



Center for Integrated Nano-Technologies

IL OAI 800MBA Mask Aligner Operating Procedure

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1. PURPOSE

This document provides information for the safe use and operation of the OAI 800MBA Mask Aligner located in the Integration Lab, Bldg 518. Any questions beyond the scope of this document should be directed to the equipment owner.

2. ACRONYMS

Many pieces of equipment and procedures are known by their associated acronym, it is important to become familiar with the following list to avoid confusion.

- SNL- Sandia National Labs
- CINT- Center for Integrated Nano-Technologies
- SOP/OP- Standard Operating Procedure/Operating Procedure
- DVPG- Digital Video Pattern Generator
- LCD – Liquid Crystal Display
- PR- Photoresist
- ES&H – Environmental Safety and Health
- S&S- Safeguards and Security
- QA- Quality Assurance
- PM- Preventative Maintenance
- UV- Ultra Violet
- NUV- Near Ultra Violet
- DUV- Deep Ultra Violet
- MUV- Mid Ultra Violet

3. DEFINITIONS

Authorized User- Personnel with the required training and subsequent approval of the Integration Lab manager to use said equipment.

CINT Key Operator- Designated Key Operators are qualified to perform tool specific training of Authorized Users, and are responsible for the maintenance of the equipment.

Visitor- Personnel trained in the cleanroom overall safety and gowning procedures, but not authorized to operate equipment.

ES&H Officer – Provides ES&H, S&S, and QA for CINT activities.

Wafer Chuck- Circular mount that holds the substrate.

4. RESPONSIBILITIES

It is the responsibility of every employee, contractor, and visitor to ensure a safe and healthy working environment. There is no experiment or procedure at Sandia that is so urgent that it needs to be done in an unsafe manner, and it is everyone's obligation to refuse to do work that he or she believes to be unsafe. If there is an activity or situation that is of concern it is their immediate responsibility to contact a supervisor or ES&H representative.

5. TRAINING

Prior to using Lithography tools or processes, users must complete all IL Unescorted Access (ILUA) Corporate and Operations training.

5.1 Corporate Training

Integration Lab Users shall complete the Corporate training specified in the *IL General OP*. Additional Corporate training classes may be required for specific activities.

5.2 Operations training

Required Operations training:

- IL Lithography OP
- MJB3 Aligner OP

5.3 Tool Specific training

Prior to using MASK2 the Key Operator of MASK2 must instruct the potential Authorized User on the safe and proper operation of the tool to minimize the risk to the user and the tool. After completion of the tool specific training, the Key Operator will provide a recommendation to the Integration Laboratory Manager for or against the tool access of the potential Authorized User. Once training is complete the user will be able to perform:

- Wafer chuck replacement
- Backside pattern to mask alignment
- Front and Backside exposures

6. APPROVAL, NOTIFICATIONS, AND SCHEDULING

After reading and signing all applicable OP's, finishing all associated training, and receiving the express permission from the Integration Lab manager the Authorized User will be issued a new Integration Lab badge indicating that they are allowed to use the mask aligners. They will then be given access to schedule the tool in the on-line tool calendar.

7. SAFETY PRECAUTIONS AND LIMITATIONS

General safety precautions are addressed in the IL General OP, which is a prerequisite for IL Lithography training. During normal operation, The OAI Mask Aligner is an inherently safe tool and has limited possibility of exposure to hazards. Only CINT Key Operator may open the tool or perform maintenance. However, to better inform the user we have included the following information on the internal hazards of the tool.

7.1 UV Burn Hazard

Prolonged exposure to diffused reflection from the output beam or a few seconds of direct output beam exposure can cause skin burns or burns to the outer layer of the eye. As with any UV light source always wear UV filtered glasses to protect eyes and limit exposure to UV radiation. During normal operation there should never be direct UV exposure.

7.2 Lamp Explosion

During operation the light source is subjected to extremely high internal pressure, and there is the possibility of a lamp exploding. A lamp explosion can be due to contamination of the quartz envelope, internal strains, or physical abuse. Handle the lamps only by metal end caps and DO NOT TOUCH the quartz with bare hands. A lamp explosion can damage other internal components and it's important to take precautions to avoid one as they can be both dangerous and costly. In the event of a lamp explosion clear the area of personnel and immediately cont85

act the tool owner so that the appropriate maintenance can be performed. Also be aware that the lamp does contain mercury, and if the lamp explodes there will be minute amounts of liquid mercury inside light source housing.

