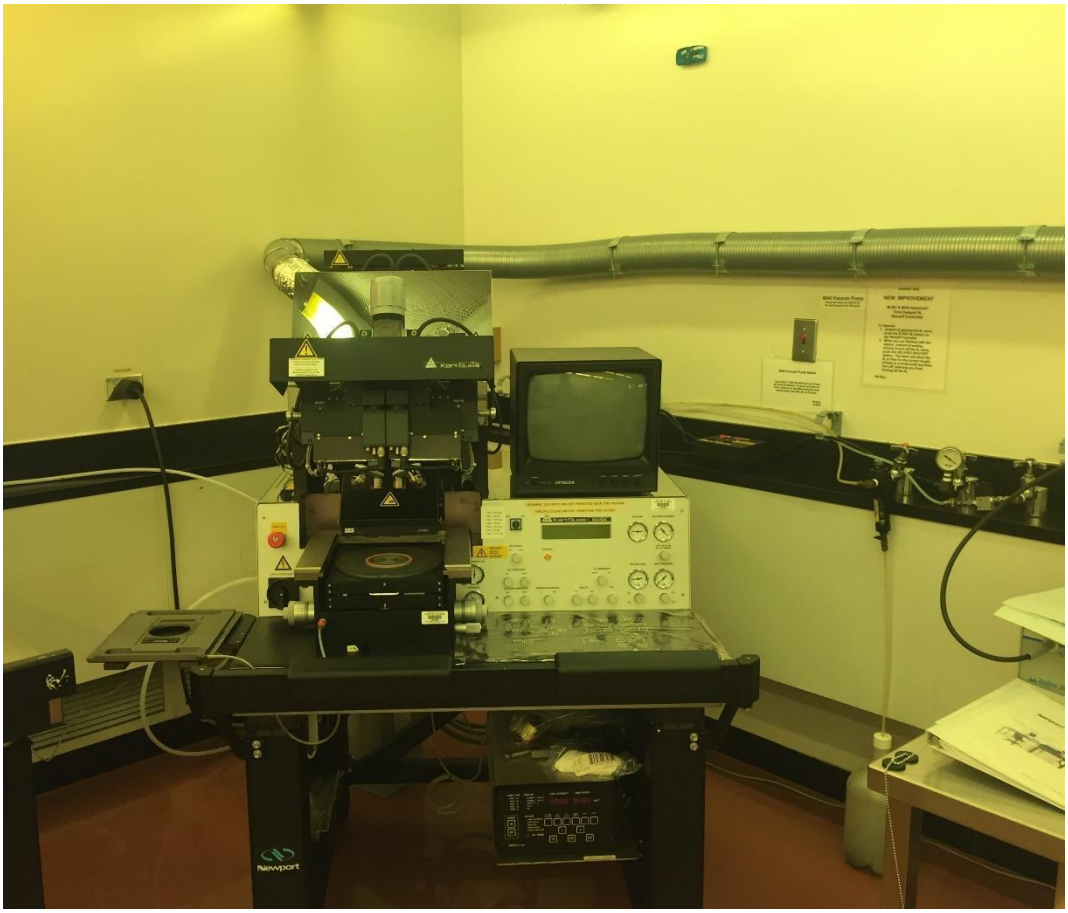
Karl Suss MA6 Mid/Deep UV Mask Aligner

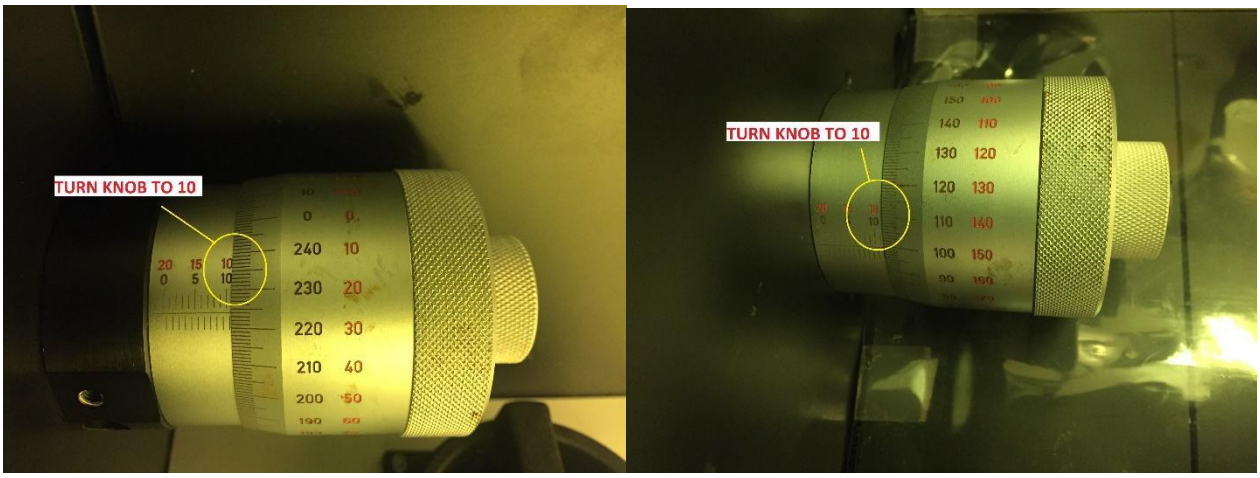


The KARL SUSS MA6 Mask Aligner is designed for high resolution photolithography in a laboratory for development, small volume production or pilot production environment. It offers flexibility in the handling of irregularly shaped substrates of varying thickness, as well as standard size wafers up to 150 mm in diameter and substrates up to 6"x6". Wafers and substrates up to 6 mm thickness may be processed with exposure programs such as vacuum, hard, soft contact, and proximity. X- and Y-shift are below 0.1 µm and not detectable by optical means. The 400 nm exposure wavelength version is capable of 0.6 µm resolution in vacuum contact. Using 300 nm or 250 nm exposure optics or an excimer laser improves resolution to 0.2 µm. **WARNING: No solvents are allowed near the machine, change your gloves before operation!!**

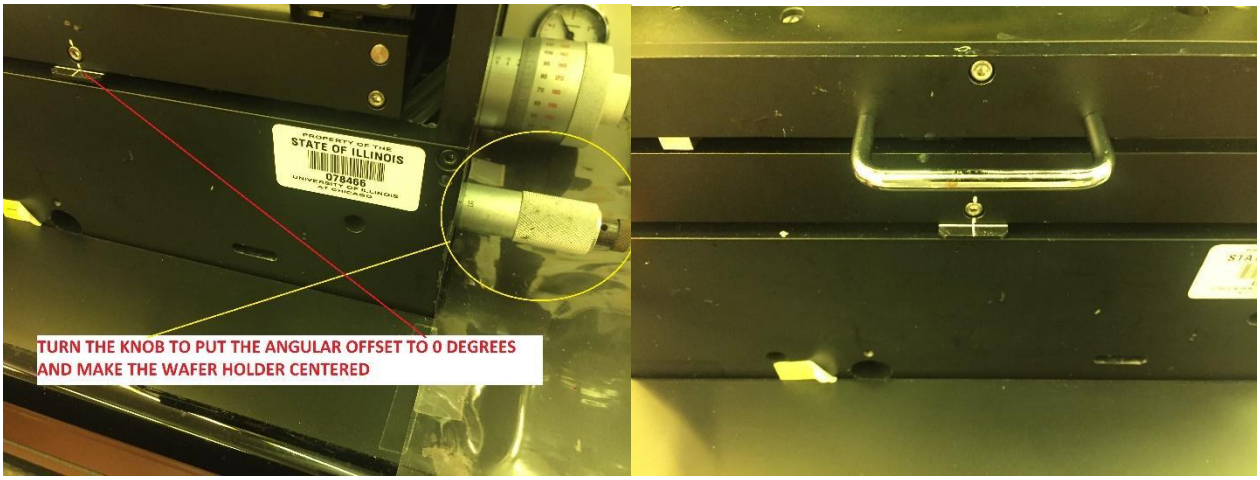
Pre-Operation

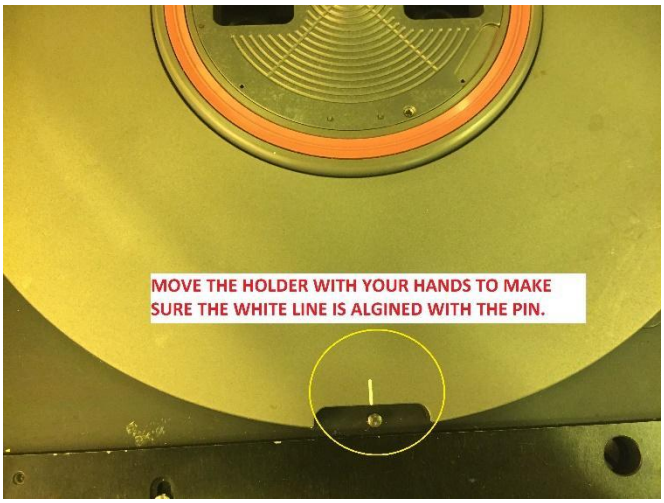
Sign the Logbook. The system's main power, compressed air and vacuum are always on. If you experience any problems such as no vacuum, please contact the NCF office.

1. Check **the X-Y micrometers** on the sides of the system and turn them to **10**.

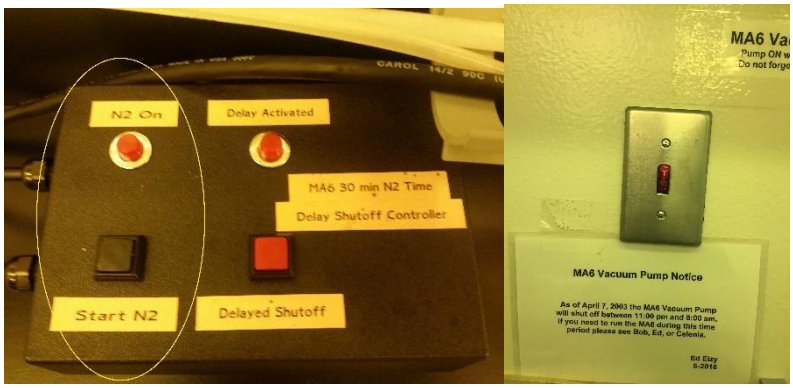


2. Also, check the angular tab and center it with the **Θ micrometer**. Check the wafer holder and move it so that the white line is aligned to the pin at the bottom.





