

Karl Suss MA6 Mask Aligner

Standard Operating Procedure

Faculty Supervisor: Prof. Robert White, Mechanical Engineering (x72210)

Safety Office: Peter Nowak x73246 (Just dial this directly on any campus phone.)

(617)627-3246 (From off-campus or from a cell phone)

Tufts Emergency Medical Services are at x66911.

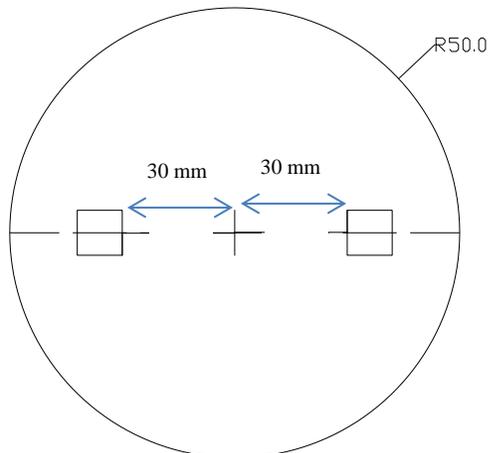
Revised: December 28, 2015

Warnings:

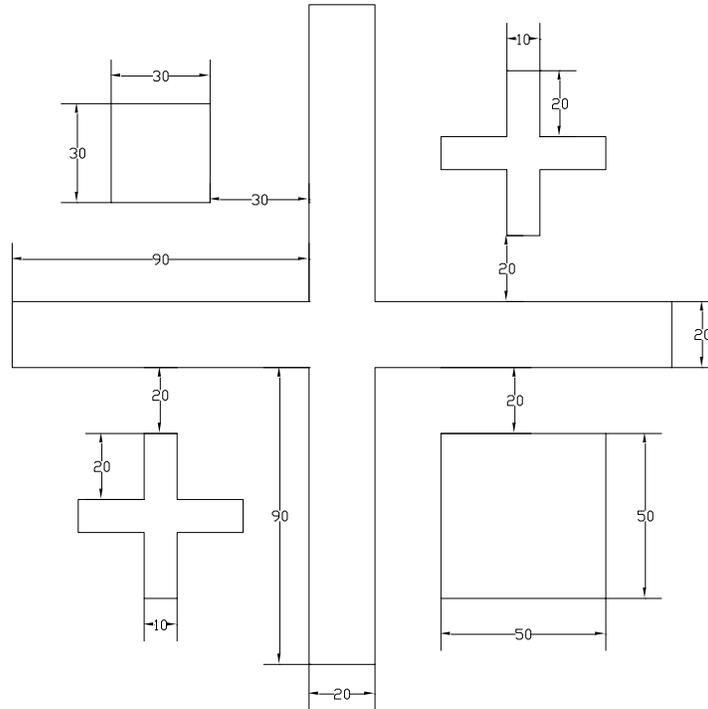
1. Whenever the shutter is open you may be exposed to UV radiation. **Never** look directly at the lamp. Do not put your hands under the lamp while the shutter is open.
2. The lamp contains mercury and is pressurized. If the lamp explodes, everyone should evacuate the cleanroom immediately (take your suit off in the hall outside). Call the safety office (number is at the top of this page) and Prof. White.

Notes:

1. The lamp is calibrated to 20 mW/cm² intensity at 365 nm (i-line). However there is additional energy at 405 nm (h-line) and 436 nm (g-line). The total broadband UV intensity from the lamp is approximately 60 mW/cm² although this is not calibrated.
2. In order to see your alignment marks at the lowest magnification (5x) you should size and place your alignment marks appropriately. Here is a suggestion:



Place alignment marks along the wafer centerline, 30 mm from the center. Make them symmetrically positioned about the wafer center!



Try using this alignment mark. Dimensions are in microns. If you make the crosses and squares transparent on your mask, make the crosses and squares slightly smaller (18 and 8 microns wide crosses, something like 48 and 28 micron square squares, but positioned at the same centerpoints!!) on the substrate. If you make the crosses and squares opaque on the mask, then do the reverse. I'm sure this isn't optimal. It's just a suggestion.