7.3 Ozone Poisoning

Do not operate the system if proper room ventilation is not available as Deep UV lamps produce significant levels of ozone.

7.4 Mechanical pinch hazards

Any equipment that has moving parts will have some sort of pinch hazard. The mask aligner has several moving pieces, some of which move independently of manual operation. It is important to be alert when working near moving parts. Some examples are the UV exposure hood, the top side alignment optics, bottom side alignment optics, and the alignment stage.

8. SPECIAL TOOLS, EQUIPMENT, PARTS, AND SUPPLIES

All parts and supplies needed for using this machine will be located in the cabinet against the wall, to the right of the machine. The cabinet contains masks and wafer chucks. Anything beyond routine use of the machine will require additional tools, however maintenance should only be performed by Key Operators.

9. OAI OPERATING AND MAINTENANCE PROCEDURES

Operation of the 800MBA Mask Aligner should only be executed by an Authorized User or the Key Operator. The 800MBA Mask Aligner will perform top side alignment by placing the substrate underneath the mask and aligning the substrate target to the mask target. Backside alignment is performed a bit differently. First the mask targets are positioned on the monitor and then crosshairs generated by a Digital Video Pattern Generator are aligned with the mask targets. The wafer is then put on the Chuck and moved into position under the mask, where the targets on the backside of wafer are aligned to the crosshairs on the monitor. Figure 9-1 labels parts that will be referred to in the Operating Procedure.

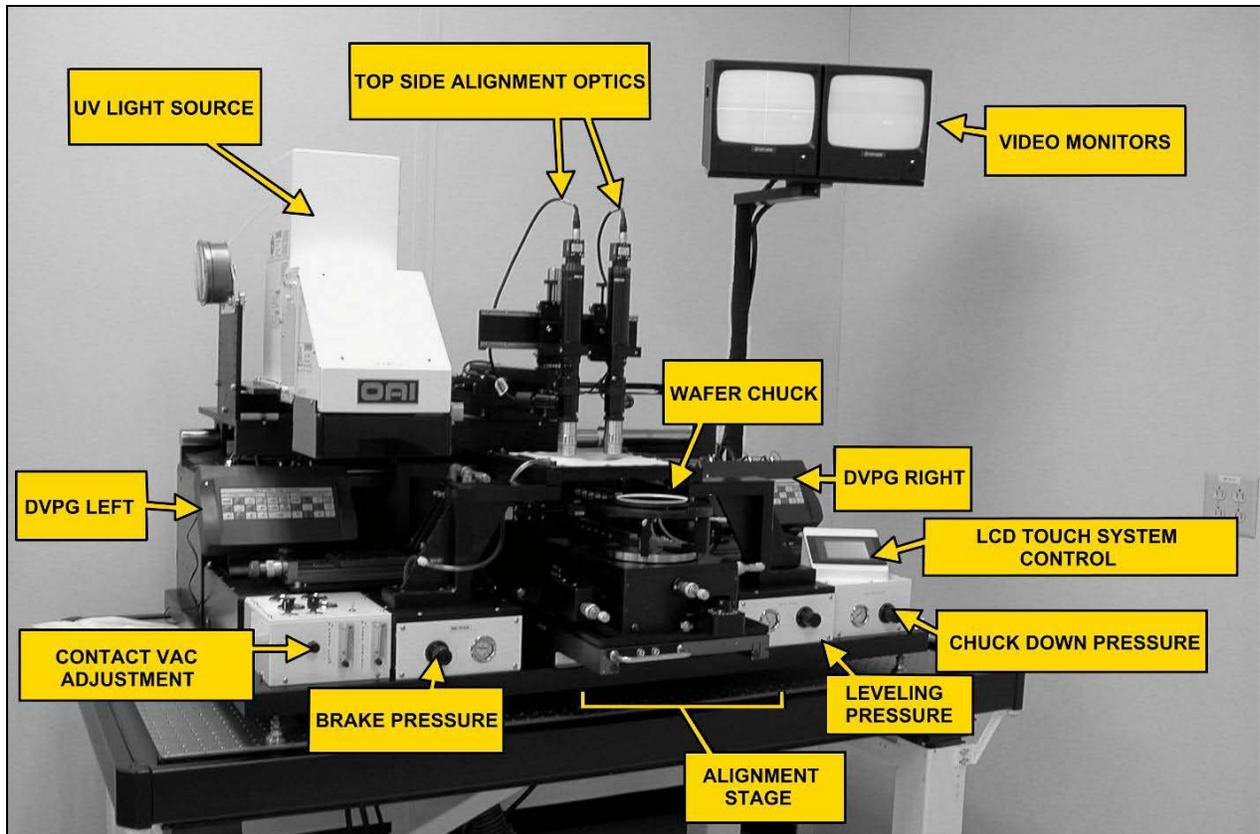


Figure 9-1 OAI 800MBA with labels

9.1 Set-up and Preparation

When you come into the lithography lab (Room 1523), the OAI 800MBA should be in its “steady state” condition. This means that most applicable power supplies, gas, and vacuum should already be set up for use, with the exception of the video monitors and possibly the UV power supply. If system is not in steady state condition please contact equipment owner and/or a Key Operator to turn on system.

