Standard Operating Procedure
BNC
OAI Lithographic Mask Aligner (Aligner 2)
Version 2008 October 31

I. Purpose
This Standard Operating Procedure (SOP) outlines requirements to be considered by an authorized user of the OAI Lithographic mask aligner (Aligner2) as well as describes the normal operation of the aligner and any hazards that may be encountered during normal operation. Finally, the SOP explains how to minimize any hazards and how to respond in an emergency situation. This document is to be reviewed one year from the date of approval or as conditions warrant, whichever is the shorter time period.

II. Personnel
A. Authorized Personnel: The Aligner2 may be operated only by authorized personnel who are fully cognizant of all safety issues involved in the operation of such a device. These personnel are to ensure that the aligner is only operated in the manner laid out in this document. To become an authorized user, one must:
   1. Complete Environment, Health & Safety (EH&S) training class.
   2. Take the baseline MicroLab (Cory Hall) Safety Orientation class
   3. Read and fully understand the SOP
   5. Sign the authorized user sheet to affirm that the above steps have been completed.

B. Unauthorized personnel: No unauthorized personnel may enter the BNC clean room facility unless accompanied by an authorized user. All visitors must be briefed on proper safety protocol and must wear appropriate protective eyewear located on the premises.

III. Hazards
A. Electrical Hazards: electrical shock or electrocution could result from direct contact with high voltage. Such hazards are typically interlocked by the aligner system. High voltage electrode and conductors are located inside the light source system chassis. In addition, the external power supply unit has connections behind the power supply chassis. Do not disconnect the external lines. Use normal precautions with external house (110VAC) connections behind the aligner and light source chassis.
C. Chemical: N/A.

D. Pressure Hazards: Pressurized house gases are used with the aligner. Do not disconnect or tamper with gas and vacuum lines behind the aligner. Contact lab management for information.

E. Other: UV radiation is generated and emitted through the light source housing and mask exposure location. Wear protective eye wear when looking at the mask exposure locations.

IV. Hazard Controls

A. Electrical

1. Enclosures for protection against the high voltages of the power supply may only be removed after the power supply has been unplugged from the outlets and after following the safety procedures outlined in the safety and operations manual provided by the manufacturer.

2. Only qualified personnel may perform all internal maintenance to the aligner and more than one user must be present when performing said maintenance.

3. Every portion of the electrical system, including the printed circuit cards, should be assumed to be at dangerous voltage level.

C. Chemical and Pressure

1. Enclosures for protection against valves and internal gas plumbing may only be removed after the system has been turned off and gases have been valve off and relieved of line pressure.

2. Only qualified personnel may perform all internal gas maintenance to the aligner and more than one user must be present when performing said maintenance.

D. Other

1. Proper eye protection must be worn at all times in the clean room and while operating the aligner.
V. Normal Operation

A. Inspect all electrical, gas, and vacuum connections for damage and connectivity. The vacuum pump typically operates in the range (-20mmHg to -30mmHg). When the main vacuum valve on the instrument front panel is turned OFF, the vacuum pump pressure should be in the range of -20mmHg to -30mmHg.

B. Complete the “check-in” log and record the lamp hour meter reading (6 digit number). This will help monitor the lifetime of the UV bulb. Log ALL problems encountered.

C. Turn aligner system on (If it is off).

1. Turn ON the vacuum pump located in the service corridor and front panel valve on aligner.
2. Turn ON the N2 gas located in the service corridor and front panel valve on aligner.
3. Rotate in the clockwise (CW) direction Z axis knob to (separate) lower the wafer chuck from the mask.
4. Turn OFF Mask Frame Lock and lift up mask frame (There should be no mask on frame). The Mask Vacuum should be OFF also.
5. Turn ON N2 purge.