3. Turn on the **NITROGEN** gas. Push the black button on the black box labeled **Start N2**. Turn on the MA6 vacuum by flipping the switch on the wall.



ATTENTION: The green light on the wall indicates nitrogen gas is flowing. If the light comes on, the system will beep loudly meaning the nitrogen tank is empty and needs to be replaced. Please contact the NCF office immediately to have the tank changed. If no nitrogen flows for longer than 5 minutes, the lamp will turn off!

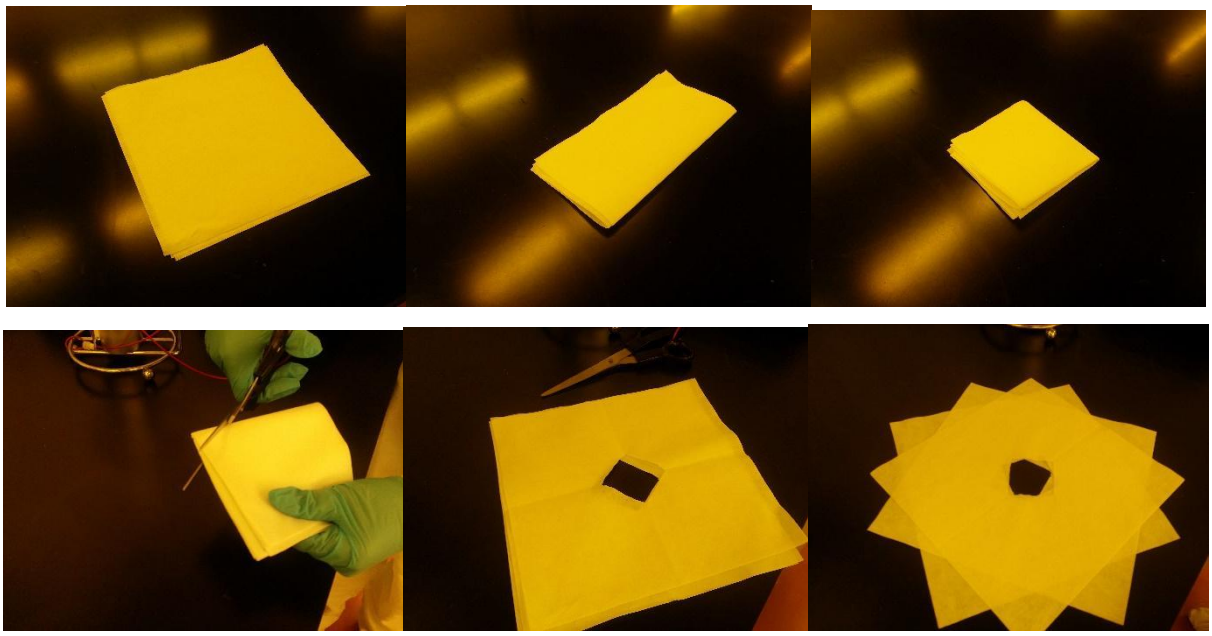
4. Push the **ON** power of the **Constant Intensity Controller (CIC)**. The **CIC** performs a self-calibration test and displays "**Ready**".

5. Press "**CP**" (constant power) key. The display shows "**Wait**", followed by "**Start**".

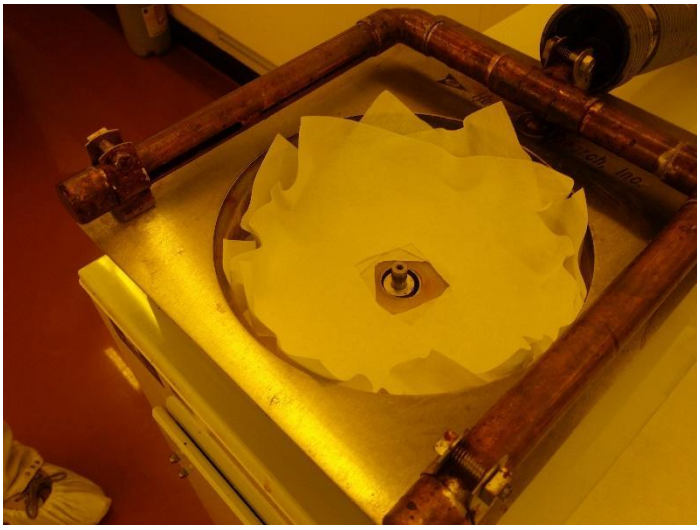
6. Press the "**START**" key. This will ignite the exposure lamp. The ***LAMP LIFE/POWER*** will be flashing until the lamp is finished warming up. The display will read **IGNITION --- LAMP COLD**. The lamp will then warm up to **900 W**.

PHOTORESIST PREPARATION

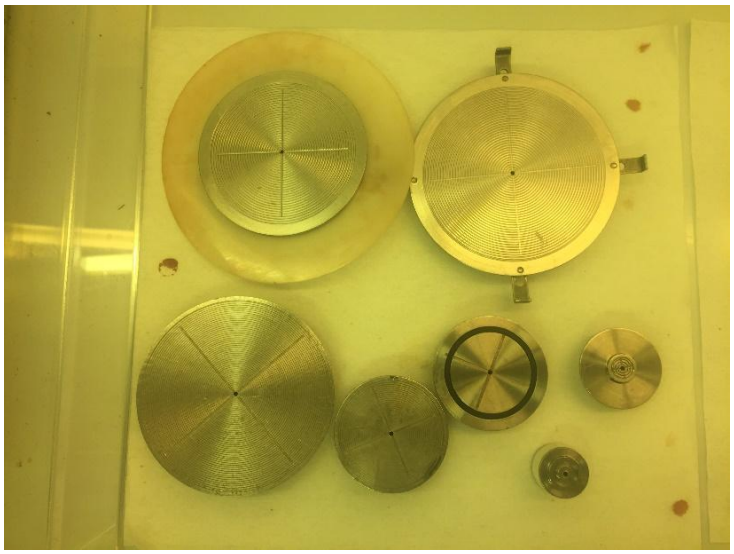
7. Take 3 or 4 cleanroom wipes and fold them into a triangle or square. The cut a hole at the corner so that when you unfold, the hole will be in the center of the wipes.



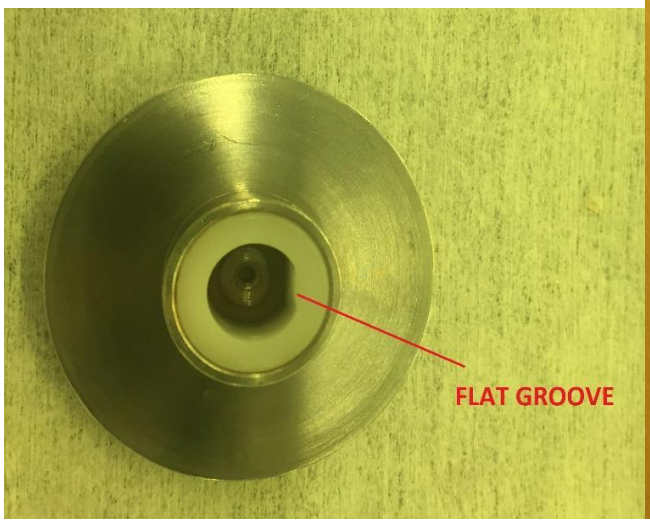
8. Place the wipes inside the Spin Coater. The wipes will catch any excess photoresist that spins off the sample.

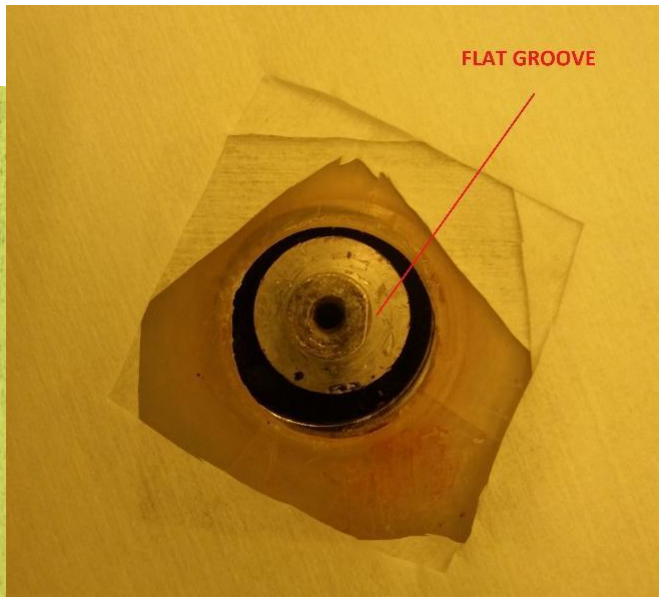


9. Choose a vacuum chuck to use. There are chucks for 2 – 4-inch wafers available. Also, there are chucks for very small samples. Usually, you want to use a chuck that is the same size as your wafer, but this is not always possible.