Before starting any work on this tool check to make sure you’ve done all the following:

- ✓ Brought/have all masks (front side and/or backside depending on particular need)
- ✓ Have exposure recipe (hard/soft/vacuum contact, exposure time)
- ✓ Brought needed substrate(s)
- ✓ Turned on both video monitors (power button located in lower right hand corner)
- ✓ Checked the magnehelic gauge for proper exhaust gas pressure (located to the left of the UV light source hood) and made sure there is .25 inches of water (if not contact Key Operator)
- ✓ Ignited power supply to UV light source and allowed it to warm up for 5 minutes (Figure 9-2)



Figure 9-2 How to ignite UV power source

NOTE: The UV power source can be supplied with Near UV, Mid UV, or Deep UV outputs. Under normal circumstances the system is set up for Near UV exposure, if another type is necessary please contact the MASK2 Key Operator so that the machine can be switched over (this will take approximately 2 hours). For NUV the system operates between 340-450nm, DUV 200-260nm, and MUV 260-325nm. The system runs at 1KW for NUV and 500W for DUV.

9.2 Operation for Front Side Exposure

STEP 1- Ensure mask vacuum is off. Go to the LCD screen on the right side of the system and press MANUAL TEST. For all the LCD controls the process is OFF when the button is white, and ON when the button is dark. Make sure MASK VACUUM is OFF i.e. white/transparent. The LCD buttons are toggle, and when the mask vacuum is on there will be a small hissing/buzzing sound. After turning the mask vacuum off, press LEVEL SCREEN in the top left corner, and then MAIN MENU in top left corner. This will take you back to the main menu screen.

STEP 2- Disconnecting the vacuum line. You will see a vacuum hose going from the top of the mask holder to the front lower left of the machine (Figure 9-3). There will be an easy release valve with the words MASK VAC next to it (Figure 9-4). Turn this valve to the left and pull forward; this will disconnect the vacuum tube. Pull the tube around the equipment so that it is not tangled around anything.

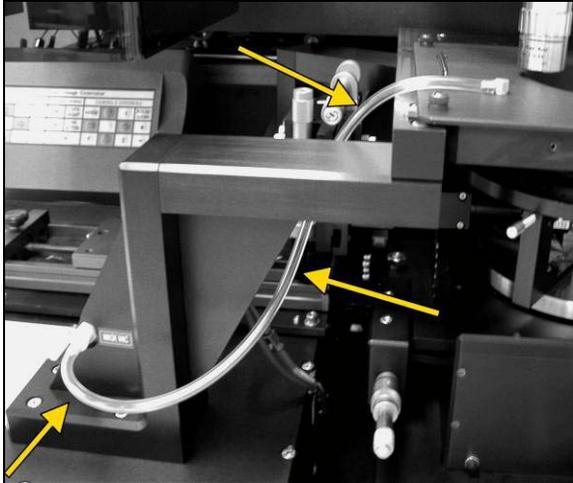


Figure 9-3 Mask vacuum tube



Figure 9-4 Disconnected mask vacuum tube

STEP 3- Mask holder removal. Unscrew the four screws on top of the mask holder (Figure 9-5) they are easily unscrewed by hand. The screws will not screw out entirely; please do not attempt to pull them out completely. Once they are unscrewed pull up on mask holder handles (Figure 9-6) and slowly pull the holder forward. Be cautious of the top optics cameras as there is very little clearance between them and the mask holder. **Please be extra careful if there is a mask in the holder. When the mask vacuum is turned off it is VERY easy for the mask to fall off the holder. It is a good idea to keep your hand under (but not touching) the mask as it is pulled out.**