D. Turn on aligner UV lamp power supply (Lamp Warm up) and aligner optical microscope lamp.

6. Turn ON aligner optical microscope lamp on the fiber light box.
7. Turn ON the aligner UV lamp by pressing the ON power switch (Bottom button) on the UV lamp power supply. Next depress the Lamp Start red momentary button (Upper button). You need to hold the red button down for an instance. Do not turn the lamp on if the lamp has not sufficiently cooled down for at least 30 minutes. This is only if the lamp was recently turned off within the last 30 minutes.
8. Allow the lamp to stabilize for 5 minutes (30 minutes is best).
9. Set up the ORIEL/OAI lamp shutter controller. Timer Interrupt is off, Timer or Integrator should be set for TIMER, and AUTO.
10. Set up the timer (100s, 10s, 1s, and 0.1s) to 2 seconds for lamp check.
11. Hit Start to check expose time (Protect eyes from UV light).

E. Mask and Substrate Loading

12. Remove at least one of the mask hold down clamps, preferably the lower most clamp (These are there for mask life insurance purposes). This can be done with the mask frame down. The wafer chuck should have been lowered in section C step 3 to prevent destroying the mask.
13. Place and align mask along the vacuum grooves on the stage. Turn ON Mask Vacuum and replace hold down clamp.
14. Turn Substrate OFF to shut substrate vacuum and release any substrates on the chuck.
15. Place substrate on the chuck. Align substrates according to the mask pattern. Typically the major flat is on the right side position. Remember to make sure all the chuck vacuum holes are covered by the substrate except for the right most vacuum hole. Otherwise substrate vacuum hold down to the chuck will be compromised. The right most vacuum hole assists in the mask to substrate vacuum contact action. If this hole is completely covered, vacuum contact release between the mask and substrate will be slowed. There are also alignment pins in the chuck that help define the substrate right and lower edge locations for substrate placement on the chuck.
16. Turn ON the substrate vacuum and the substrate should be immobile and held down on the chuck. If not, reposition the substrate on the chuck minding to cover all the respective substrate vacuum holes.
17. Turn Chuck Release OFF to free up chuck. This allows the chuck to reposition and planarize with the mask.
18. Lower the mask frame and turn the Mask Frame Lock ON. If you had lowered the chuck in step 3 by turning the Z Axis control knob in the CW direction, there would be no fear in pushing the substrate into the mask.
19. Slowly raise the substrate up to the mask with the Z axis control knob, turn in the counter clockwise (CCW) direction and watch for contact with the mask. This is shown by observing the appearance of initial fringes on the substrate surface. Once contact is made, turn Chuck release ON to lock the substrate chuck. Next, reverse the Z axis knob in the CW direction and lower the substrate away from mask by approximately 0.25mm or 5 ticks on the Z axis knob. This ensures that there is no excessive pressure on the mask from the substrate and the substrate chuck will be planarized to the mask.
20. Turn N2 Purge OFF.
21. Turn Contact ON and adjust vacuum to read between the range (-10mmHg and -15mmHg). Note that it is negative pressure. Observe for fringes on the substrate and mask interface. If no fringes appear, gently raise the substrate by turning the Z axis control knob in the CCW direction. When fringes appear, back off 5 ticks on the knob and the substrate to mask distance will be set. This may vary slightly from substrate to substrate.
22. Turn Contact OFF, Turn N2 Purge ON, and proceed to substrate exposure. (IMPORTANT NOTE: The fringes observed should have disappeared. If not, readjust distance by turning in the CW direction until fringes disappear. Do not proceed any further until this condition is met. Confirm by turning Contact ON, N2 Purge OFF with fringes appearing and Contact OFF, N2 Purge ON with fringes disappearing.)

F1. Substrate Exposure (Single mask or initial mask exposure only)