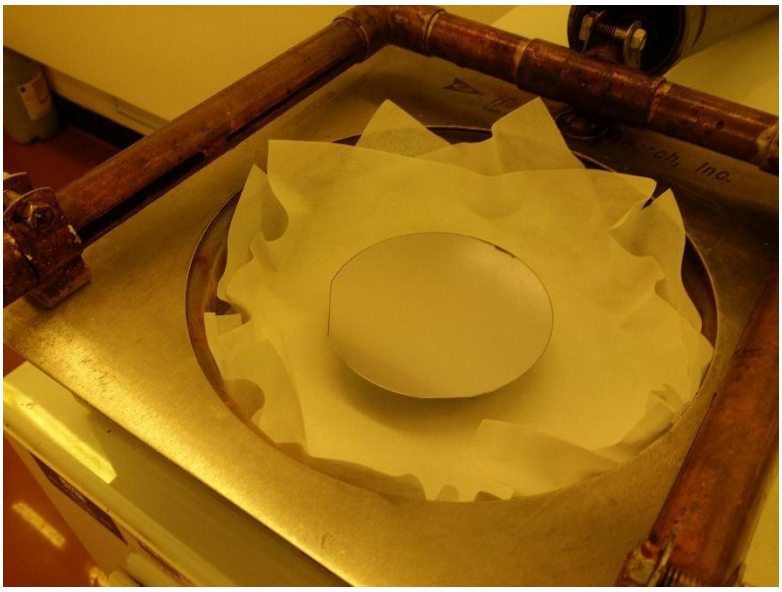


10. Place the chuck in the spin coater. Each chuck has a flat groove on the back. Align this flat groove on the chuck to the flat groove on the spin coater. The chuck should not feel any resistance when you slide in the chuck.

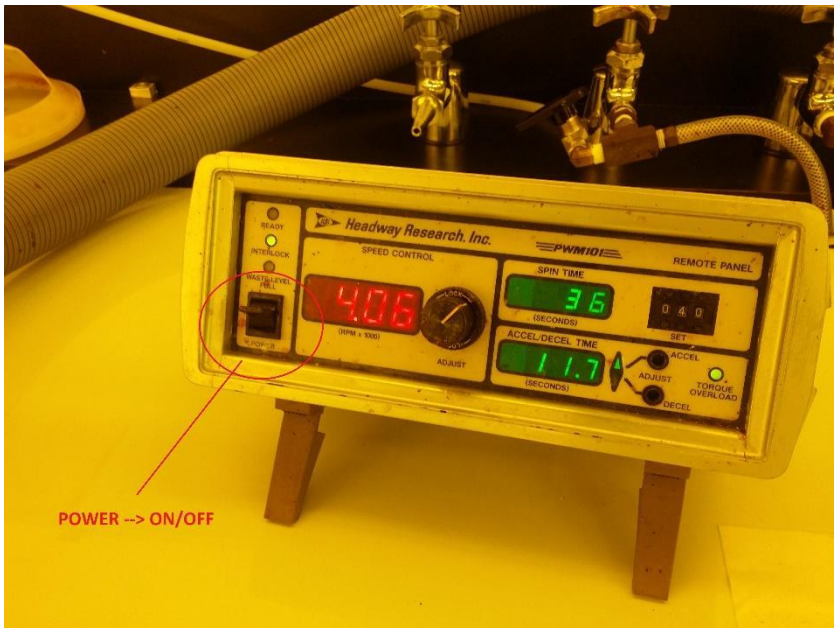




11. Place a dummy wafer on the chuck.

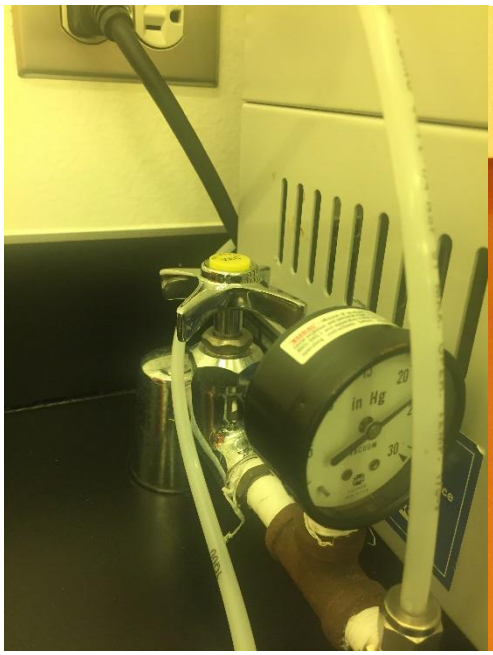


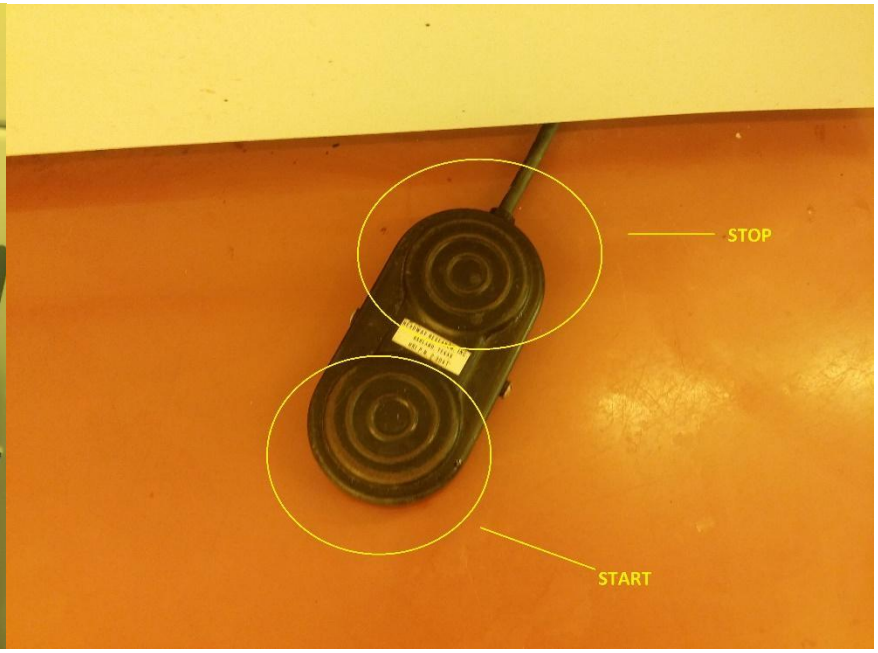
12. Turn on the Spin Coater by flipping the switch on the front.



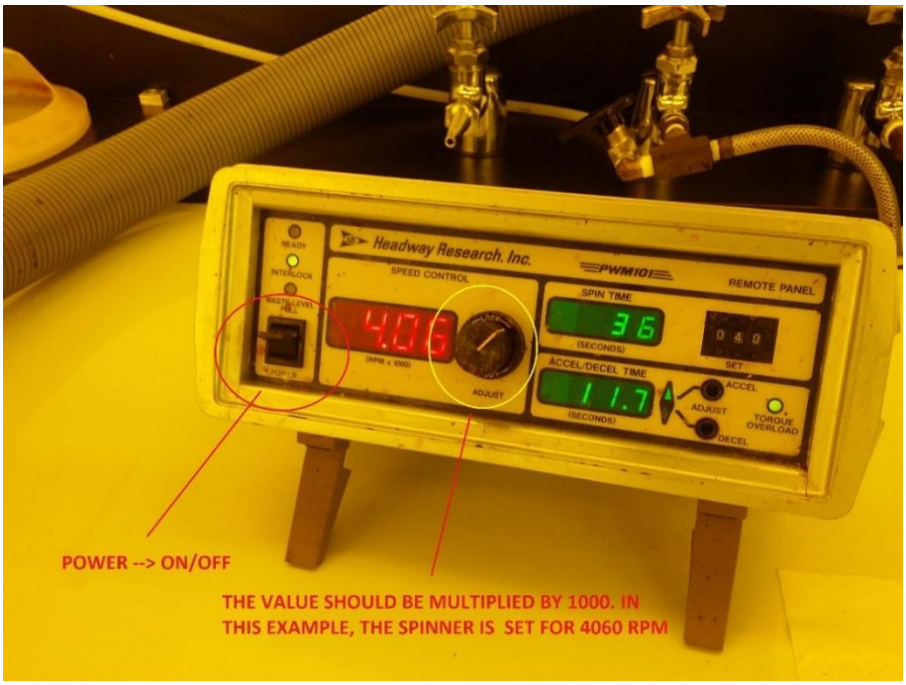
13. Open the valve for the House Vacuum. Then step on the pedal on the floor to start the spinner.

NOTE: Sometimes, the House Vacuum doesn't work, so you'll have to use the MA6 vacuum. The instructions on how to do this are posted on the wall behind the spin coater.

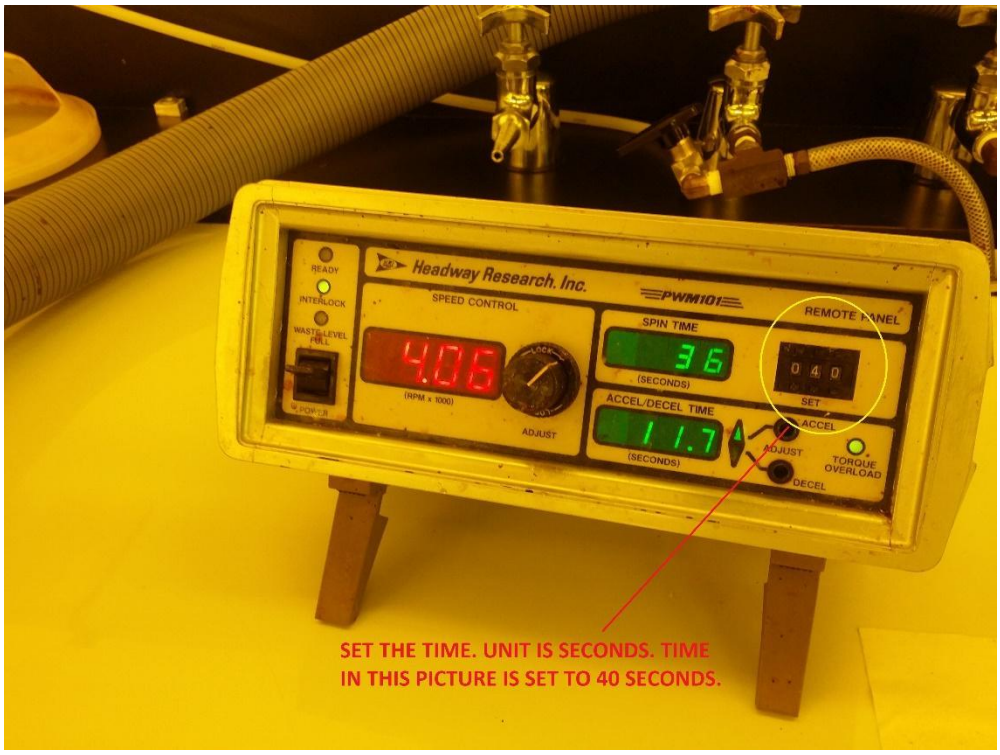




14. Once the spinner is spinning, set the spin speed you would like to use by turning the black knob on the coater. **The number on the display should be multiplied by 1000 to get the real spin speed**.