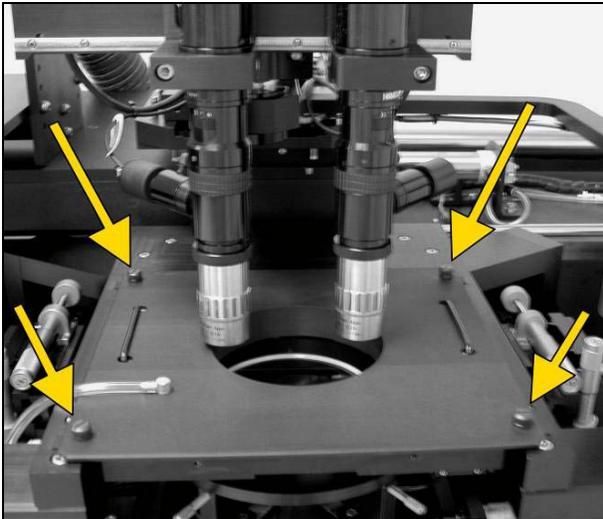


Figure 9-5 Mask Holder Screws

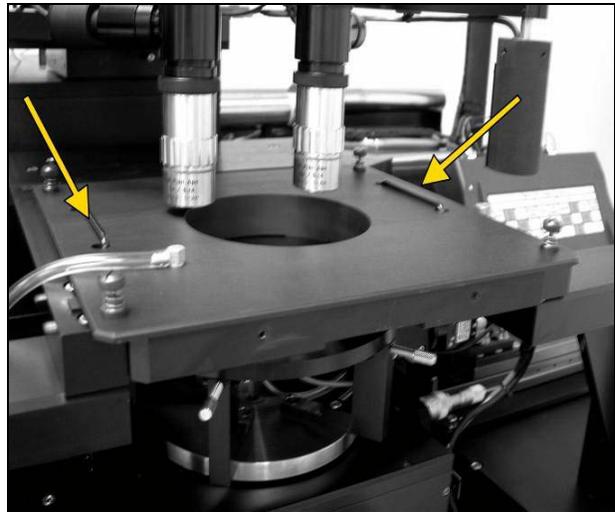


Figure 9-6 Holder handles

STEP 4- Install the mask in the holder. Once the holder is out flip it upside down and set it on the table to the left of the mask aligner. There is a silver clip keeping the mask pressed against two notches. Pull the clip down to release the mask (it sticks so pull down hard). Pick the mask up by its edges and store in appropriate container. Next place the mask that will be used onto the holder. Push the top of the mask up against the two notches on the top of the holder. There is also one on the side of the holder (Figure 9-7). It is a good idea to double check that the correct side is facing up, so that when flipped back over the correct side will be in contact with the substrate. Once the mask lined up on the mask holder, press the small black button that is on the right of the clip (Figure 9-8). This will push the clip upwards and secure the

mask into place. When it's secure flip holder over again and replace it into system. **Masks are very expensive and it can take a long time to receive replacements, so it is always a good idea to handle with care.**

