask is loaded, press ENTER to toggle the mask vacuum off, retract the mechanical mask clamp and remove the mask.

  Load mask and secure it in place: ENTER 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.

  Slide the mask holder back into machine and secure it: CHANGE MASK key
  Flip the mask holder 180º back and move it into the machine. Lock the mask holder slide by pressing CHANGE MASK key again.

  Alignment preparation
  Set the SPLITFIELD switch in request to the enabled BSA microscope. Adjust the microscope illumination using the BSA/IR microscope illumination left/right. Focus on the mask plane by activating the TOP/BOTTOM key and the corresponding *TOP SUBSTRATE LEFT/RIGHT focus regulator*. Search for a reference mask alignment mark with the BSA microscope. Store this stage position by activating the SET REFERENCE key. Search for a second mask alignment mark only by the *x-movement of the BSA-microscope*. Toggle back to the reference alignment mark

using the SCAN key. Press GRAB IMAGE key to store the reference alignment mark image. Toggle to the second alignment mark using the SCAN key.

Mask alignment

Adjust the real mask alignment mark to the stored one only with *micrometer screw* of the alignment stage about ½ of the misalignment. Switch the manipulator control to BSA deactivating the STG/TSA/BSA button. Toggle to the reference alignment mark using the SCAN key. Press GRAB IMAGE key twice to release the stored and grab the new image. Press SCAN key to toggle to the second alignment mark position. Repeat this mask alignment until there is not misalignment left.

Load mask: ENTER key

Pressing ENTER the mask moves to the mask holder and is taken by the mask holder vacuum. Transport chuck moves down for unloading.

- Load wafer

Pull out transport slide and load wafer: LOAD key

We recommend to use a transparent wafer chuck. Move the loaded transport slide in and confirm with ENTER key.

Wedge error compensation (WEC)

WEC starts automatically. The substrate moves to the alignment gap.

- Substrate alignment

Alignment preparation

Adjust the microscope illumination using the BSA/IR microscope illumination left/right. Select the Substrate focus plane by deactivating the TOP/BOTTOM key. Focus with the *BOTTOM SUBSTRATE LEFT/RIGHT focus regulator.* Search for a reference wafer alignment mark with the BSA microscope. Store this stage position by activating the SET REFERENCE key. Search for a second wafer alignment mark only by the *x-movement of the BSA-microscope.* Toggle back to the reference alignment mark using the SCAN key. Press GRAB IMAGE key to store the reference alignment mark image. Toggle to the second alignment mark using the SCAN key.

Substrate alignment

Adjust the live substrate alignment mark to the stored one only with the *movement* of the alignment stage about ½ of the misalignment. Switch the manipulator control to BSA deactivating the STG/TSA/BSA button. Press SCAN key to toggle to the reference position. Press GRAB IMAGE key to release the stored image. Deactivate the TOP/BOTTOM key and grab the new image using GRAB IMAGE key. Repeat this stubstrate alignment until there is not misalignment left.

Substrate to mask alignment

Move the substrate away using the x-y-movement of the alignment stage to see the real mask alignment mark. Focus on the mask plane by activating the TOP/BOTTOM key and using the corresponding TOP SUBSTRATE left/right focus regulator. Press GRAB IMAGE key to store the mask alignment mark. Move the substrate back using the x-y-movement of the alignment stage. Focus on the substrate plane by deactivating the TOP/BOTTOM key and using the corresponding TOP SUBSTRATE LEFT/RIGHT focus regulator. Align the substrate alignment mark central symmetrical to the mask alignment mark. Check the alignment using the ALIGN CONT/EXP key.

- **Exposure: EXPOSURE key**

  By pressing this key the substrate will move into exposure position. Exposure takes place. Despite the exposure was initiated, hitting the UNLOAD key before the light shutter has opened will continue its exposure program sequence without substrate exposure. After finishing the wafer chuck moves down to unload the exposed substrate.

- **Unload mask: CHANGE MASK key**

  Hit the CHANGE MASK key and the mask holder will be released. Pull the mask holder out, flip it by 180º and store it on the tray to your left. Hit ENTER to switch the mask vacuum off. Retract the mechanical clamping and remove the mask.

- **Turn machine off:**

  Toggle *POWER SWITCH ELECTRONIC* to position OFF.
  Turn off the CIC by pressing on the OFF button.

Important: **Leave nitrogen on for 30 minutes**, and then turn it off.

Warning: Do not attempt to ignite the lamp prior to the completion of **45 minute cooldown**. This might cause lamp to explode!

Advanced Technology

- Exposure Programs

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 exposure

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 wafers there is a distance left, the exposure gap. The gap value is adjustable with the EDIT PARAMETER key. The wedge error compensation is performed by using three precision reference spacers between mask and wafer.

Soft contact exposure

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 exposure

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 exposure

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 SAEAL regulator. 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 with 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 the parameters can be set using the EDIT PARAMETER key.

Low vacuum contact exposure

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 expose 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.

➢ Multiple exposure

For special applications the numerical value for the overall exposure time can be segmented into equal exposure intervals alternating with wait time intervals in which the wafer is not exposed. One exposure time and one wait time is named as one exposure cycle.

To perform Multiple Exposure, proceed as follows:

- Select the corresponding exposure program by the SELECT PROGRAM key.
- Press the MULTIPLE EXPOSURE key
- Press the EDIT PARAMETER key
- Edit the parameter for the exposure program. Edit the numerical value of the corresponding parameters wait time and cycles.
- Press the flashing EDIT PARAMETER key to finish editing and start alignment followed by the multiple exposure process.

➢ Wedge error compensation

During this procedure the top side of the wafer will be set exactly parallel to the bottom side of the mask. This guarantees a perfect gap setting and so a gomogeneous quality of the exposed structures over the whole wafer. Set the WEC type using the EDIT PARAMETER key. Two methods are standard:

Contact mode:

For the exact parallel setting the wafer will be moved against the mask.

Spacer mode:

To treat mask and wafer with maximum care the machine moves spacers in between both. A proximity mask holder is necessary. Contact area is reduced to three points near the wafer edge.