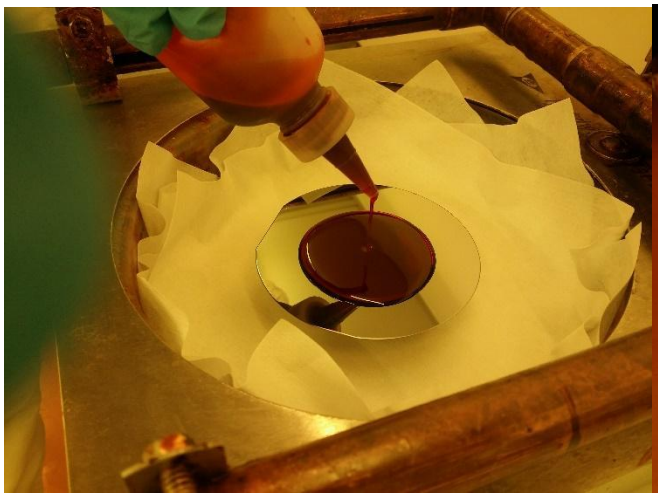
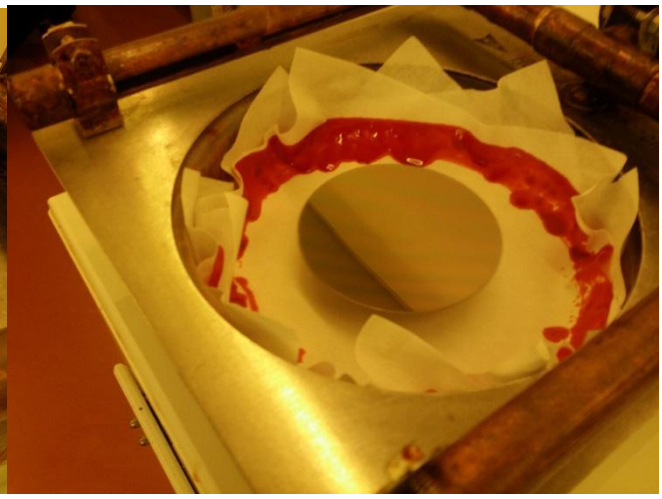


15. Set the time you would like to spin the photoresist for. The unit is in Seconds.

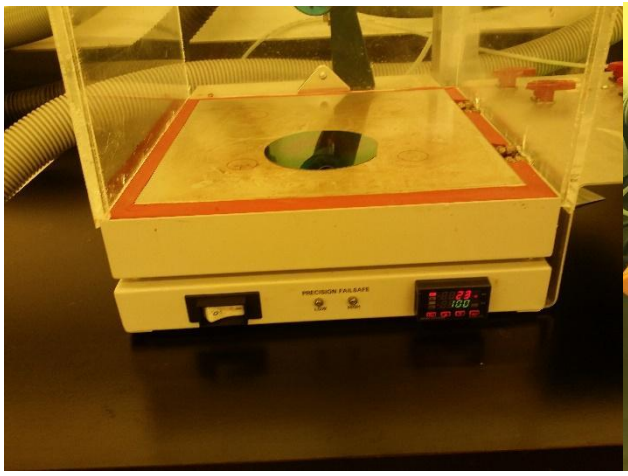


16. After setting spin speed and time, stop the spin coater by stepping on the pedal in Step 7.
17. Grab your desired photoresist from the fridge in the room. **NCF provides AZ 1518, OIR 906-12, and SU-8 2035 photoresists for general purpose use**. If need another type of resist, you'll have to purchase it yourself.

18. Place your sample on the spinner and then pour your desired photoresist on your sample. Then step on the pedal again to start spinning.

19. Once done, take off your sample and bake it on either of the two hotplates with attached suction. This is to suck away the photoresist vapor from the sample away from you.




SWITCHING BETWEEN HOUSE AND MA6 VACUUM

Spin Coater Vacuum Control

Vacuum not working?

First: Try using the house vacuum

1. Turn the vacuum select switch to CLOSE
2. Open the house vacuum valve
3. Check the house vacuum gauge
4. Once finished, close the house vacuum valve

Second: Use the MA6 vacuum

1. Close the house vacuum valve
2. Turn the vacuum select switch so it points to MA6 Vacuum
3. Turn on the MA6 vacuum pump
4. Once finished, turn the vacuum select switch to CLOSE and turn of the MA6 vacuum

Vacuum Select Switch
Closed Position

Vacuum Select Switch
Red Arrow = MA6 Vac. Position

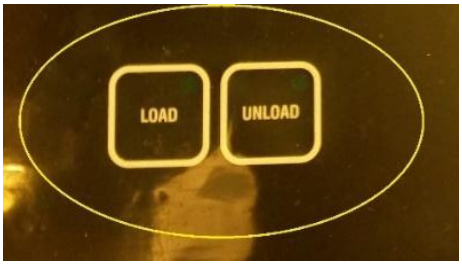
House Vacuum Valve and Gauge

MA6 Vacuum Pump Switch

TURNING ON THE CONTROL PANEL

20. Turn the **POWER SWITCH** on the front panel control clockwise into **ON** position. Wait while the machine initializes. The display will show **"Ready for Start – press LOAD Button".**

21. Press the flashing "**LOAD**" key on the keyboard.



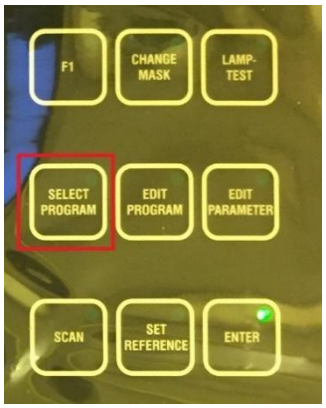
22. The software is loaded, and the machine is in its initial *state*, ready for operation: "**Ready for Load**"

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

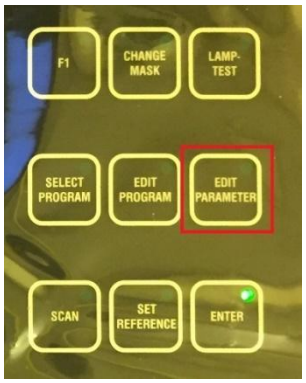
Exposure without Alignment

Usually, the first lithography on a wafer is done without alignment. Follow the steps below.

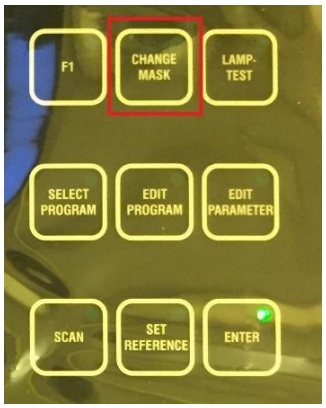
23. Press the **SELECT PROGRAM** key. Go through the menu using the arrow keys. Once you choose your exposure mode, confirm it by pressing **SELECT PROGRAM** key again. You can read about the diverse types of exposures in the ***Appendix*** at the end of this document.



24. Press **EDIT PARAMETER** key to edit the parameters. Change the time and any other necessary parameters and confirm them by pressing the **EDIT PARAMETER** key again.

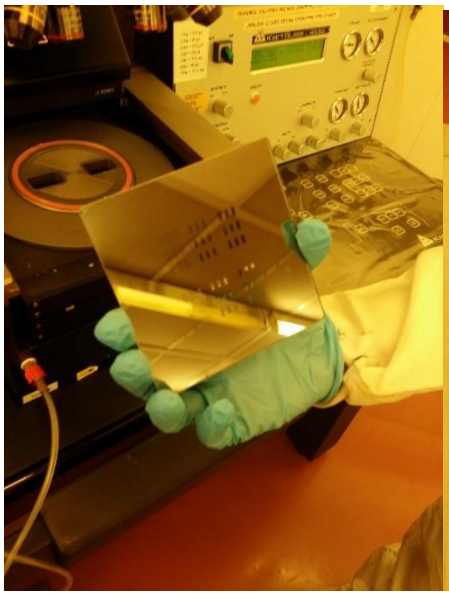


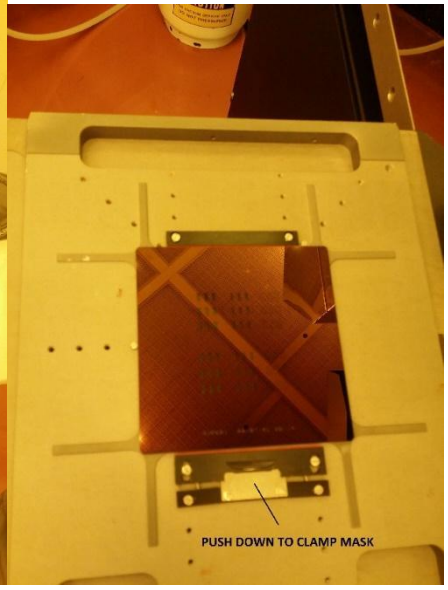
25. Start the mask loading sequence by pressing the **CHANGE MASK** key.



Note: Channel 2 on the MA6 is calibrated to output 15mW/cm$_2$ on the 365nm lamp.