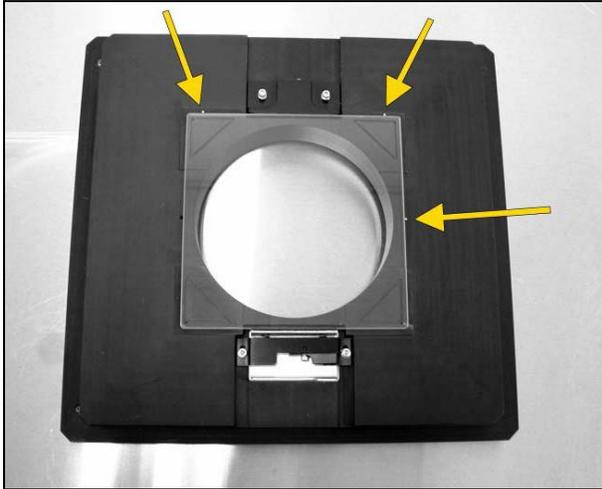


Figure 9-7 Arrows indicate notches

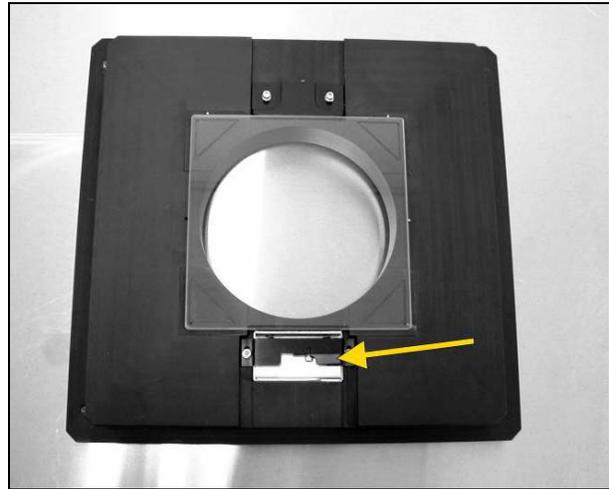


Figure 9-8 Black secure button

STEP 5- Reinstall the mask holder. Once the mask holder has been put back into the system reattach the vacuum hose in the same manner as it was disconnected. Make sure that the hose is wrapped appropriately to ensure it doesn't get in the way. Once the hose is connected immediately turn on the mask vacuum, this ensures that the mask won't fall off. Go to the LCD main menu screen and select RUN SCREEN. There will be another menu, press MASK VACUUM so that it turns dark (ON). If there is any doubt about the vacuum pressure, go to the lower left hand corner of the table, there will be a box with four gauges (Figure 9-9). One of the gauges will say 'mask vac' and the psi will be given. Now the screws can be screwed back into place. The screws may need to be wiggled a little to position them back into the holes.



Figure 9-9 Vacuum pressure gauges and optics illumination knobs

STEP 6- Verify wafer chuck. Before the substrate can be loaded make sure that the wafer chuck is the correct size for the wafer. Start by pulling the wafer chuck out manually by the handle in front. There are magnets in back of the alignment stage and you will need to pull hard. Typically the 4 inch wafer chuck will be on. If a 3 inch or 2 inch wafer will be used the wafer chuck will need to be replaced with a different size. If the 4 inch (or whatever is present) is appropriate then proceed to next step. To replace wafer chuck first go to LCD control panel and press LEVEL SCREEN and make sure that the substrate vacuum is turned OFF (i.e. the button should be white). Then return to main menu and press RUN SCREEN and ensure that the CONTACT VACUUM is turned OFF. Now disconnect the vacuum tubes located at the base of the wafer chuck. There are not easy release valves so it may be necessary to wiggle the tubes off. The vacuum tube labeled BALL LOCK or BALL VACUUM will not be able to be shut off, so a hissing sound will be present after it is disconnected. Now unscrew the chuck screws (Figure 9-10) and remove the wafer chuck. There is a cabinet to the right of the mask aligner that houses the different sized chucks. Put the chuck that was just removed into the cabinet and replace with the correct size. Once the new wafer chuck is screwed in place the tubes can be reconnected to correct valves.

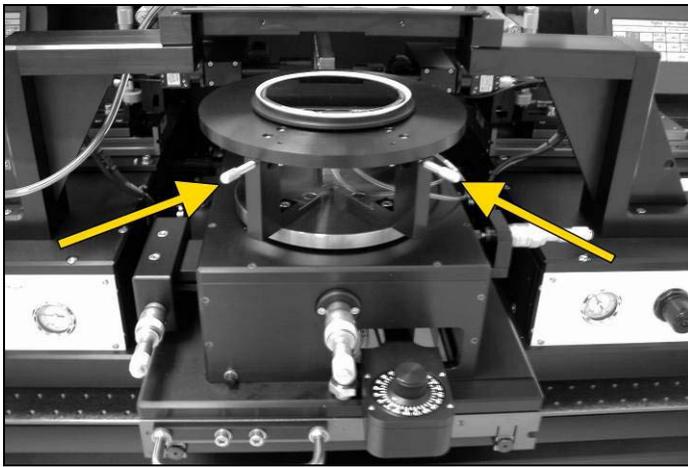


Figure 9-10 Wafer chuck screws

STEP 7- Loading the substrate. Place the wafer on top of chuck and line it up. This is achieved by making sure the flat end of wafer is at the front of the wafer chuck. Once the substrate is lined up go to the LCD screen and press LEVEL SCREEN and press SUBSTRATE VACUUM so that it is on (dark). Double check that the vacuum is on by going over to the four gauges (Figure 9-9) and looking at the 'substrate vac' psi to be sure that it is appropriate. When finished push the alignment stage back into position with the handle. The magnets in back of the alignment stage ensure that it returns to the initial position with extremely good accuracy.