1. The initial exposure should be with a power meter. You will take the mJ per centimeter square measurement and divide it by your mW per centimeter square resist exposure requirement and arrive at the time (seconds) of exposure you need to provide.
2. The Oriel /OAI exposure timer should have already been turned on and warmed up per section D.
3. Set the time for exposure with the timer (100s, 10s, 1s, and 0.1s) settings based upon your power meter exposure measurements and calculation.
4. Depress the Start button to check the timer (Protect your eyes from UW exposure).
5. At this time, the substrate to mask contact should be ON. Purge should be OFF. Use the aligner inspection microscope if necessary to inspect the features on the mask and substrate. Fringes should be observed on the substrate to mask interface. Proceed by using the aligner stage handle to push the aligner stage with the substrate and mask forward until the entire stage is beneath the lamp lens housing.
6. Depress the Start timer button on the ORIEL/OAI timer (Protect your eyes from UV).
7. After exposure has completed, using the handle on the aligner stage, pull the aligner stage with the substrate back towards you. Turn substrate to mask contact OFF.
8. Turn Mask Frame OFF. This will allow you to lift the mask frame and mask off the substrate. Be extra careful not to let anything make contact with your mask as you are lifting.
9. Turn Substrate Vacuum OFF to release the substrate. Remove the substrate with a pair of wafer forceps. If you are finished, proceed to section G. If you have other substrates, proceed to 10.
10. The substrate can now be replaced with another substrate and the entire exposure process restarted. Replace the substrate on the substrate chuck. Turn Substrate Vacuum ON to immobilize the substrate. Lower the Mask Frame and turn Mask Frame Vacuum ON. Turn mask to substrate contact ON. Observe for fringes on mask to substrate interface. Push the aligner stage using the handle into position beneath the UV lamp lens housing. Depress Start Timer ON to begin exposure (Protect your eyes from UV).
   If this is the last substrate exposure, proceed to section G. Otherwise, for further exposures, go back to Section F1, step 8.

F2. Substrate Exposure (Multiple mask or follow-on mask exposures)

1. The initial exposure should be with a power meter. You will take the mJ per centimeter square measurement and divide it by your mW per centimeter square resist requirement and arrive at the seconds of exposure you need to provide.
2. The Oriel /OAI exposure timer should have already been turned on and warmed up per section D.
3. Set the time for exposure with the timer (100s, 10s, 1s, and 0.1s) settings based upon your power meter exposure measurements.
4. Depress the Start button to check the timer (Protect your eyes from UV).
5. At this time, the substrate to mask contact should be ON. Purge should be OFF. The mask and substrates were loaded per section E.
6. Pull the aligner microscope over the aligner stage with the handle.
7. Center the aligner microscope relative to the center of the mask and the substrate.
8. Adjust the objectives as to align them with respect to the alignment fiducial marks; both left and right objectives can be independently adjusted. Focus the right eye piece...
with the Right Eyepiece and Overall Focus Knob. Then focus the left eye piece with the Left Eye Piece Focus Knob. The Septum can be positioned by pushing in or pulling out to the ideal position. Often times, the entire alignment microscope might have been rotated by other users. If necessary, rotate the alignment microscope about its pivot axis on the back. Be careful not to damage the microscope or alignment stage while rotating.

The alignment objective is to allow viewing both left and right side alignment fiducial marks of the mask and substrate in the microscope image view.

9. Next position the substrate X, Y, and theta rotation as to overlay the similar left and right side alignment fiducial marks of the substrate with the mask fiducial marks. (Note: The mask to substrate contact should be OFF, Purge ON in order to allow independent movement between the mask and substrate. There should be NO FRINGES OBSERVED. If you attempt to position the overlay with fringes present, you may destroy either your mask or substrate pattern. Refer to Section E for adjustments on mask to substrate contact. Some adjustment to the overall focus may be necessary to aid visualization of the substrate alignment pattern if the prior substrate pattern is shallow. Continue adjusting the substrate X, Y, and theta rotation until the overlaid substrate and mask alignment fiducial marks are completely aligned to your satisfaction.

10. When alignment is complete, turn mask to substrate to mask contact ON. Turn N2 purge OFF.

11. Using the aligner stage handle, push the aligner stage with the substrate and mask forward until the entire stage is beneath the lamp lens housing.

12. Depress the Start timer button on the ORIEL/OAI timer (Protect your eyes from UV).

13. After exposure has completed, using the handle on the aligner stage, pull the aligner stage with the substrate back towards you. Turn mask to substrate contact OFF. Turn N2 purge ON.

14. Turn Mask Frame OFF. This will allow you to lift the mask frame and mask off the substrate. Be extra careful not to let anything make contact with your mask as you are lifting.