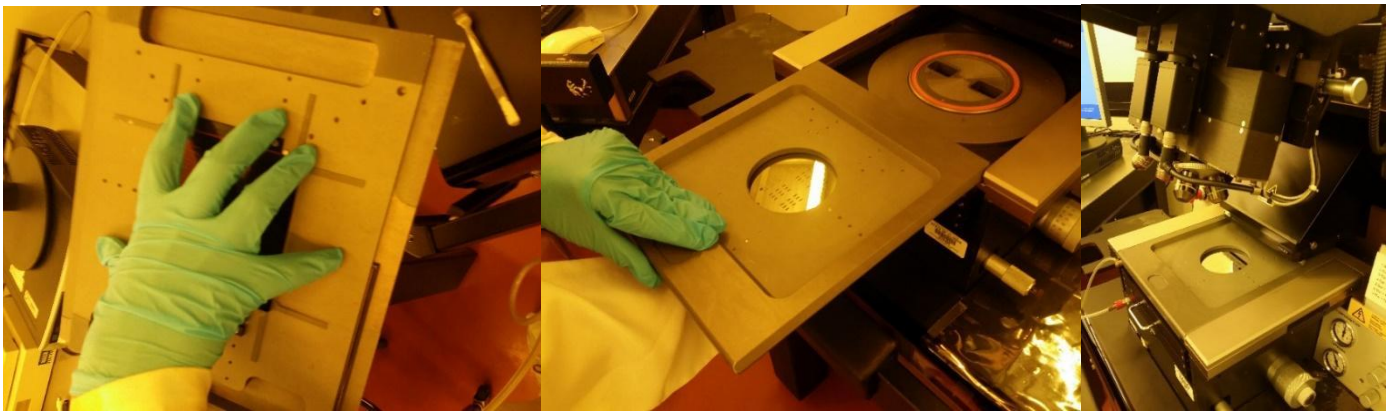
26. Place your mask on the holder with the top side of the mask facing up. Press **ENTER** to turn on the mask vacuum. Push the silver tab to clamp down the mask.



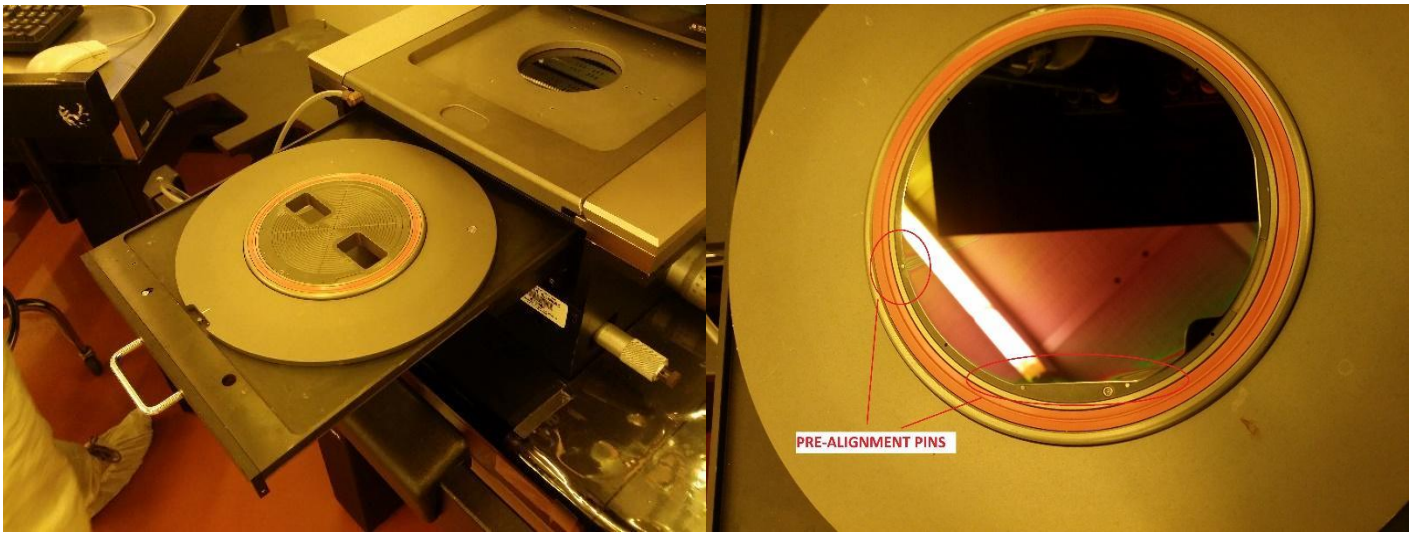


Note: If the machine says LOSS OF MASK VACUUM, unclamp the mask and try to re-sit the mask. Try the mask loading sequence again. If the error continues, contact the NCF office.

27. Pick up the mask holder and flip it over. Then slide the mask holder into machine. The press the **CHANGE MASK** key again to confirm the mask is loaded.



28. Press the flashing **LOAD** key on the keyboard. Then pull out transport slide and load wafer. Make sure to place the wafer against the pre-alignment pins.



29. Press the **ENTER** key. This will turn on the wafer vacuum. Push the transport slide back into the machine and confirm with the **ENTER** Key.

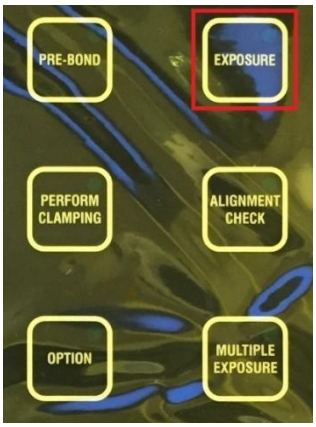
Note: If Flood Exposure was selected, exposure will take place automatically after you press ENTER.

Note: If the machine says LOSS OF WAFER VACUUM, you can proceed with your exposure but there is a risk the wafer might move during alignment. If you don't want this, you can press the UNLOAD button. Once the machine is ready, press the LOAD button again try to re-sit the wafer. If the error continues, contact the NCF office.

30. After WEC, the wafer moves automatically in exposure position. Depending on the exposure program selected all program steps will be performed automatically.

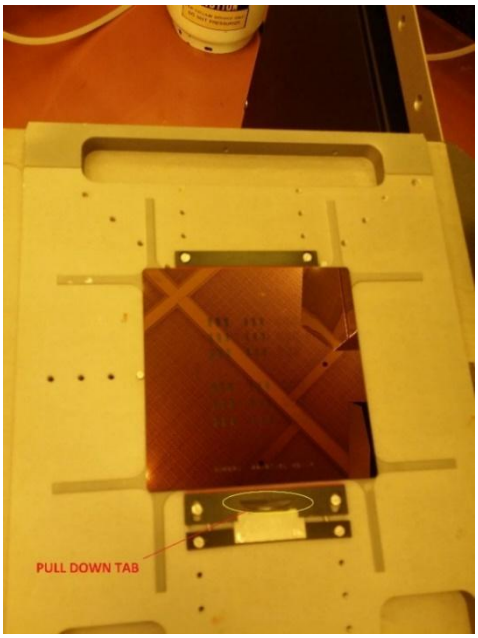
Note: Wedge error compensation (WEC) starts automatically after the last action is completed. The wafer is adjusted parallel to the mask and a correction for photoresist edge beads is done.

31. Press the **EXPOSURE** button. **TURN AROUND AND DON'T LOOK AT THE UV LIGHT. ALSO, ANNOUNCE TO THE ROOM THAT EXPOSURE IS TAKING PLACE SO THAT OTHERS DON'T LOOK AT THE UV LIGHT.** After exposure, wait for the wafer chuck to move down. Pull the slide out and Press **ENTER** to turn off the wafer vacuum. Then unload the exposed wafer.



Note: Even if the EXPOSURE button was pressed, if you press the UNLOAD key before the light shutter has opened the and the UV light comes on, the program will stop the sequence without wafer exposure.

32. To expose another wafer, repeat steps 28 - 30.
33. To unload the mask, press the **CHANGE MASK** key. Pull the mask holder out, flip it by 180º and store it on the tray to your left.
34. Press the **ENTER** button to switch the mask vacuum off. Retract the mechanical clamp and remove the mask.



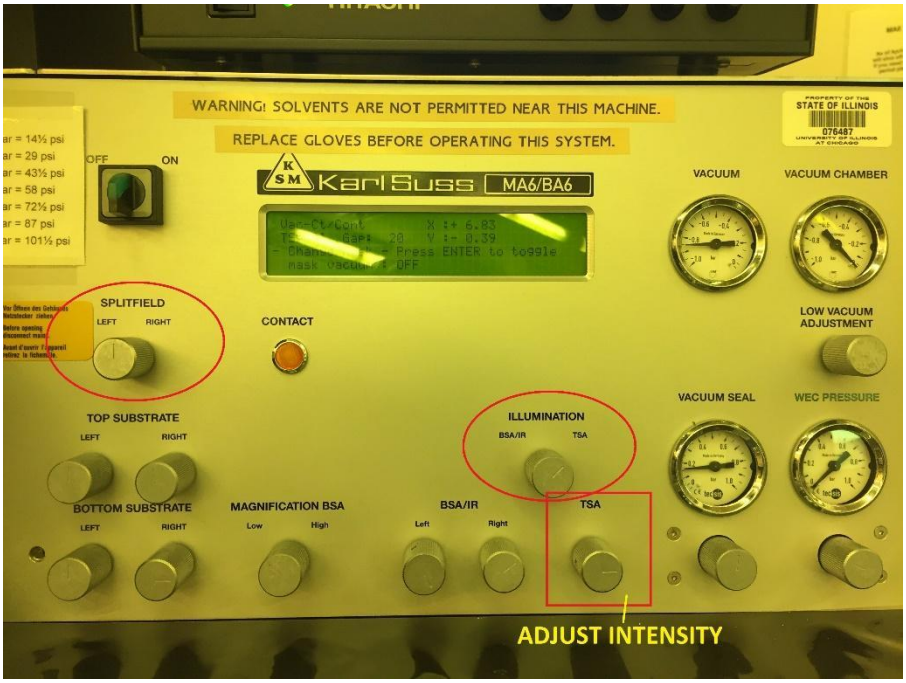
Top side alignment

In this mode the wafer is aligned to the mask using the topside alignment microscope (TSA). The following explains the steps to align and expose with a mask. **Please make sure the current program is not Flood Exposure.**