STEP 8- Align the substrate. Because this is a top side exposure only the top side alignment optics will be used. The optics cameras can be maneuvered using the joystick on the right side of the apparatus (Figure 9-11). On the back of the joystick there will be two buttons. Holding the bottom button down allows movement of the optics in the X direction (i.e. left and right). To move in the Y direction press the top button down and the system will only move forward and backward. If both are held down at the same time the optics will move whichever way desired. If the substrate is anything other than 4 inches it may be necessary to adjust the X distance between the optics cameras. To do this, manually unscrew the cameras and slide them inward or outward so that they are at an acceptable distance. To change the theta angle of the cameras use the theta micrometer located on the back of the optics. The DVPG LEFT unit only controls the left (top and bottom) optics and monitor. The DVPG RIGHT unit only controls the right optics and monitor. If it's necessary to see both top side camera images in the monitors, press the 1

ONLY button on both of the DVPG units. Now the monitors should be linked up to the left and right optics cameras respectively. The DVPG's have six different types of reticle patterns available. To toggle between the different types of reticle patterns merely press the MODE button located on the top left of each DVPG unit. In addition pressing SOLID/DASH switches between solid and dashed lines. Pressing + or - switches the reticle color between white and black. The arrows move the reticle pattern around the screen. The type used will really be dependent on the mask pattern being dealt with. On the box at the left of the machine (Figure 9-9) there will be a switch for top/bottom optics next to two illumination knobs. Make sure the switch is switched to top optics. Then look at the monitors and adjust the illumination on the knobs so that the images are clear in the monitors (knobs control left and right cameras respectively). Top side alignment (first layer) can just be eyeballed. The mask holder and alignment stage are set up to give a centered exposure. Use the monitors/optics to double check that everything is lined up properly. If it isn't lined up appropriately move the wafer chuck to align it. This is done by using the X, Y, and THETA positioning controls (Figure 9-13), but this should not be necessary.

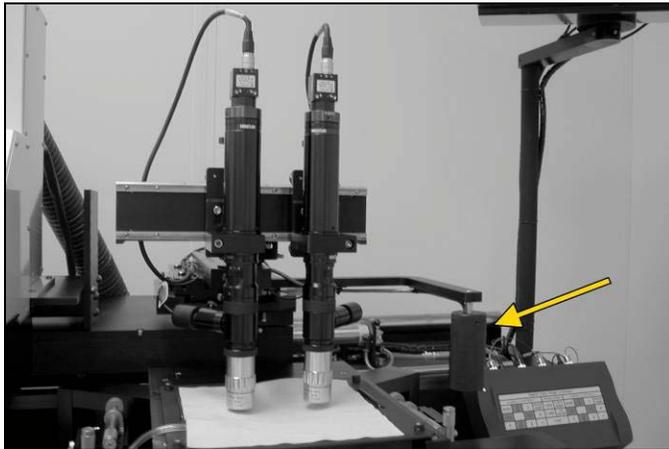


Figure 9-11 Top side optics joystick

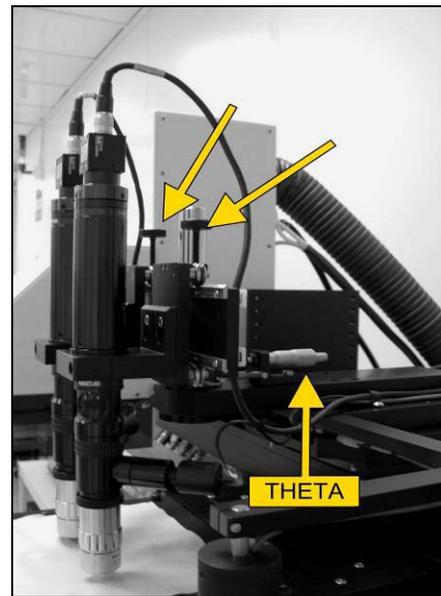


Figure 9-12 X-axis manual adjustment screws and Theta Micrometer

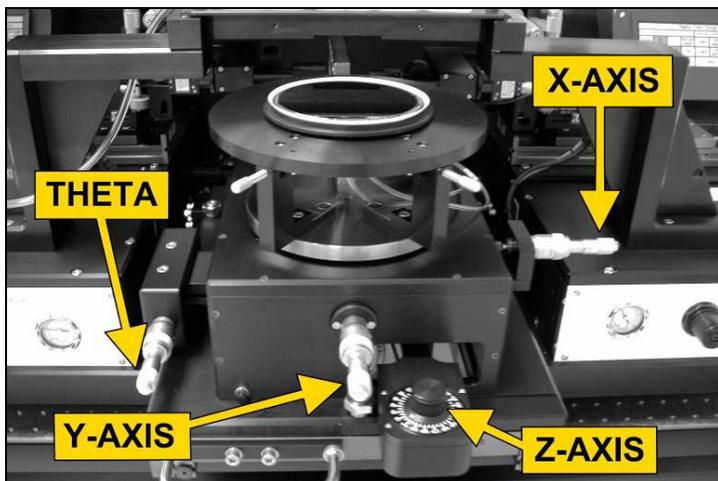


Figure 9-13 X, Y, THETA, and Z Chuck controls

STEP 9- Level wafer chuck. The OAI 800MBA has an auto level system. Before leveling check the pressure gauges on the Leveling pressure and Chuck Down pressure boxes (Figure 9-14).