15. Turn Substrate Vacuum OFF to release the substrate. Remove the substrate with a pair of wafer forceps. If this is the last substrate for exposure, go to Section G. If you have more substrates to exposure, proceed to 16.

16. The substrate can now be replaced with another substrate and the entire exposure process restarted. Replace the substrate. Turn Substrate Vacuum ON to immobilize the substrate. Turn mask to substrate contact ON. Turn N2 purge OFF. Lower the Mask Frame and turn Mask Frame Vacuum ON. Push the aligner stage using the handle into position beneath the UV lamp lens housing. Depress Start Timer On to begin exposure (Protect your eyes from UV).

17. If this is the last substrate exposure, proceed to section G. Otherwise, for further exposures, go back to Section F2, step 14.

G. Shutdown and Cleanup.

1. Mask to Substrate Contact OFF.
2. N2 Purge ON.
3. Mask Frame Lock OFF. Turn Z Axis substrate chuck knob in CW direction to (separate) lower chuck away from mask.
4. Mask Frame Vacuum OFF (Mask is now loose), and remove lower most Mask Frame Hold-down Screw. Remove Mask and put away in protective container.
5. Substrate Vacuum OFF and remove substrate.
6. Substrate Chuck Vacuum OFF.
7. Complete Log book entries with UV lamp (6 digit number) usage entry.
8. Turn off UV Lamp by switching lamp power controller OFF (Leave ON, if someone else is expected to use aligner during the next few hours).
9. Turn OFF aligner microscope power.
10. Turn OFF aligner vacuum pump power in the service corridor and the front panel valve.
11. Turn OFF N2 gas line in service corridor and the front panel valve.

VI. Emergency Procedures

A. Aligner accidents: Notify lab management and PI immediately.

B. Power outage: If there is a power outage, turn off the aligner per the aligner shut down procedure (Section G in Normal Operation) to avoid a hazardous situation when power is restored. If there is an emergency, leave laboratory immediately and either return after emergency to shut down aligner or contact lab management.
Authorized Users
I have read and understood the Standard Operating Procedures for RIE 1

<table>
<thead>
<tr>
<th>Name (print)</th>
<th>Signature</th>
<th>Date</th>
<th>PI or Super User Initial</th>
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Appendix A – In case of medical emergencies, consult lab safety protocol or lab safety plan.

In the event of an aligner accident, follow the procedure below:

1. Ensure that the aligner is shut off per Section G in **Normal Operation**.
2. Provide for the safety of the personnel (first aid, evacuation, etc.) as needed.
3. Obtain medical assistance for anyone who may be injured.

<table>
<thead>
<tr>
<th>UC Optometry Clinic (Normal Hours)</th>
<th>642-2020</th>
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<tbody>
<tr>
<td>UC Optometry Clinic (24 Hour Emergencies)</td>
<td>642-0992</td>
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<tr>
<td>University Health Services (Emergency)</td>
<td>642-3188</td>
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<tr>
<td>Ambulance (urgent medical care)</td>
<td>9-911</td>
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4. If there is a fire, pull the alarm, and contact the fire department by calling 9-911. Do not fight the fire unless it is very small and you have been trained in fire fighting techniques.

5. Inform the Office of Environment Health, & Safety (EH&S) as soon as possible.

6. During normal working hours, call the following:

<table>
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<tr>
<th>EH&amp;S Office</th>
<th>642-3073</th>
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<tr>
<td>BNC Safety Officer</td>
<td>666-3356</td>
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<tr>
<td>EH&amp;S Health &amp; Safety Manager</td>
<td>642-3073</td>
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After normal working hours, call 642-6760 to contact the UC Police Department who can contact the above using their emergency call list.

7. Inform **(PI NAME)** and the BNC safety officer (BNC Management) as soon as possible. If there is an injury, **(PI NAME)** will need to submit a report of injury to the Worker’s Compensation Office.

8. After the incident, do not resume use of the aligner system until the BNC lab manager and EH&S has reviewed the incident and approved the resumption of research.
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