1.0 Material Requirements:

- 1.1 Equipment: A 5" by 5" by 0.09" mask plate (usually we use Chrome on Soda Lime glass)
- 1.2 Personal Protective Equipment: Nitrile gloves and safety glasses (standard cleanroom gear)

2.0 Procedure:

Facilities

Facilities should already be hooked up and turned on. However, if there is any question:

1. The air and vacuum valves at the wall should be open (handle in line with the body of the valve)
2. The two air regulators should be set to 75 psi (5 bar) for the line going to the compressed air inlet, and 15 psi (1 bar) for the line going to the nitrogen inlet.
3. Vacuum should read < -0.6 bar on the dial on the front of the MA6.

Turning on the Lamp:

When you first come in to use the aligner, the lamp may be powered down. To check if the lamp is powered down, look at the lamp controller under the aligner on the right. If the power switch is off then the lamp is off.

If the lamp is off:

1. Hold down the Up Arrow and CI1 buttons on the front of the controller and simultaneously turn on the power, continue to hold down for 2-3 seconds after the controller powers up. This sets the controller to be in Constant Intensity mode based on CI1 (365 nm).

2. The controller should turn on and briefly flash “C1” to show it is in constant intensity mode. *It is very difficult to see the CI flash on the controller – it goes by very fast - try to pay careful attention to make sure it worked and you are in constant intensity mode!*
3. It will then go through a series of checks and say “rdy”.
4. Push “start” – the lamp will attempt to ignite. It will make a nasty buzzing sound and flash the word “FIRE”. This is normal. It will attempt to ignite up to 9 times, and, if not successful, will give up. If this happens, notify lab staff and put a note on the tool telling people the tool is down.
5. If the lamp starts successfully, it will stop buzzing/beeping and the display will flash “COLD” (this is normal). Wait 15 minutes for the lamp to warm up; it should stop flashing “COLD”.

Turning on the aligner:

1. Once the lamp has been started, turn on the aligner by gently turning the green switch on the electronics front panel to “on” and letting go.
2. The electronics should immediately start up.
3. Watch the screen as it goes through startup and note any error messages.
4. The screen should say “Rdy for start – push load button”.
5. Push “Load...” This will complete the startup process. You are not actually loading a wafer yet.
6. The screen should read “Ready for load...”
7. Make sure the X and Y stage micrometers are set to the middle of travel (X stage to “10”, Y stage to “5”).
8. Make sure the Theta micrometer is adjusted so that the white cross marker on the front of the stage is centered. (Steps 7 and 8 make sure you start out with everything centered).

Loading the Mask:

1. Handle the mask by the edges, it is bad practice to touch the mask’s exposure area. Also a fresh pair of gloves before handling the mask is a good idea
2. Inspect your mask under the microscope and make sure it is clean.
3. Push “Change mask...”
4. Slide out the mask frame, flip it over and put it on the wing-table to the left of the aligner.
5. Pull the small metal clip gently a few millimeters towards you by putting your fingernail into the notch in the black plastic. It should snap into place.
6. Load the mask against the alignment pins **with the metal facing up** (this is the side that will touch the wafer after you flip the frame over to put it back in the tool).
7. Push “enter” to engage mask vacuum. The mask should now be held to the frame.
8. Push down on the metal part of the clip with your fingernail – the clip should pop back into place, securing the mask further.
9. Slide the mask frame back into the tool.
10. Push “Change mask...” to complete the process.
11. If you are using a mylar mask, load the glass blank following the directions above. The mylar mask can be secured to the blank using bits of vacuum type tape. Be careful not to place any tape in the exposure area, or where the mask and wafer may contact. Alternatively, the mylar mask can be trimmed to match your substrate size and carefully placed directly onto the substrate when you load the substrate later.

Setting up the Exposure Parameters:

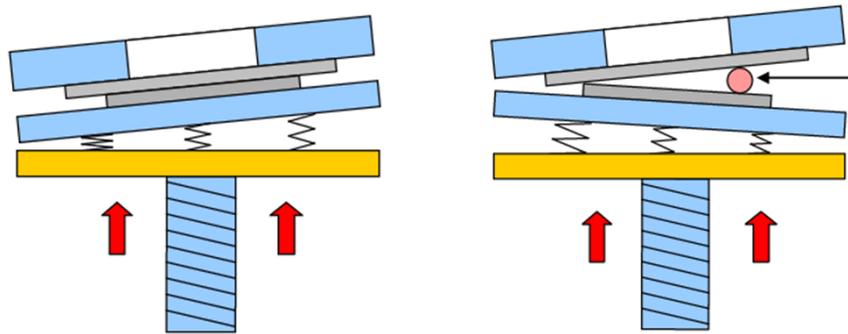
(Do this before loading the wafer – once the wafer is loaded you cannot change the contact type)

1. Push “edit parameters...”
2. Use the left and right arrows to select the exposure parameter to change.
3. Use the up and down arrows to change the value.
4. Choose either proximity, soft contact, hard contact, or vacuum contact - whichever you want to use. If you don’t know what these are, look them up.
5. Change the exposure time in seconds based on the total exposure dose you want. Remember, the source is calibrated to 20 mW/cm² at i-line (365 nm) and has approximately 60 mW/cm² broadband UV intensity (not calibrated). It is highly recommended to check the log to see the parameters other users have chosen and the results.

6. Change the alignment separation distance here too, if desired. A typical separation distance would be about 30 microns.
7. Do **not** change the following settings – Pre Vac [s] : 4 ; Vac Purge [s] : 4 ; Full Vac [s] : 4
WEC type : Cont ; WEC – offset: 0
8. Once everything is all set, push “Edit parameters...” again to lock those parameters in.

Loading the substrate:

1. Push “Load...”
2. Pull out the wafer slide.
3. Load your wafer, pushing it up against the alignment pins. Make sure the wafer is **not ON TOP** of the pins or it may break!
4. Push “enter” to engage the wafer vacuum. The wafer should be held down. A hissing indicates misalignment, or the back of the wafer is contaminated and cannot make a good vacuum seal with the holder.
5. Slide the frame back in.
6. Push “enter” again to indicate that the wafer is in.
7. The tool will automatically perform WEC (wedge error compensation) at this point, parallelizing the wafer and mask, and will then go into separation. Wait for the process to complete. Lithography results depend on perfectly parallel surfaces, thus the wafer and mask must be flat. Any contamination (particles, old resist) that interferes with surface flatness will degrade your results (and possibly harm the aligner), see image below



Wedge Error Compensation (WEC) – proper planarization on the left, poor planarization on the right

Alignment – Align/focus microscopes on mask targets

1. Adjust overall illumination using the TSA illumination knob on the main panel.
2. Adjust individual illumination to the two sides by opening or closing the apertures (using the small silver levers located under each microscope camera).
3. Move the microscopes over the mask by using the X and Y arrow buttons on the main control panel. You can toggle “fast” on and off as needed.
4. Set the coarse and then the fine focus -
 - a. Set fine individual microscope focus – left/right TSA adjustments - to midpoint of travel (3 turns total, so 1.5 turns from clockwise stop)
 - b. Adjust coarse microscope focus together using the large aluminum knob on the top of the tool.
 - c. Adjust individual microscope fine focus using the left and right TSA adjustments
 - d. If you run out of fine focus travel, reset to midpoint, readjust coarse focus and try again
5. Rotate microscope theta using the small knob near the spring above the microscopes.
6. Move the individual microscope objectives left and right in the X direction using the two medium silver knobs on the left and right sides of the microscope.

Alignment – Align substrate to mask

Note: The “Contact” light on the aligner dashboard. If it is lit, the mask and substrate are in contact, no alignment adjustments can be made in this condition

1. Move the wafer in X, Y, and Theta using the large labelled knobs under the stage. Coarse and fine adjustment is available.
2. You can rotate the microscope objective turrets to change magnification if needed. Be careful not to crash an objective into the mask!!
3. Once alignment has been achieved, you can toggle contact by pushing the Align/Cont button the panel. When the wafer and mask are in contact the yellow contact light will be on – do not attempt to move the wafer when the wafer and mask are in contact!!
4. To change the separation between the mask and the wafer, push “Edit parameters...” and change the alignment distance parameters (use left and right arrows to find it and up and down arrows to change it). Next time you go in and out of contact it will go to the new separation distance. This is useful if the substrate targets are outside the depth of field of your microscope objectives.
5. If you need to move the microscope out of the way to get a look at your wafer, push F1 and enter. Repeat F1 and enter to bring them back down.

Exposure

1. If you change your mind and don't want to expose, push “Unload”
2. When everything is aligned and all parameters are set push “Exposure...” Exposure will occur for the specified length of time! **Do not look at the UV light, turn away. If there are others in the lab with you tell them you are exposing so they know to look away as well.**

Removing your substrate

1. The wafer will automatically be ready to be removed after exposure
2. Substrate removal is the reverse of loading described above.
3. Pull out the substrate slide, toggle the wafer vacuum off by pushing “enter” (if needed – see instructions on the screen).
4. Remove the wafer.
5. Slide the wafer slide back into position.

Removing your mask:

1. Mask removal is the reverse of loading described above.
2. Push “change mask...”
3. Pull the mask frame out and flip it over.
4. Push “enter” to release the mask vacuum.
5. Pull the clip forward as before.
6. Remove the mask taking care not to touch the exposure area.
7. Slide the mask frame back into position.
8. Push “change mask ...” to lock the frame back in.

Shutting down the system:

1. Reset the X and Y micrometers back to the center (X=10, Y=5), Set the Theta micrometer back to center (white cross alignment marker on the front of the stage centered).
2. Once exposure is complete, if another user will do lithography soon, just leave the tool on with no mask and no wafer in it, but with the slide and mask frame loaded.
3. If no other user will use the tool today:
 - a. Turn off the lamp controller (just turn the power switch off on the lamp controller, it is that easy, cooling air is still flowing to the lamp, don't worry)
 - b. Turn off the green key switch on the electronics to shut the system down.

Terminology

WEC – Wedge Error Compensation. Procedure employed to parallelize the mask and substrate, performed automatically. There are two basic options:

Contact WEC – utilizes global planarity of mask and wafer to bring both into planarity. Wafer and mask will be brought into contact to complete procedure.

Proximity WEC – utilizes a 3 point contact procedure to bring mask and wafer into planarity.

TSA – Top Side Alignment, use of upper optics to align substrate to mask

BSA – Back Side Alignment, use of bottom side optics to align substrate and mask. This feature is not available on our aligner

Soft Contact – one possible lithography mode, the mask and wafer are brought into contact at a preset pressure. Recommended for feature sizes in the 10's or 100's of microns scale.

Hard Contact – one possible lithography mode, the mask and wafer are brought into contact at the same preset pressure with additional pressure provided by N₂ gas. Recommended for features sizes in the 10's of microns or less.

Vacuum Contact – one possible lithography mode, the mask and wafer are brought into contact and the vacuum seal inflates to seal the volume which is then evacuated. The parameter **PreVac Time** allows the vacuum to proceed slowly, preventing any alignment shift. Recommended for absolute minimum feature sizes. I have been told sub micron feature sizes are achievable with this aligner.

Proximity – one possible lithography mode, the mask and wafer are separated by a user-defined exposure distance. The mask and wafer never make contact. Recommended for particularly sticky and viscous resists and very large feature sizes

If at any time you feel a situation is dangerous, do not hesitate to call the safety office (x73246, Peter Nowak) the faculty supervisor/lab manager (x72210, Robert White), or Tufts Emergency Services (Police/Fire/Ambulance at x66911).

Report all accidents (injuries, major spills, fires) to the safety office at x73246 (Peter Nowak) and Prof. White at x72210. For emergencies, call Tufts Emergency Services at x66911.