Figure 9-14 Leveling and Chuck Down Pressure gauges

The leveling pressure will be different for different sized wafers. Four inch wafers will be ~40psi, 3 inch wafers ~30psi, and so on. The Chuck Down pressure is the pressure to bring the chuck down after contact, usually gravity is sufficient for this and so the pressure should be at 0psi. If gravity cannot pull substrate away from mask, increase this setting incrementally by 5psi until separation is successful. Also glance at the Brake Pressure gauge (on the left side), this pressure controls the break of the chuck fall after separating from mask, and should be ~15-20psi. To initiate auto level go to the LCD screen, LEVEL SCREEN, and press LEVEL. The chuck will then move up to planarize the substrate surface with the mask and will automatically move up to alignment gap.

STEP 10- Set process settings for exposure. To set exposure time go to PROCESS SETTINGS on the main menu and press the EXPOSURE TIME button. Enter in the time (in seconds). Double check that the process mode below exposure time says FRONT, if it doesn't press the button until it does. To set exposure type, go to RUN SCREEN and depending if you are using N2 Hard Contact, Contact Vacuum, or Gap Contact, press which ever applies. During and after a gap exposure the flow of nitrogen across the surface of the substrate is regulated using the N2 Purge Flow Regulator (bottom left of system). The N2 Hard Contact flow regulator controls the flow of nitrogen underneath the substrate such that the substrate is forced hard against the mask. The vacuum achieved during a contact vacuum exposure is regulated by the combination of the Contact Vac Adjustment valve and the N2 Purge Flow valve. When using these contact modes always be sure to watch the monitor to ensure that the contact does not move alignment.

STEP 11- Expose. Once the substrate is in proper position for exposure always double check that it is still aligned properly. If it is then it is ready to be exposed. Go to RUN SCREEN and press CYCLE. This will begin exposure. While the mask is being exposed be sure and turn away from machine, even while wearing UV protective goggles it's a good idea to get as little exposure to the UV light as possible.

STEP 12 – Unload substrate and mask. Once the exposure is finished turn off Hard Contact/Vacuum Contact. After that press the UNLOAD button. Then turn off the substrate vacuum, pull the alignment stage out by the front handle, and carefully remove the substrate from the chuck. After removing the substrate remove the mask from the holder. See STEPS 1-6 for how to do this.

9.3 Operation for Backside Exposure

Backside Exposures can be a lot more tedious than front side. The biggest difference is that the mask pattern and reticles need to be aligned prior to loading the substrate. Once the substrate is loaded it will block the bottom cameras from being able to see the mask pattern.

STEP 1- *Load the mask.* Please see STEPS 1-6 of front side exposure to see how to do this.

STEP 2- *Pick a reticle pattern.* Once the mask is in place decide which reticle pattern will best suit the alignment needs. Go to the DVPG units and press MODE to toggle through the six different types of reticle patterns available, as well as deciding on SOLID/DASH lines. Reticle patterns play a much more important roll in backside alignment than in front side.

STEP 3- *Set up reticle pattern to mask pattern.* Now align reticle pattern with mask pattern and top/bottom cameras. Go to DVPG units and press TOP/BOTTOM or LEFT/RIGHT button so that each monitor has a split screen. The top/bottom and left/right split screens are associated with the left side and right side optics respectively. So if LEFT/RIGHT is chosen the monitors will have split screens and the left side will be associated with top optics, the right associated with bottom optics. The same is true of top/bottom split screens: top is top optics, bottom is bottom optics. Be sure to not get confused as to what the monitor is showing.

IDEA: The point is to match the top and bottom cameras to the mask pattern. Then match the reticle pattern with a piece of the mask pattern. That way when the substrate loads into the wafer chuck (and blocks the mask from the bottom cameras) the top cameras/reticles can be used as a reference to match the backside pattern. This can be very confusing and it's a good idea to be clear on this before exposing.

Adjust both cameras so that the top and bottom optics are looking at the same piece of mask in the monitor. Figure 9-14 shows the bottom optics adjustment controls.