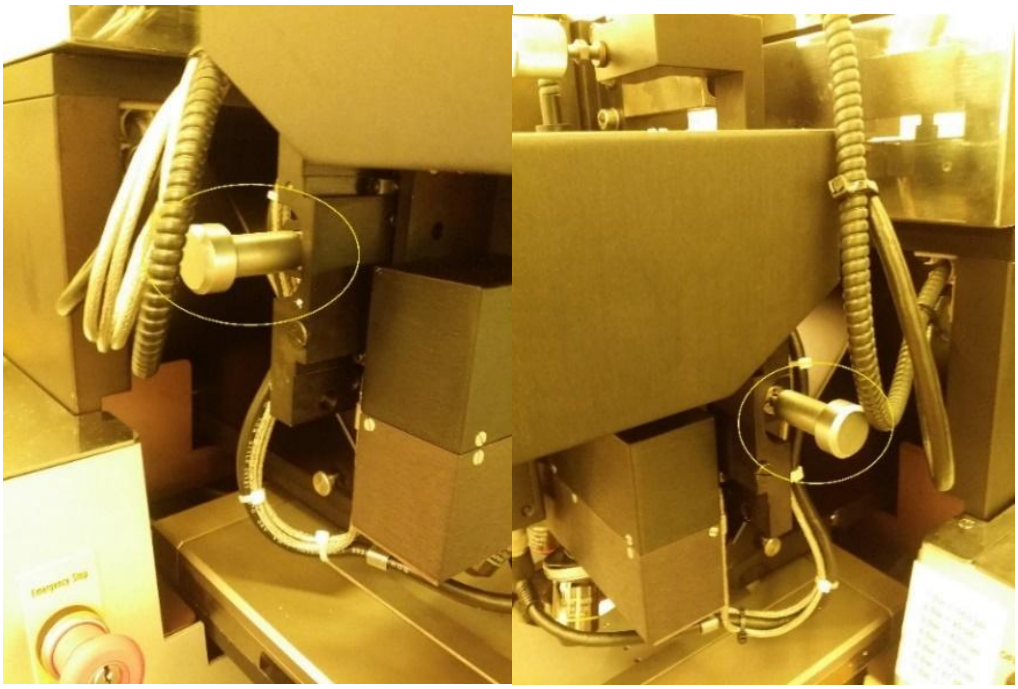
35. If needed, repeat steps 23 – 30.
36. If the microscope is not lowered automatically, press **F1** key, and then press **ENTER**. Watch out for the microscope movement!

37. Press the **BSA** button to turn off the backside microscope. This key also switches the controlled manipulator motors from **BSA** to **TSA** (top-side alignment).

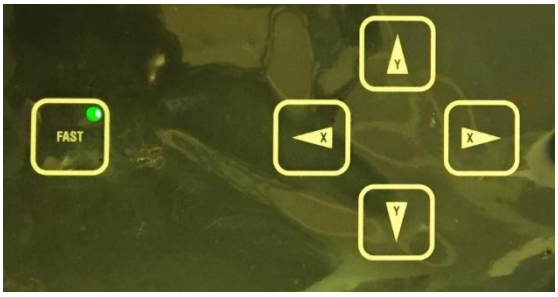
38. An actual TSA-microscope image on the monitor is enabled by turning the **SPLITFIELD** switch to **LEFT** or **RIGHT**. Leaving the switch in the middle position would display both left and right microscope images on the screen.
39. Turn the **ILLUMINATION** switch to **TSA** and turn the light intensity with the potentiometer underneath this switch.



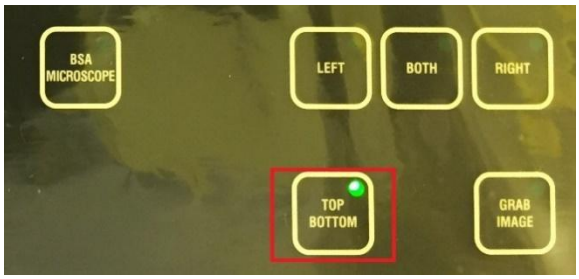
40. Adjust microscopes to the mask's alignment marks. Move the left/right objective to the left/right mask alignment marks using the ***OBJECTIVE X-SEPARATION*** *knobs*.

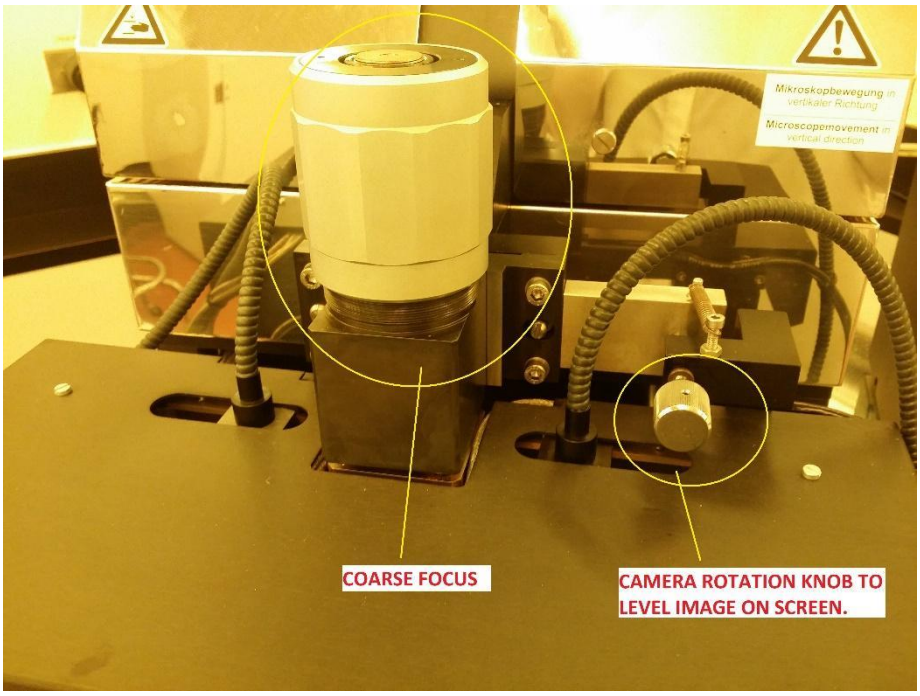


41. You can move the **TSA** cameras by using the *arrow keys*. You can press the **FAST** button to move the cameras fast. Press the **FAST** button again to turn off fast movement.

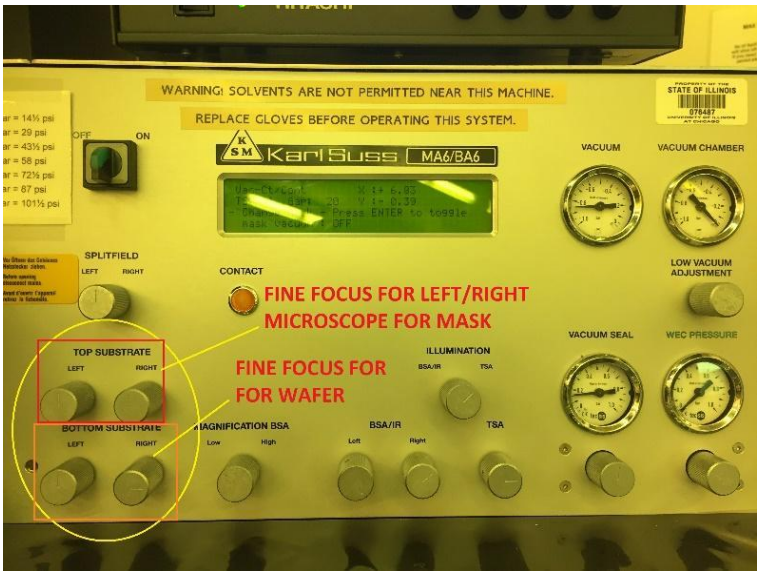


42. Coarse focus is possible by using the **TSA Z-MOVEMENT** knob on top of the system. Make sure the **TOP/BOTTOM** key LED is on. **After finding your alignment keys, the image on the left/right screen could be rotated and not level. Use the camera rotation knob to make the images on screen level.**





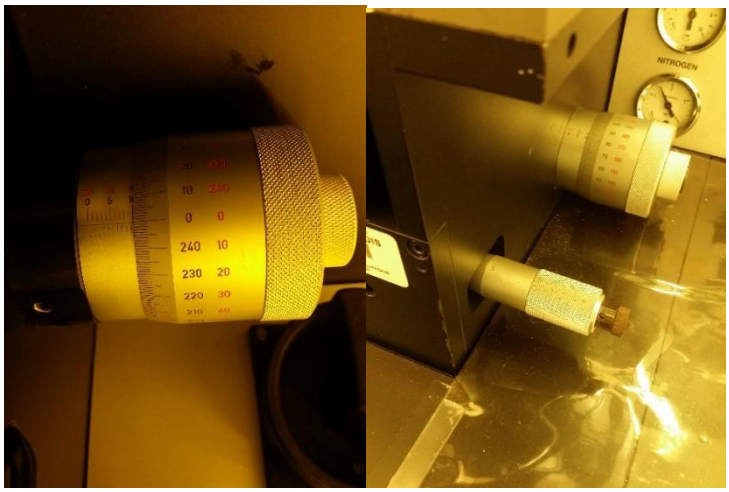
43. Adjust the fine focus separately using the **TOP SUBSTRATE LEFT/RIGHT** knobs.



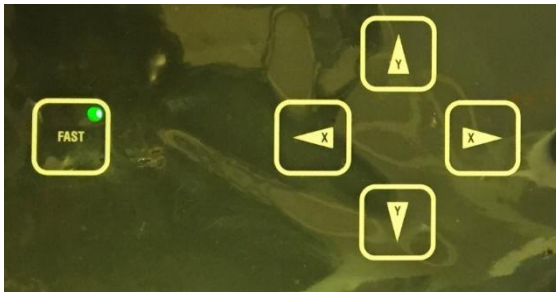
Optional: Press the **GRAB IMAGE** Key. The system takes an image and the objectives move the focal plane to the wafer and the **TOP/BOTTOM** key LED goes off. The motor control of the microscope manipulator is disabled at this time. To go back, press the **GRAB IMAGE** key again to delete the stored image and enable the manipulator again.

44. **Focus on the wafer plane and find your alignment keys on the wafer**. Adjust the left/right microscope image with the **BOTTOM SUBSTRATE LEFT/RIGHT** knobs.

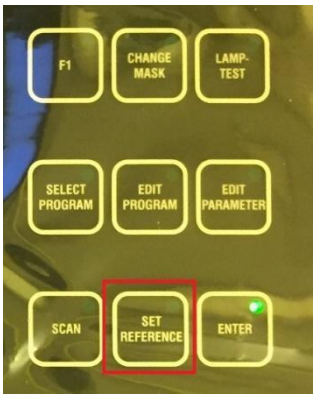
45. Use the micrometer screws of the alignment stage for *X-Y-Θ-MOVEMENT* to align your wafer to the mask**. If mask and wafer are in contact (*CONTACT INDICATOR* on), don't align the wafer!**



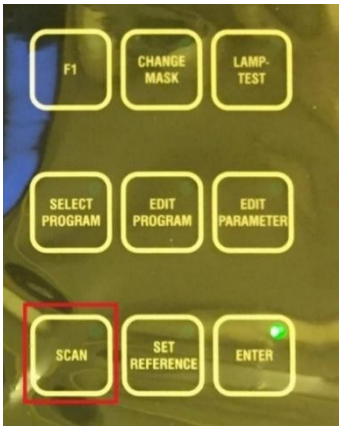
46. You can check the alignment at multiple locations setting one or two alignment keys on your mask as a reference. To do this, move the **TSA** cameras by using the *arrow keys* to the first set of your alignment keys. You can press the **FAST** button to move the cameras fast. Press the **FAST** button again to turn off fast movement.



47. Press the **SET REFERENCE** button. Then move the **TSA** cameras to another set of alignment keys.



48. At this new location on the mask/wafer, align the alignment keys. Then press the **SCAN** button to go back to the first set of alignment keys and check the alignment there.



49. Keep pressing **SCAN** to go between the two sets of alignment keys and keep adjusting the alignment until the alignment is good.

50. Depending on your requirements, an alignment check could be helpful. Press the **ALIGNMENT CHECK** key to check if your alignment is good. The wafer and mask will come into contact. If it is good, move to the next step. **If it's not good, press the ALIGNMENT CHECK key again to release the contact and repeat steps 29 and 34**.

51. Press the **EXPOSURE** button. **TURN AROUND AND DON'T LOOK AT THE UV LIGHT. ALSO ANNOUNCE TO THE ROOM THAT EXPOSURE IS TAKING PLACE SO THAT OTHERS DON'T LOOK AT THE UV LIGHT.** After exposure, wait for the wafer chuck to move down. Pull the slide out and Press **ENTER** to turn off the wafer vacuum. Then unload the exposed wafer.

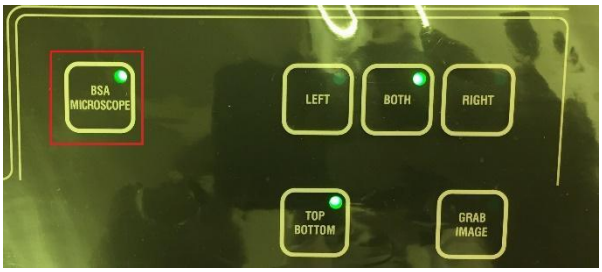
Note: Even if the EXPOSURE button was pressed, if you press the UNLOAD key before the light shutter has opened the and the UV light comes on, the program will stop the sequence without wafer exposure.

52. To expose another wafer, repeat steps 20 - 35.
53. To unload the mask, press the **CHANGE MASK** key. Pull the mask holder out, flip it by 180º and store it on the tray to your left. **Watch out for the microscope movement**!
54. Press the **ENTER** button to switch the mask vacuum off. Retract the mechanical clamp and remove the mask.

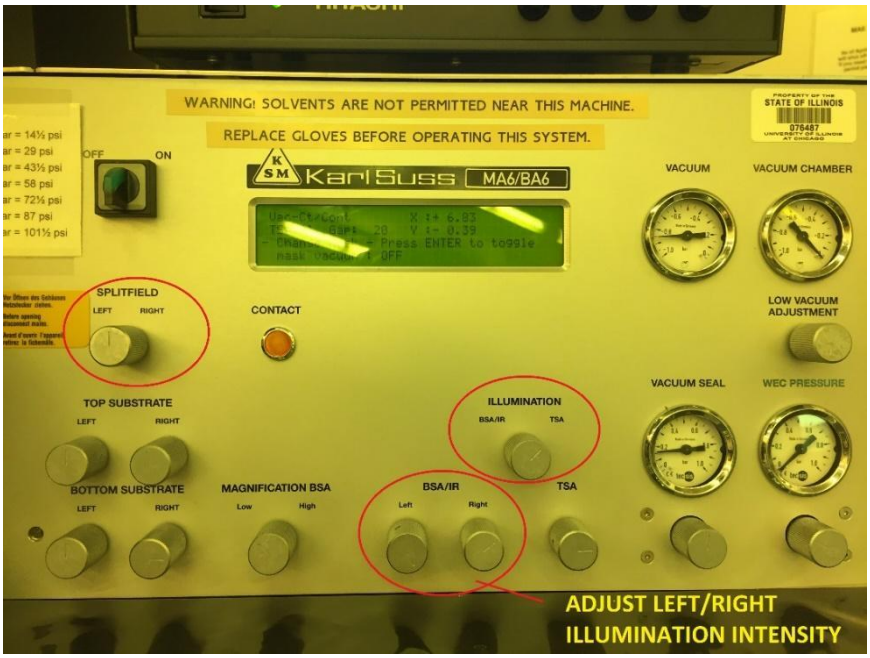
Bottom/ Back side alignment (BSA)

If you will be using both sides of your wafer for devices, you'll need to do bottom side alignment. Here, the wafer is aligned to the mask using the bottom side alignment microscope (BSA). The following explains the steps to align and expose the backside of your wafer.

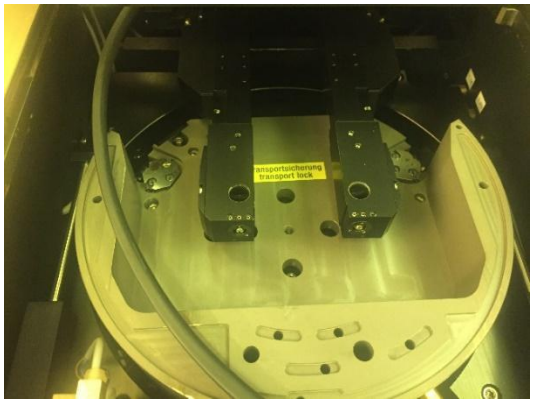
55. If needed, repeat steps 28 – 30.
56. Make sure the **BSA** light is on. If not, press the **BSA** button to turn on the backside microscope. This key also switches the controlled manipulator motors from BSA to TSA.



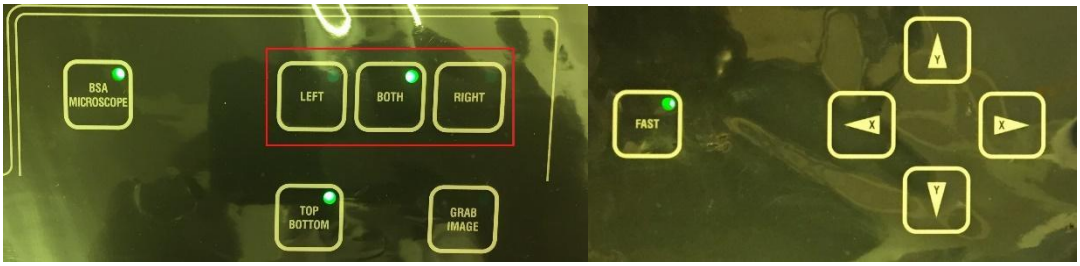
57. An actual BSA-microscope image on the monitor is enabled by turning the **SPLITFIELD** switch to **LEFT** or **RIGHT**. Leaving the switch in the middle position would display both left and right microscope images on the screen.
58. Turn the **ILLUMINATION** switch to **BSA/IR** and select the left/right light intensity with the potentiometers labeled **BSA/IR**.



59. If the wafer chuck is not centered, move them it with the micrometer screws. You should be able to see the bottom microscopes through holes in the wafer chuck.

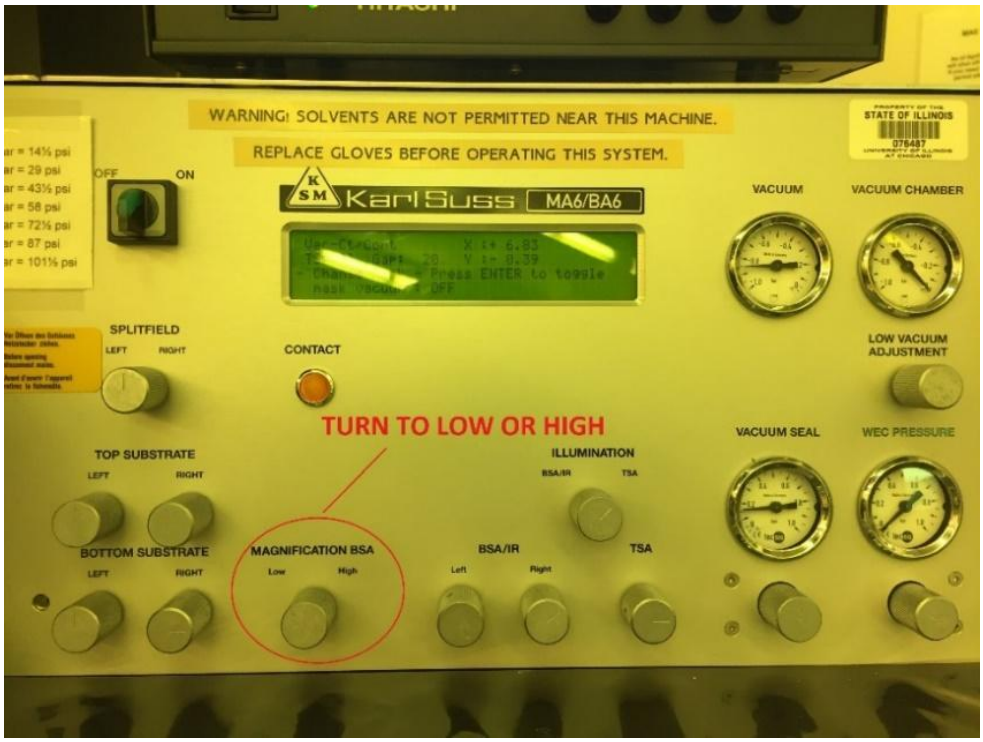


60. Adjust back-side microscope to the mask's alignment marks. Move the left/right objective to the left/right mask alignment marks using the *arrow keys*. You can move one microscope or both at the same time by pressing **LEFT**, **RIGHT**, or **BOTH**. Press **FAST** to make the microscopes move fast and press it again to move slowly.



61. Make sure the **TOP/BOTTOM** key LED is on.
62. Adjust the fine focus separately with the **TOP SUBSTRATE LEFT/RIGHT**.
63. Press the **GRAB IMAGE** Key. The system takes an image of the mask's alignment marks and says "**BSA/Image stored**." You can press the **GRAB IMAGE** key again to delete the stored image and enable the manipulator again.

Note: You can see a high magnification image of your alignment marks by switching the dial labeled **MAGNIFICATION BSA** to **HIGH**.



64. Once you have an image, press the flashing **LOAD** key on the keyboard. Then pull out transport slide and load wafer upside down. Make sure to place the wafer against the pre-alignment pins.
65. Press the **ENTER** key. This will turn on the wafer vacuum. Push the transport slide back into the machine and confirm with the **ENTER** Key.
66. **Focus on the wafer plane and find your alignment keys on the wafer**. Adjust the left/right microscope focus with the **BOTTOM SUBSTRATE LEFT/RIGHT** *regulator.*
67. Use the micrometer screws of the alignment stage for *X-Y-Θ-MOVEMENT* to align your wafer to the mask**. If mask and wafer are in contact (*CONTACT INDICATOR* on), don't align the wafer!**
68. Depending on your requirements, an alignment check could be helpful. Press the **ALIGNMENT CHECK** key to check if your alignment is good. The wafer and mask will come into contact. If it is good, move to the next step. **If it's not good, press the ALIGNMENT CHECK key again to release the contact and repeat steps 51 and 52**.

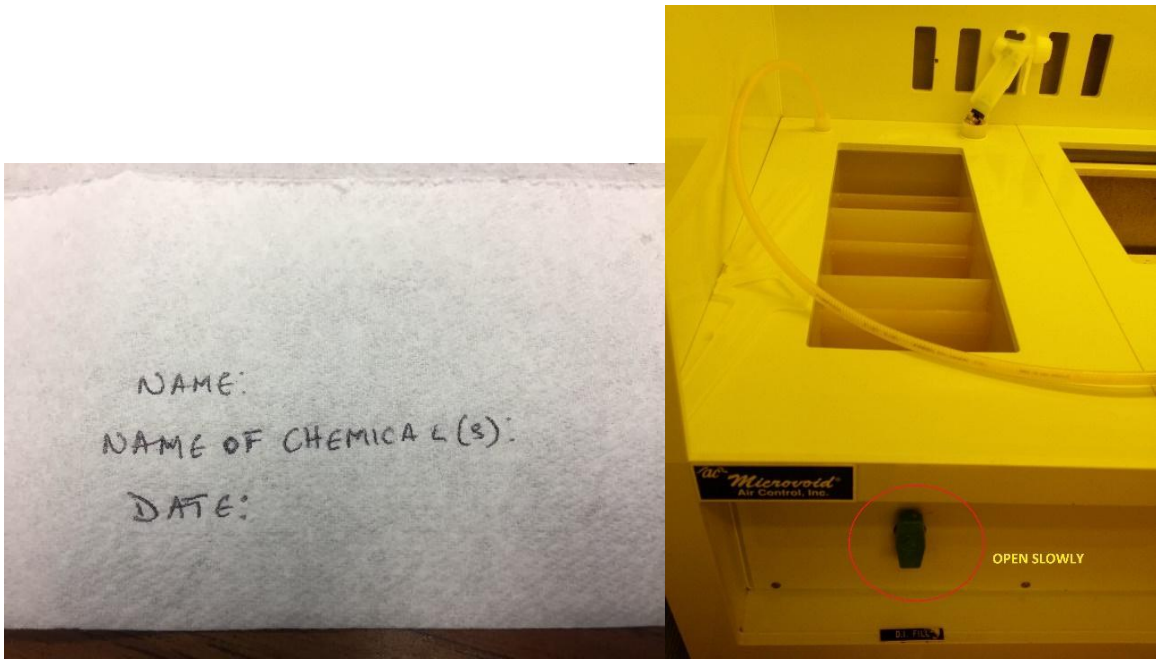
69. Press the **EXPOSURE** button. **TURN AROUND AND DON'T LOOK AT THE UV LIGHT. ALSO ANNOUNCE TO THE ROOM THAT EXPOSURE IS TAKING PLACE SO THAT OTHERS DON'T LOOK AT THE UV LIGHT.** After exposure, wait for the wafer chuck to move down. Pull the slide out and Press **ENTER** to turn off the wafer vacuum. Then unload the exposed wafer.

Note: Even if the EXPOSURE button was pressed, if you press the UNLOAD key before the light shutter has opened the and the UV light comes on, the program will stop the sequence without wafer exposure.

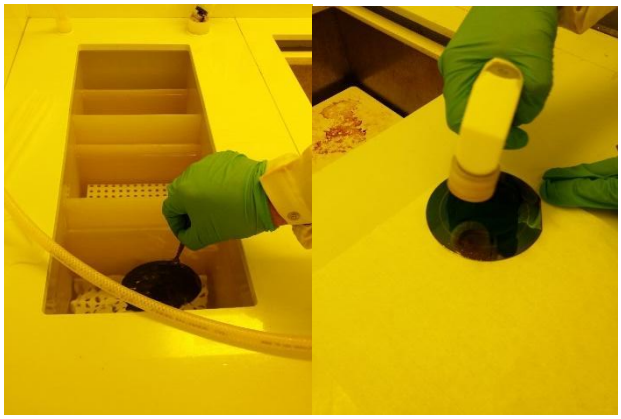
70. To do another back-side alignment, repeat steps 55-69.
71. To unload the mask, press the **CHANGE MASK** key. Pull the mask holder out, flip it by 180º and store it on the tray to your left. **Watch out for the microscope movement**!
72. Press the **ENTER** button to switch the mask vacuum off. Retract the mechanical clamp and remove the mask.

PHOTORESIST DEVELOPMENT

1. Depending on the developer you are going to use, please pick one of the white or red tray near the sink to use for development.
2. Place a clean-room wipe in the fume hood and label the wipe with your name, the name of the chemical (s), and the date. **Open the water valve in the fume-hood slowly**.



3. After developing, rinse your wafer in water and dry your wafer with the nitrogen gas.



SYSTEM SHUTDOWN

NOTE: DO NOT TURN ANYTING OFF UNTILL YOU ARE SURE THAT YOUR PHOTOLITHOGRAPHY PROCESS HAS BEEN SUCCESSFUL.

1. To unload the mask, press the **CHANGE MASK** key. Pull the mask holder out, flip it by 180º and store it on the tray to your left. **Watch out for the microscope movement**!
2. Press the **ENTER** button to switch the mask vacuum off. Retract the mechanical clamp and remove the mask.

3. Check **UICore** to see if anyone else has the system reserved within 30 minutes of your reservation ending. If someone else will be using the system in the next 30 minutes, leave the system on. If not, follow the next steps to shutoff the system.
4. Flip the **POWER** switch to the **OFF** position.
5. Turn off the **Constant Intensity Controller** (**CIC)** by pressing on the **OFF** button.
6. Push the **DELAYED NITROGEN** button. This will leave nitrogen on for 30 minutes, after which it will automatically turn itself off.

NOTE: If both the START N2 and DELAYED NITROGEN lights come on, unplug the black box and quickly plug it back in and then press the DELAYED NITROGEN button again.

Warning: Wait at least 30 minutes before turning the lamp back on. If you don't wait the lamp might explode!

APPENDIX

Saving a program: There is an option to save your parameter set for the future. Press the EDIT PROGRAM key and using the X-ARROW keys, go to "SAVE Pgm.". With the Y-ARROW keys, select a program number. Save the settings by pressing the EDIT PROGRAM key. Existing programs can be loaded from here by selecting the program number. Prior programs saved to the same number will be overwritten without warning.

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 like 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 like 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:

1. Select the corresponding exposure program by the SELECT PROGRAM key.
2. Press the MULTIPLE EXPOSURE key.

3. Press the EDIT PARAMETER key. Edit the parameter for the exposure program. Edit the numerical value of the corresponding parameters wait time and cycles.
4. 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 homogeneous 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.