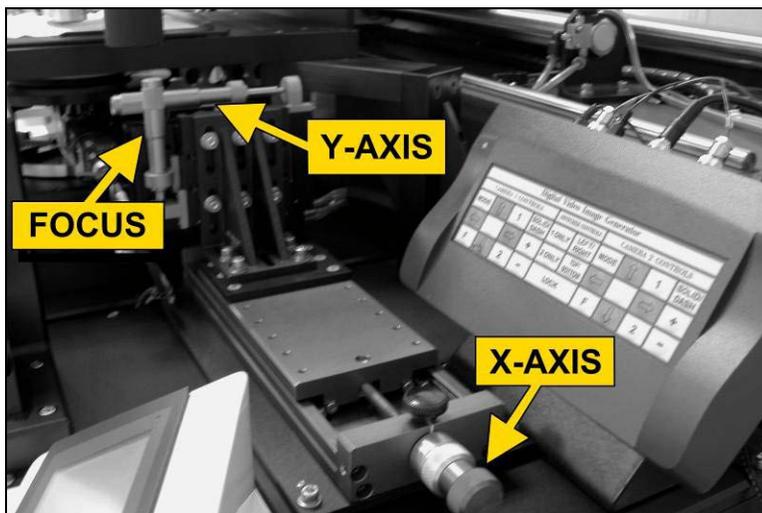


Figure 9-14 X, Y, and Focus for bottom side cameras.

Once the top and bottom cameras match up on the same piece of mask pattern **DO NOT MOVE THEM AGAIN**. Once aligned moving them at all will alter the alignment. At this point both sides of the split screen will be aligned to the same piece of mask pattern. Now move reticle pattern using the arrows on the associated DVPG unit. Pressing them once or twice will move them slowly or hold them down to

move them quickly. Remember that the reticle pattern will basically be the reference guide once the substrate is in. For example if part of the mask pattern has a line going through it you may want to align the reticle pattern so that it is parallel with the top portion of the line. When finished with this each monitor should have a split screen, and both portions of the split screen should be aligned in both the mask pattern and reticles.

STEP 4- Load substrate. Once reference points down are made, load the substrate. Load the substrate with the correct side facing up (back side of wafer) and push alignment stage back into position. The back of the alignment stage has magnets so pushing it back completely will put stage back in same position with very good accuracy. Turn the substrate vacuum on by going to LCD, RUN SCREEN, and then pressing the SUBSTRATE VACUUM button.

STEP 5- Align front and backside patterns. When the substrate is loaded the front side pattern will show up on the backside cameras. The mask pattern will be in the same position as it was previously on the top cameras. By using the wafer chuck adjustment controls move the wafer chuck so that the backside mask pattern is on top of the front side pattern appropriately. Remember: **DO NOT MOVE ANY OF THE CAMERA CONTROLS!** Only move the substrate at this point. Move the X, Y, and THETA wafer controls so that when looking at the monitors the reticles on the frontside align to backside mask pattern.

STEP 6- Process Settings. Once the pattern is properly aligned go to RUN SCREEN on the LCD and set your exposure time as well as making sure that the exposure type is set to BACK (not FRONT). After that press whichever contact exposure is appropriate (Hard, Vacuum, etc). After selecting contact type ALWAYS double check in monitor that front and back patterns are still aligned. Pushing the substrate and the mask together can mess up your alignment. If you notice that your alignment has been altered go back to the LCD screen, turn your contact type OFF and then readjust the alignment. Never adjust alignment when you have substrate/mask contact!

STEP 7- Exposure. When you have proper alignment with proper contact mode you can now press CYCLE to begin exposure. Be sure and turn away during exposure.

STEP 8- Remove mask and substrate. Once exposure is finished turn off exposure contact and substrate vacuum. Remove your substrate and remove mask.

9.4 Clean-up/Shut down

After you've completed your exposure(s) be sure and check the following:

- ✓ Both monitors are OFF
- ✓ All applicable (i.e. LCD controlled) vacuums are OFF
- ✓ All masks are put away properly in cabinet
- ✓ If the wafer chuck was changed for the exposure it may be necessary to replace the original for the next person using the machine
- ✓ Alignment stage is securely pushed into the machine
- ✓ **DO NOT** turn off UV power supply

This should take the machine back into the steady state position. Please do not attempt to turn off any controls other than the monitors, this need to be done by a Key Operator so that appropriate vacuum/power steps can be applied.

10. SIGNATURE OF COMPLETION

By my signature below, I affirm that I:

